East Liberty Garage
Battery Electric Bus Implementation Plan

Port Authority of Allegheny County

Final Report

October 30, 2020

EAST LIBERTY GARAGE BATTERY ELECTRIC BUS IMPLEMENTATION PLAN

TABLE OF CONTENTS

List of Figures

1. Executive Summary

Overview

Port Authority of Allegheny County (Authority) is seeking to evaluate the infrastructure of their existing East Liberty Bus Garage facility to accommodate charging stations for Battery Electric Buses (BEB).

The East Liberty Bus Garage is a maintenance and parking facility adjacent to the East Busway that houses 225 diesel buses. The Authority has also implemented a pilot program for storing and charging two 40' New Flyer BEBs with 150kW depot chargers in the East Liberty Garage. The existing Training Room, Room #101 has been used to house the charging rectifiers. A second dedicated electrical utility service was added to accommodate this program.

The Authority is now planning to expand the BEB fleet for the East Liberty Garage and has requested a report to determine how many chargers the East Liberty Garage can accommodate based on the existing infrastructure with certain mechanical and electrical upgrades as identified throughout the report.

The Authority has requested that four scenarios be evaluated as part of this report:

Scenario 1 provides the maximum number of chargers that can be accommodated without mechanical or electrical upgrades with the exception of adding circuits to existing electrical equipment.

The findings of Scenario 1 indicate that the electrical capacity is inadequate to support the pantograph charger but could support the addition of 2 depot chargers. However, the ventilation in Room 101 is inadequate for adding any interior chargers while maintaining the room at 90 degrees F. Alternatively, if PAAC raises the allowable temperature to 100 degrees F, then one new charger could be added. The calculations below are for theoretical and for reference only and are not to be used as a recommendation for construction due to heat gain in the room.

The Authority has requested that an evaluation be provided to include one 450kW Pantograph charger from the outdoor switchboard. The limiting factor for the pantograph would be the utility transformer. To accommodate the pantograph charger load a 1.5MVA transformer should be provided to replace the existing 750kVA transformer.

Scenario 2 provides the maximum number of chargers that can be accommodated by the existing electrical system by only adding required circuits. The required circuits are determined by the limits of the existing mechanical ventilation, without making mechanical upgrades.

The findings of Scenario 2 indicate that one depot charger can be added in the facility with electrical upgrades as further described below. However, the ventilation in Room 101 is inadequate for adding any interior chargers while maintaining the room at 90 degrees F. Alternatively, if PAAC raises the allowable temperature to 100 degrees F, then one new charger could be added.

The Authority has requested that an evaluation be provided to include one 450kW Pantograph charger from the outdoor switchboard. The limiting factor for the pantograph would be the utility transformer. To accommodate the pantograph charger, a 1.0MVA transformer should be provided to replace the existing 750kVA transformer. A dedicated 750A breaker will need added to the outdoor switchboard for a dedicated underground feed to the equipment.

Scenario 3 provides the maximum number of chargers based on upgrades to both the mechanical and electrical systems, coupled with the space constraints of Room 101.

The findings of Scenario 3 indicate that 14 additional depot chargers, plus two existing depot chargers, for a total of 16 depot chargers and one pantograph charger can be added with electrical and HVAC upgrades. HVAC upgrades would be for the training room and include ventilation and cooling. Electrical upgrades to accommodate the charging equipment includes an additional bank of generators, distribution panel upgrades, and utility transformer upgrades. The fire line located at the rear of the building was also relocated to avoid equipment interferences.

Scenario 4

Scenario 4 evaluated the electrical, structural, and infrastructure modifications required to provide a total of 30 (28 in addition to the existing 2) 150kW Depot Chargers, and 2 outdoor 450kW Pantograph Chargers at the East Liberty.

A dual service entrance is proposed for power redundancy in lieu of the multiple generators proposed in Scenario 3. Due to space constraints and the financial and physical burden of maintenance associated with generators, a second utility is recommended. In the event both utility circuits fail the two 500kW generators can provide backup power for eight 150kW depot chargers.

The charging scheme for the chargers would rely on the main tie-main dual service entrance to provide utility power to twenty-two chargers. The remaining eight chargers would be normally powered from a single utility circuit and switch over to generator power in the event of a power loss. This configuration provides flexibility and multiple options for a power outage plan. The two 450kW pantograph chargers would only be powered from a single utility circuit and would not have the option for a redundant power supply.

WRA and PAAC have evaluated the site for the optimum location for the electrical equipment and decided the employee parking area behind East Liberty garage (adjacent to the busway) would be the most efficient location since there is adequate space and it maintains separation from day to day activities in the garage. There are three new areas for the service entrance proposed to the existing generator area in the rear of the building to accommodate the BEB charging equipment. The equipment areas in the rear of the building are: a dual medium voltage utility service entrance switchgear, two low voltage switchgears, an equipment platform, the existing generator area.

BEB depot charging dispensers are proposed with a ceiling mounted remote dispenser panel and motorized cable reel. WRA coordinated with PAAC staff and decided overhead motorized reels provide the safest option available for operators and is the most efficient system due to limited space between parked buses. BEB parking will start at lane 24 and progress toward lane 1 as required.

Scenario	150kW Depot Charger			450kW Pantograph Charger - New
	Existing	New	Total	
Scenario 1	2	2	4	1
Scenario 2	2	1	3	1
Scenario 3	2	14	16	1
Scenario 4	2	28	30	2

Figure 1 Bus Charger Quantity Summary Table by Scenario

Opinion of Probable Construction Cost

The opinion of cost is based on the historical data for cost per square foot for facilities of this type. Additional factors specific to this site and project have been incorporated into the cost model. Anticipated costs associated with charging equipment; 150kW Depot chargers ($95,000 each) and 450kW Pantograph chargers ($1,000,000) were provided to WRA by the Authority.

Scenario 1: *See Appendix C for Scenario 1 cost estimate*

Costs Associated with Required Building Improvements (G, H, E, P contracts):	$	34,000
Costs Associated with Rectifier Equipment (not including contractor markup):		
(2) 150kW Depot Chargers:	$	190,000
(1) 450kW Pantograph Charger:	$	1,000.000
Grand Total:	**$**	**1,224,000**

Scenario 2: *See Appendix C for Scenario 2 cost estimate*

Costs Associated with Required Building Improvements (G, H, E, P contracts):	$	17,000
Costs Associated with Rectifier Equipment (not including contractor markup):		
(1) 150kW Depot Charger:	$	95,000
(1) 450kW Pantograph Charger:	$	1,000,000
Grand Total:	**$**	**1,112,000**

Scenario 3: *See Appendix C for Scenario 3 cost estimate*

Costs Associated with Required Building Improvements (G, H, E, P contracts):	$	4,850,000
Costs Associated with Rectifier Equipment (not including contractor markup):		
(14) 150kW Depot Chargers:	$	1,330,000
(1) 450kW Pantograph Charger:	$	1,000,000
Grand Total:	**$**	**7,180,000**

Scenario 4: *See Appendix C for Scenario 4 cost estimate*

Costs Associated with Required Building Improvements (G, H, E, P contracts):	$	11,080,000
Costs Associated with Rectifier Equipment (not including contractor markup):		
(28) 150kW Depot Chargers:	$	2,660,000
(2) 450kW Pantograph Charger:	$	2,000,000
Grand Total:	**$**	**15,740,000**

2. Overview

Port Authority of Allegheny County (Authority) is seeking to evaluate the infrastructure of their existing East Liberty Bus Garage facility to accommodate charging stations for Battery Electric Buses (BEB).

The East Liberty Bus Garage is a maintenance and parking facility adjacent to the East Busway that houses 225 diesel buses consisting of both 40' coach and 60' articulating buses manufactured by New Flyer and Gillig.

The Authority has also implemented a pilot program for storing and charging two 40' New Flyer BEBs with 150kW depot chargers (BC-1 and BC-2) in the East Liberty Garage. The existing Training Room, Room #101 has been used to house the charging rectifiers. A second electrical utility service was added to accommodate this program. The second utility entrance was installed strictly for BEB charging and is not used to support building equipment.

The Authority is now planning to expand the BEB fleet and has requested a report to determine how many chargers the East Liberty Garage can accommodate based on the existing infrastructure with certain mechanical and electrical upgrades as identified throughout the report. There are specific directives and assumptions that govern the scope of this evaluation:

1. If possible, potential scenarios will all include one 450kW pantograph charger located outdoor with a maximum number of 150kW depot chargers located indoor. With the exception of scenario 4; two 450kW pantograph chargers will be provided from the existing SWBD-1.

2. Charger rectifiers (although NEMA 3R rated), will be located indoors, in Room 101 adjacent to the existing chargers for scenario 1-3. Scenario 4 will suggest locating the rectifiers outdoors.

3. Building expansions are not to be considered as part of this evaluation. The proposed equipment platform in scenario 4 is not anticipated to be attached to the existing structure and will be free standing.

4. For scenarios 1-3 electrical upgrades being considered do not include a new service entrance. Electrical upgrades are based on what can be accomplished within the capacity of the existing switchboard as further described below. Scenario 4 will consider a third (to the two existing (1) building operations, (1) BEB charging) service entrance for the additional equipment.

5. The Authority's desired ratio of chargers to buses is 1:1.

6. The Authority requested Training Room 101 design temperature is 90°F.

7. Heating for Room 101 is considered adequate and has not been evaluated for this report.

8. HVAC (existing and proposed) is fed from secondary utility entrance for scenario 3

9. For scenario 1-3 Duquesne Light Company can provide a pad mounted transformer adequately sized for the maximum capacity of the switchboard SWBD-1. Transformer load is utilized and calculated up to 100% of the anticipated transformer capacity which may exceed the utilities' discretion.

10. Secondary Utility service electric equipment is under construction and is currently being installed at the East Liberty facility. For this report the service entrance equipment, two chargers, one 500kW diesel generator, and ATS are assumed to be installed and in operation.

11. Charging is considered 100% utilization; power load was calculated without a demand factor since all equipment is assumed to be operating at once (total connected load will operate simultaneously).

12. The existing roof joists do not have the capacity to support the weights of the proposed equipment. Roof Joists supporting conduit banks from the rectifiers need additional reinforcement.

13. The report is based on Siemens charging rectifiers and the assumption that an overhead, remote charging cabinet can be mounted at ceiling level and coupled with an electric cord reel.

The Authority has requested that four scenarios be evaluated as part of this report:

Scenario 1 provides the maximum number of chargers that can be accommodated without mechanical or electrical upgrades.

Scenario 2 provides the maximum number of chargers that can be accommodated by upgrading electrical, but without upgrading the mechanical system, meaning to work within the constraints of the existing ventilation system in Room 101.

Scenario 3 provides the maximum number of chargers based on upgrades to both the mechanical and electrical systems, coupled with the space constraints of Room 101.

Scenario 4 evaluated the electrical, structural, and infrastructure modifications required to provide a total of thirty 150kW depot chargers, and two outdoor 450kW pantograph chargers at the East Liberty Garage.

2.1 East Liberty Garage – Facility Overview

The East Liberty Bus Garage is a maintenance and storage facility. Facility accommodations include a bus wash (and fueling) bay, maintenance bays, paint booth, tire bay, and administration office areas. The facility provides indoor and outdoor bus parking with direct access to the East Busway.

Room 101 was constructed in 1990 as an addition to the original building. The original space was designed for tire storage, and subsequently converted into an employee maintenance training area. Two 150kW rectifiers for depot chargers and a 1200A 480Y/277V distribution panel (EBC-1) were added to the room. An optional standby generator was added for backup power to the chargers in the event of a utility service loss.

Indoor bus parking was originally designed and constructed for diesel buses. Two bus parking lanes share one garage door, with lane striping in-between. The original design for the diesel bus parking configuration is compact affording minimal space between buses.

Available electrical service includes two electrical utility service entrances:

Primary Garage Utility Service: Utility owned 750kVA 480/277V oil filled pad mounted transformer feeds MDP-A, a 480Y/277V 1200A distribution panel. Branch circuits from various panelboards provide power to all of the general building equipment, HVAC, and lighting. The primary garage utility service is separate from BEB charging equipment and will not be considered or used during the scenario evaluations.

Secondary BEB Charging Utility Service. Utility owned 750kVA 480Y/277V oil filled pad mounted transformer feeds SWBD-1, a 480Y/277V 4000A NEMA 3R rated outdoor switchboard. SWBD-1's main circuit breaker is a 100% rated 4000A LSIG breaker with electronic trip settings, ground fault alarm, and display. SWBD-1 sub feeds panelboard "EBC-1" for the existing electric bus rectifiers BC-1 and BC-2. One 500kW pad mounted diesel generator and ATS provide power to panel EBC-1 in the event of utility power loss.

Mechanical equipment serving Room 101 includes one rooftop mounted EF-23 (1.5hp 10,600 CFM) exhaust fan with two 3' x 3' motorized intake dampers. There is currently no additional cooling provided in Room 101.

2.2 Code Summary Overview

The International Building Code does not preclude the storage of BEBs or the installation of rectifiers as proposed in Room 101. Room 101 will be classified as an electrical equipment room. Any code required upgrades to the room will be as directed by the National Electric Code (NEC) and National Fire Prevention Association (NFPA).

Code required upgrades to Room 101 and the bus storage area are not anticipated at this time.

The code analysis for NEC was based on the following relevant criteria:

- NFPA 70 2017 NEC: Article 625.41 Overcurrent Protection. Overcurrent protection for feeders and branch circuits supplying equipment shall be sized for continuous duty and shall have a rating of not less than 125 percent of the maximum load of the equipment.

Where noncontinuous loads are supplied from the same feeder, the overcurrent device shall have a rating of not less than the sum of the noncontinuous loads plus 125 percent of the continuous loads.

- NFPA 70 2017 NEC: Article 625.52 Ventilation (Bus Storage). The ventilation requirement for charging an electric vehicle in an indoor enclosed space shall be determined by 625.52(A) or (B). Where electric vehicle storage batteries are used or where the equipment is listed for charging electric vehicles indoors without ventilation and marked in accordance with 625.15(B), mechanical ventilation shall not be required.

  NFPA 70 2017 NEC: Article 110.34(a) Minimum depth of clear working space at electrical equipment.

Table 110.34(A) Minimum Depth of Clear Working Space at Electrical Equipment

Nominal Voltage to Ground	Minimum Clear Distance		
	Condition 1	Condition 2	Condition 3
1001–2500 V	900 mm (3 ft)	1.2 m (4 ft)	1.5 m (5 ft)
2501–9000 V	1.2 m (4 ft)	1.5 m (5 ft)	1.8 m (6 ft)
9001–25,000 V	1.5 m (5 ft)	1.8 m (6 ft)	2.8 m (9 ft)
25,001 V–75 kV	1.8 m (6 ft)	2.5 m (8 ft)	3.0 m (10 ft)
Above 75 kV	2.5 m (8 ft)	3.0 m (10 ft)	3.7 m (12 ft)

Note: Where the conditions are as follows:
(1) **Condition 1** — Exposed live parts on one side of the working space and no live or grounded parts on the other side of the working space, or exposed live parts on both sides of the working space that are effectively guarded by insulating materials.
(2) **Condition 2** — Exposed live parts on one side of the working space and grounded parts on the other side of the working space. Concrete, brick, or tile walls shall be considered as grounded.
(3) **Condition 3** — Exposed live parts on both sides of the working space.

2.2.1 Existing Site Layout

Figure 1 shows the East Liberty Garage existing site plan with shaded areas identifying general use. Additional site information is also shown in Appendix A, Exhibit 2.1.1.

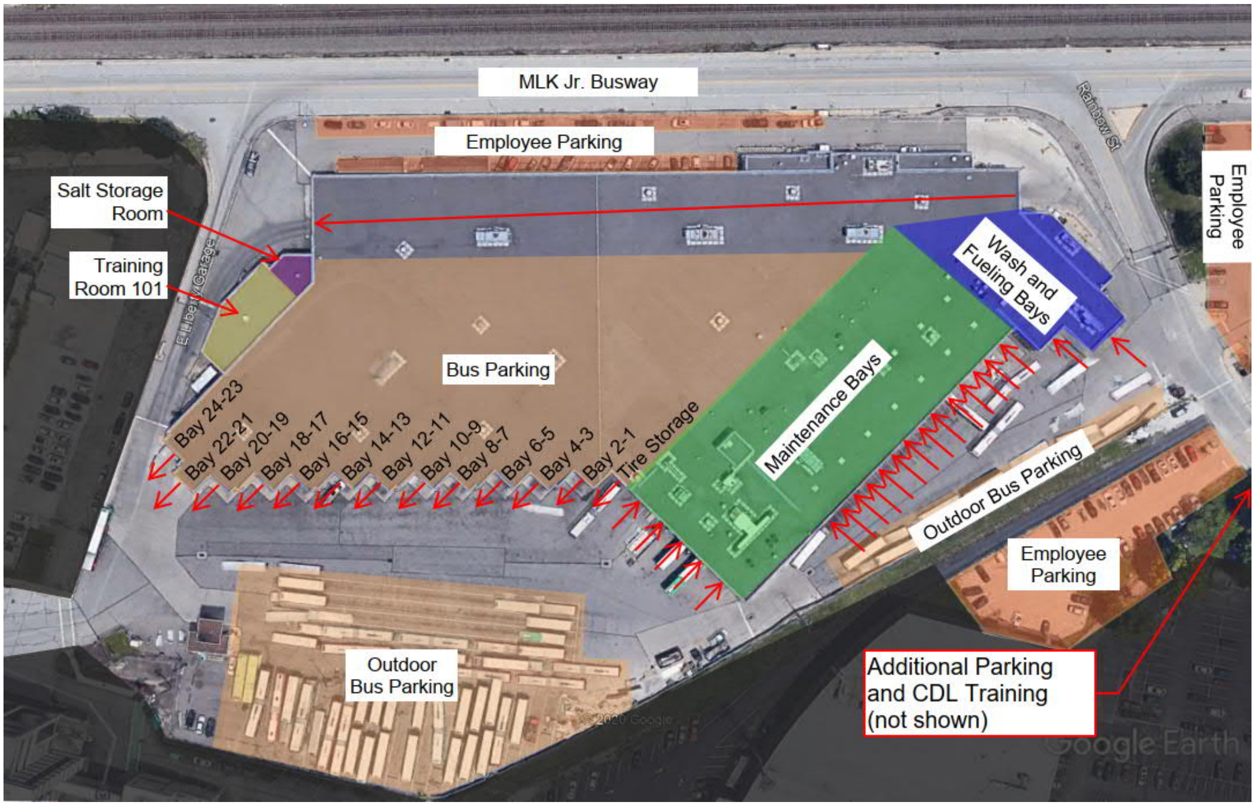


Figure 2 Existing Site Plan

3. Design Criteria

3.1 Proposed BEB Fleet

This evaluation is based on a combination of 40’ BEBs and 60’ articulating BEBs. The calculations are based on 40’ buses with battery capacities of 466kWh, and 60’ buses rated at 880kWh. Buses are equipped with charging ports located on the rear passenger side and overhead rails for pantograph charging.

3.2 Bus parking:

The Authority indicated parking lanes for BEB charging stations to start at lane 24 and progress towards lane 1 based on need. The lane layouts are shown in Figure 1 above.

3.3 Bus Charging Rectifiers

The equipment used for this evaluation are rectified chargers manufactured by Siemens: the “High Power Charging 2.0 with Pantograph” (450kW) and the “Rave 750VDC depot charger (150kW) with separate dispenser” rectifiers.

3.3.1 Pantograph – Siemens 450kW

The Siemens High Power Charging 2.0 with Pantograph” (450kW) is an outdoor rated UL certified rapid charger complete with pantograph charging rails for electric buses to quickly charge their battery banks. The unit is comprised of a charging cabinet and a mast. The mast can be remotely located from the charging cabinet located up to 100m apart.

Figure 3 Pantograph Charger Mast

Operation: The BEB communicates wireless with the charger via patch antennas, which are located on the bus roof and on the pantograph. Wireless connectivity between the antennas is established when the antennas are in receiving range to each other, this is given when the BEB approaches the charging mast longitudinally. The charging process starts when the driver activates the hand brake and ends if the hand brake is released.

Siemens Pantograph Charger Specifications	
Rated Power - 450kW	
Input	
Voltage	480 VAC (L1, L2, L3, N, PE) ±10%
kW Rating	~460kW
Frequency	50/60 Hz
Efficiency	97%
Energy Consumption in Standby	3.1kWh to 1.61kWh
DC Output	
Rated Current	600 A (450kW@750V)
Voltage Range	450Vdc to 750Vdc
Environmental Conditions	
Operation Temperature	-35ºC to + 45ºC
Mechanical Specifications	
Protection	Cabinet and Mast steel structure: IP23D optional IP44 possible (IEC 60529), IK10 (IEC 62262 Power Electronics: IP54 (IEC 60529) Mast Electronics: IP56 (IEC 60529)
Communications	
WiFi	Protocol ISO 15118 IPv6
4G	SIM Card Required (Mini-SIM)
Communications	ETHERNET interface / 4G/ Fiber Optic

Figure 4 Pantograph Charger Specifications

Electrical Implementation Requirements	
Overcurrent Protection	750A (80% rated) Circuit Breaker - Electronic Trip
Wiring Method	2 sets of 4-500 kcmil + 1/0G (75°C) in 4" conduit (underground encased in concrete)

Figure 5 Pantograph Charger Electrical Implementation Requirements

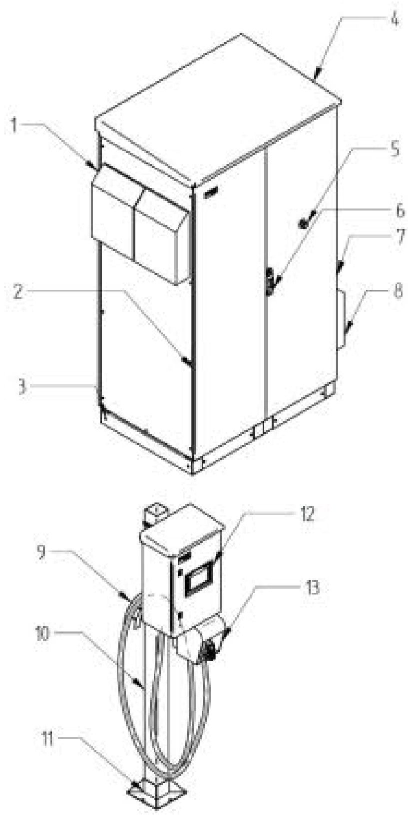
Installation: The wiring will extend from a dedicated breaker in SWBD-1 adjacent to Room 101 underground with handholes to the proposed charger location shown in Appendix A, Exhibit 3.2.1. Trenching the underground power feed to the pantograph may be challenging due to undocumented utilities in the area. The second proposed location is shown in scenario 4 Appendix A Exhibit 4.4.1.

The pantograph foundation is assumed to be a mat foundation slab beneath the footprint of the pantograph. The dimensions of the footprint and foundation are based off the basis of design pantograph product data.

3.3.2 Depot Charger – Siemens 150kW

The Siemens Rave 750V 150kW CCS DC charger with separate dispenser is an indoor / outdoor rated UL 1950 certified depot charger. The unit is comprised of a charging cabinet (rectifier) and a remote plug in dispenser. The dispenser can be remotely located from the charging cabinet located up to 200m apart.

Operation: Bus operators pull up to the dispensing unit which can be wall, pedestal, or overhead mounted. The operator plugs the dispenser nozzle into the buses charging receptacle and the charging unit starts a series of internal safety checks. With the handshake and safety checks complete the bus will charge the onboard batteries until full (90% charge), then enter into trickle charge mode at a rate of 2-8 amps until the dispenser cable is removed.



Charger Components	
Part Nº	**Description**
1	Ventilation (Exhaust air)
2	Cabinet door (Power module)
3	Removable side panels
4	Rain Hood
5	Emergency button)
6	Handle System
7	Cabinet door (Control module)
8	Ventilation (Outside air)
9	Management support cable
10	Pole/Mast
11	Pole Ground base
12	Touch Screen Display
13	Plug Support

Figure 6 Depot Charger with pedestal dispenser

Siemens Depot Charger Specifications	
Rated Power - 150kW	
Input	
Voltage	3 phases + PE, 480 Vac ±10%
Current per phase	220 A
Frequency	60 Hz
Power Factor	> 0,98
Efficiency	> 93 %
Total harmonic distortion	Inferior to 4% at full charge
DC Output	
Rated Current	200 A (@750V)
Voltage Range	500Vdc to 750Vdc
Ripple	Less than 1% of the nominal voltage
Protections	
Input	Thermic Relay
Overvoltage	DST´s Valvetrab Modules
Output Current Limitation	Limited by Reading circuit of current shunt / Circuit independent of the output voltage
EMC s	According to European Policy
Safety	Designed and built according to EN60950, IEC 950, UL1950
Environmental Conditions	
Operation Temperature	-13°F to 122°F (-25ºC to + 50ºC)
Storage Temperature	-40°F to 158°F (-40ºC to + 70ºC)
Humidity	5 - 95% of relative humidity without condensation
Altitude	0 - 3,280 ft (0 – 1000m) in operation
Mechanical Specifications	
Protection	NEMA 3R
Charging Station	
Overall Dimensions	(WxDxH) 55.1 x 47.2 x 78.7 in (1400 x 1200 x 2000 mm)
Charging Station Weight	5,291 lb (2,400 kg)
Pole Weight	110 lb (50 kg)
General	
Efficiency	> 95%
Automation System	Siemens SIMATIC S7-1200
Local Interface (MMI)	Siemens HMI TP700
Communications	ETHERNET interface / 3G / 4G / Fiber Optic
Charging standard	EN61851-1/23/24
Max. distance between charger and dispenser	(656 ft) 200m
Connectors CCS type 1	CCS Type 1

Figure 7 Depot Charger Specifications

Electrical Implementation Requirements	
Overcurrent Protection (480/3)	250A (80% rated) Circuit Breaker - Electronic Trip
Wiring Method AC (rectifier)	3-250 kcmil + #4 G (75°C) XHHW-2 in 2-1/2” GRC
Wiring Method DC (dispenser)	2-3/0 + #4g (75°) XHHW-2 (1000V rated) in 2" GRC

Figure 8 Depot Charger Implementation Requirements

3.3.2.1 Depot Charger Installation Requirements Per-Unit:

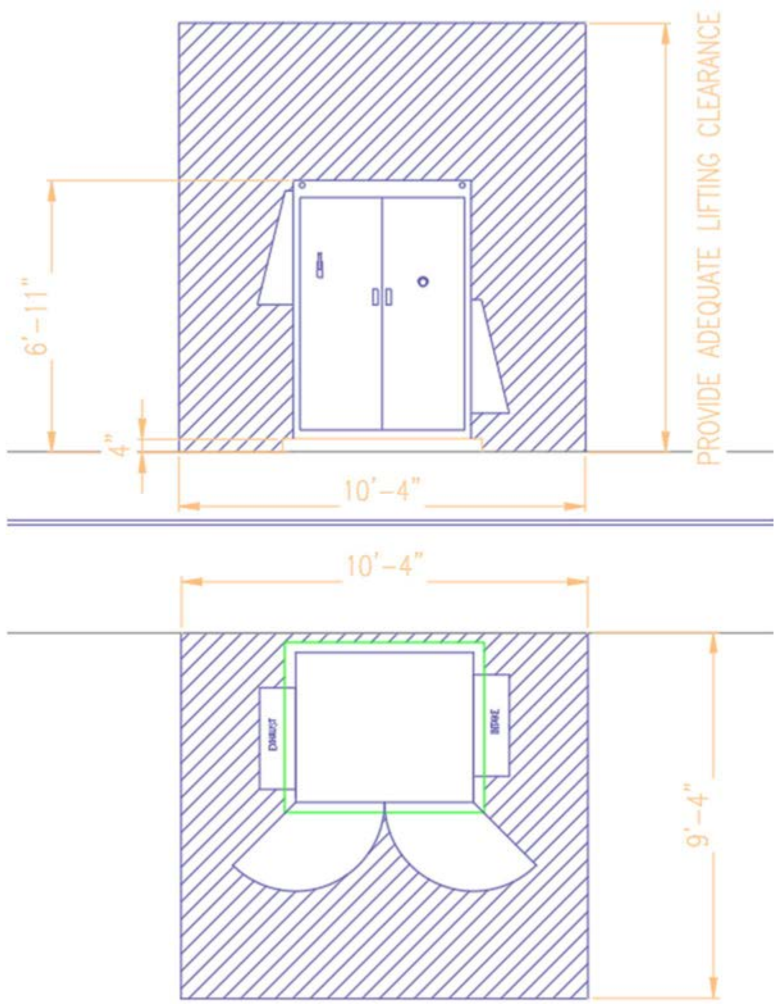


Figure 9 Depot Charger Footprint

150kW Depot Charger Installation Requirements		
Electrical Requirements	Supply Volts	480V 3-Phase 4-Wire 60hz
	Supply Load (@480/3)	184 Amps
	Supply kW	150
	Power Factor	0.98
	Supply kVA	153
	Breaker size	250A 3 pole
	Conduit (Rectifier)	2-1/2 " GRC
	Conductor (Rectifier)	4-250kcmil + #4G (XHHW-2)
	Conductor (Dispenser)	2-3/0kcmil + #4G (XHHW-2 1000V)
	Conductor (Dispenser)	2" GRC
Comms	Communications (Rectifier)	CAT-6 to nearest switch
	Communications (Dispenser)	CAT-6 to Rectifier 2-#12 in 3/4" GRC (24VDC Supply)
Mechanical	Heat dissipation	36 MBH
	Airflow Per unit (10°F delta)	3,300 CFM
Physical	Temperature Range	-13°F to + 122°F (-25°C to + 50°C)
	Humidity Range	5-95% RH (non-condensing)
	Footprint	10'-4"W x 9'-4"D x 6'-7"H
	Footprint Area	96.5 sqft
	Weight (Rectifier)	5,291 lbs (2,400 kg)
	Lifting requirements	Overhead Lifting Eyes: Additional overhead clearance should be provided depending on lifting means
	Max. Distance Between Rectifier and Dispenser	656 ft (200m)

Figure 10 Depot Charger Installation Requirements

Mechanical: Heat dissipation (per 150 kW unit):

With each unit listed at 150kW input and 93% efficient, the estimated heat gain to the space from each operating unit is as follows:

150 kW x 3.413 MBH/kW x ((100-93) / 100) = 35.8 MBH → 36 MBH heat gain

Outside air ventilation required for “cooling” (per 150 kW unit)

To maintain the space temperature at 10 degrees above ambient using strictly ventilation air from the building exterior, the ventilation requirement per unit is as follows:

((36 MBH x 1000) / (1.08 x 10 deg)) = 3,330 cfm

3.3.3 Bus Charging Rates and Duration

Bus battery charging times are dependent on the battery capacity and the associated charging rectifier output. The following charging rates and times are based on Port Authority provided observation data for the Siemens 150kW depot charger powering a 466kWh battery. The Authority does not have an 880kWh battery or 450kW pantograph charger to observe for data, so the following information was extrapolated based on the provided 150kW depot charger data. The extrapolated information will need validated in field and is being provided as a general estimate of charging rate.

				Usable Charge Range		Trickle Charge	Usable Charge 30%-90% (kWh)	Usable Capacity 30% to 92% (kWh)*
	Battery Capacity (kWh)	0%	20%	30%	90%	92% (max)		
40' Bus	466	0	93.2	139.8	419.4	428.7	**279.6**	288.9
60' Bus	880	0	176.0	264.0	792.0	809.6	**528.0**	545.6

Figure 11 Charge (kWh) by percentage of battery capacity

	Batt Capacity kWh**	Charger Output* (kW)	Charge Time (hours)	Charge Time Minutes	Charge Percentage per Minute (to 90%)
40' Bus	279.6	130	2.15	129	0.70%
	279.6	390	0.72	43	2.09%
60' Bus	528.0	130	4.06	244	0.37%
	528.0	390	1.35	81	1.11%

* Output data for 130kW based on Authority Provided Observations
Output data for 390kW extrapolated based on 150kW (86%) efficiency.

** Usable capacity from 30% to 90% used due to 92% reduced charge rate in trickle charge mode.

Figure 12 Battery charging time based on charging rate

4. Scenarios

4.1 Scenario 1

4.1.1 Summary

Provide the maximum number of chargers that can be accommodated without mechanical or electrical upgrades with the exception of adding circuits to existing electrical equipment.

The findings of Scenario 1 indicate that the transformer capacity is inadequate to support the pantograph charger but could support the addition of two depot chargers. However the ventilation in Room 101 is inadequate for adding any interior chargers while maintaining the room at 90 degrees F. Alternatively, if PAAC raises the allowable temperature to 100 degrees F, then one new charger could be added. The calculations below are for theoretical and for reference only and are not to be used as a recommendation for construction due to heat gain in the room.

4.1.2 Electrical

The existing secondary utility entrance transformer is rated at 750kVA 480/277V and is dedicated to BEB charging. Room 101 has one 1200A (EBC-1) distribution panel currently providing power to two rectified 150kW depot chargers BC-1 and BC-2. The existing exhaust fan EF-23 (1.5hp 480/277V) is circuited to “Panelboard GG” and will remain fed from “Panelboard GG” for this evaluation.

The limiting factor in the secondary utility entrance circuit in this case would be the diesel generator GS-1 rated for 500kW at 480Y/277V with a power factor of 0.8. being able to produce a total of 750 amps. This evaluation is based on utilizing maximizing output of the 500kW genset.

The pantograph charger is rated for 460kW with a power factor of .97 with a total load of 570A at 480V 3 phase. The power scheme for the pantograph charger would be to provide power from the outdoor SWBD-1, without the availability of generator backup power. Panel EBC-1 will provide power to two additional 150kW depot chargers for a total of 4 (150kW) chargers for maximum generator load. The addition of the pantograph would require the utility transformer to be upgraded to a minimum 1,100kVA capacity and since this option exceeds the scenario requirements it has been removed from the calculation table below.

Scenario 1 - Electrical Equipment Capacity Calculation					
	Quantity	**kW**	**Quantity x kW**	**PF**	**Apparent Power kVA**
Existing Rectifier 150kW	2	150	300	0.98	306.1
Additional Rectifier 450kW	0	460	0	0.97	0.0
Additional Rectifier 150kW	2	150	300	0.98	306.1
Existing 1.5 HP EF-23	0	1.4	0.0	0.86	0.0
			600.0	0.98	612.24

Existing EBC-1 Capacity	997.66	kVA (1200A)
EBC-1 Proposed Load	612.24	kVA
EBC-1 Load	61.4%	
Utility Transformer Capacity	750.00	kVA
Utility Transformer Proposed Load	612.24	kVA
Utility Transformer Load	81.6%	
Generator GS-1 Capacity	625.00	kVA
Generator GS-1 Proposed Load	612.24	kVA
Generator GS-1 Load	98.0%	- Limiting Factor

Figure 13 Scenario 1 Calculations

The rectifier layout for Scenario 1 is shown in Appendix A, Exhibit 4.1 1
EBC-1 Panel schedule and feeders are shown on Appendix B Schedule 4.1.1(1)

4.1.3 Mechanical

Room 101 has one rooftop mounted EF-23 (1.5hp 10,600 CFM) exhaust fan with two 3' x 3' motorized intake dampers. Considering the heat gain associated with the two existing depot chargers, this existing ventilation system is capable of maintaining just above 96 degrees F in the space on a design day (90 degrees F ambient). The desired space temperature of 90 degrees F is not achievable for the current configuration using ventilation air of the same temperature.

The current mechanical design does not allow for any additional 150kW chargers to be added to the space while maintaining the room at 90 degrees F.

If the space temperature setpoint could be raised from 90 degrees F to 100 degrees F (10 degrees above ambient), the existing exhaust fan can remove the heat associated with a total of 3 depot chargers in the space.

4.2 Scenario 2:

4.2.1 Summary

Provides the maximum number of chargers that can be accommodated by the existing electrical system by only adding required circuits. The required circuits are determined by the limits of the existing mechanical ventilation, without making mechanical upgrades.

The findings of Scenario 2 indicate that one depot charger can be added in the facility with electrical upgrades as further described below. However the ventilation in Room 101 is inadequate for adding any interior chargers while maintaining the room at 90 degrees F. Alternatively, if PAAC raises the allowable temperature to 100 degrees F, then one new charger could be added.

4.2.2 Electrical

In this case the electrical load requirements require the following upgrades to the existing electrical infrastructure: Provide a 250A 480-3 pole breaker added to EBC-1, wiring, and equipment pad. The limiting factor in this case would be the exhaust fan serving the space, with the capacity of three units (with a 100° design temperature). The addition of the pantograph charger to the outdoor switchboard would require the utility transformer to be upgraded to a minimum 1,000kVA capacity and since this option exceeds the scenario requirements it has been removed from the calculation table below.

Scenario 2 - EBC-1 Capacity Calculation (Full utilization of existing Exhaust Fan EF-23 10°ΔT)						
	Quantity	**kW**	**Quantity x kW**	**PF**	**KVAR's**	**Apparent Power kVA**
Existing Rectifier 150kW	2	150.0	300.0	0.98	60.92	306.1
Additional Rectifier 450kW	0	460.0	0.0	0.97	0.00	0.0
Additional Rectifier 150kW	1	150.0	150.0	0.98	30.46	153.1
			450.0	0.98	91.38	459.18

Existing EBC-1 Capacity	997.66	kVA
EBC-1 Proposed Load	459.18	kVA
EBC-1 Load	46.0%	
Utility Transformer Capacity	750.00	kVA
Utility Transformer Proposed Load	459.18	kVA
Utility Transformer Load	61.2%	
Generator GS-1 Capacity	644.00	kVA
Generator GS-1 Proposed Load	459.18	kVA
Generator GS-1 Load	71.3%	

Figure 14 Scenario 2 Calculations

4.2.3 Mechanical

Room 101 has one rooftop mounted EF-23 (1.5hp 10,600 CFM) exhaust fan with two 3' x 3' motorized intake dampers. Considering the heat gain associated with the two existing depot chargers, this existing ventilation system is capable of maintaining just above 96 degrees F in the space on a design day (90 degrees F ambient). The desired space temperature of 90 degrees F is not achievable for the current configuration using ventilation air of the same temperature. The current mechanical design does not allow for any additional 150kW chargers to be added to the space.

If a space temperature setpoint of 100 degrees F (10 degrees above ambient) is acceptable, the existing exhaust fan can remove the heat associated with a total of 3 depot chargers in the space.

Room (101) infrastructure modifications are not required.

The Rectifier layout for Scenario 2 is shown in Appendix A, Exhibit 4.2 1
EBC-1 Panel schedule and feeders are shown on Appendix B Schedule 4.2.1(1)

4.3 Scenario 3

4.3.1 Summary

Provides the maximum number of chargers based on upgrades to both the mechanical and electrical systems, coupled with the space constraints of Room 101.

The findings of Scenario 3 indicate that 14 additional depot chargers (and two existing depot chargers) and one pantograph charger can be added with electrical and HVAC upgrades as further described below.

See Appendix A Exhibit 4.3.1 –for Room 101 equipment layout.

4.3.2 Electrical

Existing Utility Entrance: The existing utility transformer is rated for 750kVA 480Y/277 and serves SWBD-1 by an underground encased 8-way conduit bank.

Utility Additions and Modifications: East Liberty's secondary utility entrance transformer will need sized and replaced by the utility to match the maximum capacity for SWBD-1. The associated primary and secondary feeders and conduit bank will need evaluated for size and replacement.

The primary circuit demand load will need coordinated with the utility to accommodate the additional equipment. The current primary circuit has a capacity of 72A, with the proposed load being 77.3A the utility will need to provide an additional 5.3A for the additional load

Scenario 3 - 23kV Primary Circuit Electrical Demand Calculation			
	kVA	**kV**	**Total Amps**
Utility Demand Load	3075.09	23	77.3

Figure 15 Scenario 3 Utility Primary Load

Existing Outdoor rated Switchboard - SWBD-1: The outdoor NEMA 3R rated switchboard (SWBD-1) is service entranced rated for a 4000A 480Y/277V supply with a 100% rated main circuit breaker and full load rated bus bars. There are 3 sections included as part of the switchboard assembly: one for service entrance and two distribution sections. SWBD-1 includes one 1600AF/1200AT breaker and three spare 800A breakers which will be utilized for panel additions in Room 101.

SWBD-1 Additions and Modifications: SWBD-1 equipment pad will need evaluated and replaced to accommodate changes in conduit stub-up configurations for the final design. The utility transformer size will dictate the size and layout for the secondary lateral. Duct bank derating calculations need to be conducted to complement the new utility transformer.

One additional 800A breaker will need added to one of the available spaces within the third distribution section. The 1600AF/1200AT breaker space can be replaced with an 800A breaker to limit the available current to ECB-1 for the proposed scenario 3. Replacing the breaker will also provide another available space for additional overcurrent protection for a pantograph charger.

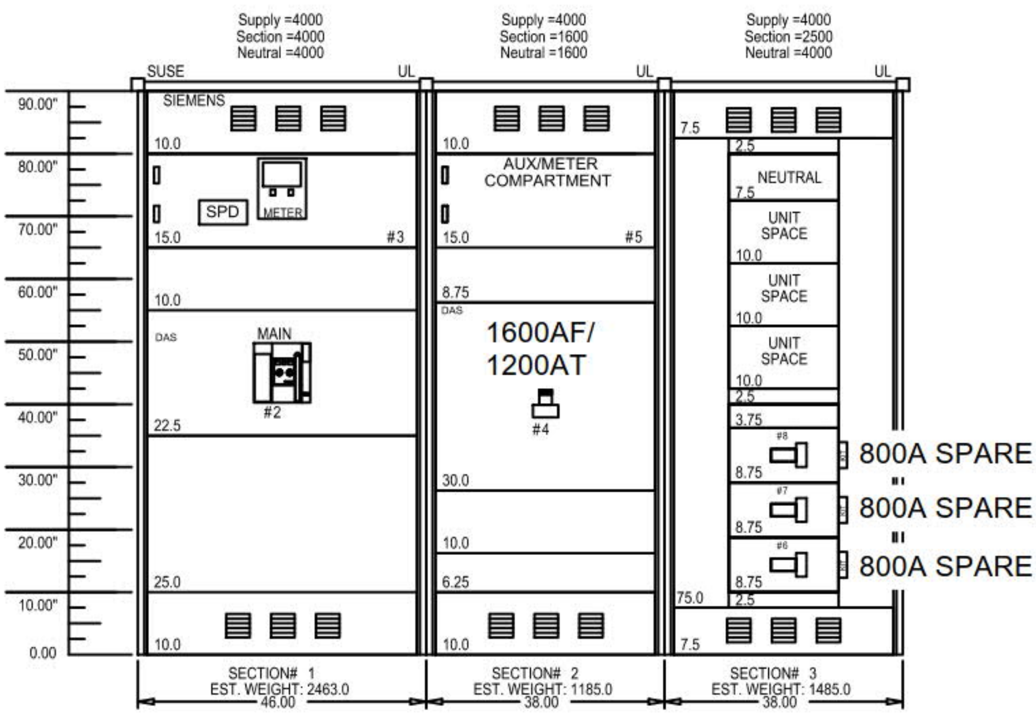


Figure 16 SWBD-1 Elevation

Scenario 3 - SWBD-1 Capacity Calculation					
	Quantity	**kW**	**Quantity x kW**	**PF**	**Apparent Power kVA**
Existing Rectifier 150kW	2	150.0	300.0	0.98	306.1
Additional Rectifier 450kW	1	460.0	460.0	0.97	474.2
Additional Rectifier 150kW	14	150.0	2100.0	0.98	2142.9
Existing 1.5 HP EF-23	1	1.4	1.4	0.86	1.6
Additional 3HP EF	3	6.1	18.3	0.86	21.3
Additional RTU-AC Unit	1	133.4	133.4	1.00	133.4
			3013.1	0.98	3075.09
	SWBD-1 Capacity	3325.54	kVA		
	SWBD-1 Proposed Load	3075.09	kVA		
	SWBD-1 Load	92.5%			
	Utility Transformer Capacity	3750.00	kVA		
	Utility Transformer Proposed Load	3075.09	kVA		
	Utility Transformer Load	82%			

Figure 17 Scenario 3 SWBD-1 Capacity Calculation

The outdoor SWBD-1 is capable of serving a total of sixteen (150kW) depot chargers, one (450kW) Pantograph charger, one rooftop air conditioning unit, three exhaust fans, and recircuiting EF-23.

<u>Existing Standby Generator:</u> The existing Kohler 500kW diesel generator (GS-1) is a pad mounted, outdoor rated, level II sound enclosure, genset with 24 hour sub base tank, and maintenance platform. GS-1 is connected to the 1200A ASCO NEMA 3R ATS located outdoor adjacent to SWBD-1 and switches between utility and generator power for panel EBC-1.

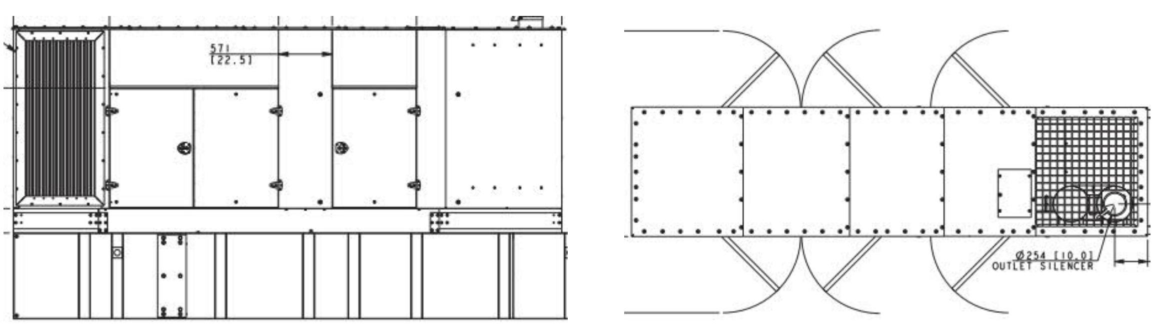


Figure 18 Kohler Diesel Generator

<u>Generator Additions and Considerations:</u> GS-2 through GS-5 will be added to the electrical scheme to individually serve their correlating ECB-2 through EBC-5 panelboards. GS-2 through GS-4 will mirror the same make, model, size, and options as the existing GS-1 for commonality of parts, service, and overall standardization. The 500kW gensets complement the 800A panelboards for 150kW depot charger power with power being transferred by a 800A automatic transfer switch. This setup also allows for the standardization and commonality of parts. The

generator GS-5 is rated for 150kW and is dedicated to HVAC loads. The 150kW genset feeds a 250A automatic transfer switch and 250A panelboard.

- GS-1 Existing - 500kW for EBC-1 utilizing existing outdoor ATS.
- GS-2 500 kW for EBC-2 dedicated to 800A panel with ATS located indoors.
- GS-3 500 kW for EBC-3 dedicated to 800A panel with ATS located indoors.
- GS-4 500 kW for EBC-4 dedicated to 800A panel with ATS located indoors.
- GS-5 150 kW for EBC-5 dedicated to 250A panel with ATS located indoors.

Scenario 3 - Generator Capacity Calculation						
Panel EBC-1 (800A)	Existing GS-1	500	kW		625	kVA (.8 PF)
				Panel EBC-1 Load	612.2	kVA
				Existing Generator GS-1 Load	**98%**	
Panel EBC-2 (800A)	GS-2	500	kW		625	kVA (.8 PF)
				Panel EBC-2 Load	612.2	kVA
				Generator GS-2 Load	**98%**	
Panel EBC-3 (800A)	GS-3	500	kW		625	kVA (.8 PF)
				Panel EBC-3 Load	612.2	kVA
				Generator GS-3 Load	**98%**	
Panel EBC-4 (800A)	GS-4	500	kW		625	kVA (.8 PF)
				Panel EBC-4 Load	612.2	kVA
				Generator GS-4 Load	**98%**	
Panel EBC-5 (250A)	GS-5	150	kW		187.5	kVA (.8 PF)
				Panel EBC-5 Load	158.2	kVA
				Generator GS-5 Load	**84%**	

Figure 19 Scenario 3 Generator layout and Capacity Calculation

Generator Considerations: The bank of rectifiers produce harmonics within the circuit which should be evaluated and mitigated with a tuned / de-tuned filter bank, and/or 200% neutrals. Voltage and frequency dips during the depot charger startup needs to be evaluated and accounted for during generator selection. Environmental concerns – The EPA may require a Tier 4 emissions rating for a bank of 5 generators and will have to be considered during design. Permitting with the AHJ may require a sound wall or other sound mitigation to compensate for the bank of generators. Currently the layout shows the generators constructed over an existing underground fire line, it is proposed to relocate the fire line to avoid interference with transformer footprint and has been included in the cost estimate ($52,000) for Scenario 3.

See Generator Layout in Appendix A Exhibit 4.3.2.

4.3.3 Distribution Panel Layout for New Equipment:

Individually circuiting the equipment fed from SWBD-1 will require modifications to EBC-1 and the addition of four distribution panels (EBC-2 to EBC-5).

Distribution Panel EBC-1: EBC-1 is a surface mounted Siemens-P5 (P5E60N1120ETS) NEMA-1 1200A (480Y/277V) 3PH 4W with silver platted copper bus bars and an IR rating of 35kAIC. There are 32 available breaker spaces in the panel with 6 breaker spaces currently occupying two 250A 3 pole FXD6 breakers.

EBC-1 Upgrades: Due to limited breaker space in ECB-1 and to maximize the utilization, the existing 1200A main circuit breaker should be replaced with a 1200AF / 800AT MCB. This will also allow full utilization of the Kohler 500kW Genset GS-1.

EBC-1 Panel schedule and feeders are shown on Appendix B Schedule 4.3.3(1)

Scenario 3 - EBC-1 / GS-1 Capacity Calculation					
	Quantity	**kW**	**Quantity x kW**	**PF**	**Apparent Power kVA**
Depot Charger 150kW	4	150.0	600.0	0.98	612.2
			600.0	0.98	612.24
EBC-1 Capacity	665.11	kVA (800A)			
EBC-1 Proposed Load	612.24	kVA			
EBC-1 Load	92.1%				
Utility Transformer Capacity	3750.00	kVA			
Utility Transformer Proposed Load	612.24	kVA			
Utility Transformer Load	16.3%				
Existing Generator GS-1	625.00	kVA			
Generator GS-1	612.24	kVA			
Generator GS-1 Load	98.0%				

Figure 20 Scenario 3 EBC-1 Capacity Calculation

Distribution Panel EBC-2: The addition of an 800A 480Y/277 (100% Rated) distribution panel will provide power to 4 depot chargers.

EBC-2 Panel schedule and feeders are shown on Appendix B Schedule 4.3.3.(2)

Scenario 3 Generator - EBC-2 / GS-2 Capacity Calculation					
	Quantity	**kW**	**Quantity x kW**	**PF**	**Apparent Power kVA**
Depot Charger 150kW	4	150.0	600.0	0.98	612.2
			600.0	0.98	612.24
EBC-2 Capacity	665.11	kVA (800A)			
EBC-2 Proposed Load	612.24	kVA			
EBC-2 Load	92.1%				
Utility Transformer Capacity	3750.00	kVA			
Utility Transformer Proposed Load	612.24	kVA			
Utility Transformer Load	16.3%				
Generator GS-2 Capacity	625.00	kVA			
Generator GS-2 Proposed Load	612.24	kVA			
Generator GS-2 Load	98.0%				

Figure 21 Scenario 3 EBC-2 Capacity Calculation

Distribution Panel EBC-3: The addition of a 800A 480Y/277 (100% Rated) distribution panel will provide power to 4 depot chargers.

EBC-3 Panel schedule and feeders are shown on Appendix B Schedule 4.3.3.(3)

Scenario 3 Generator - Proposed EBC-3 / GS-3 Capacity Calculation					
	Quantity	**kW**	**Quantity x kW**	**PF**	**Apparent Power kVA**
Depot Charger 150kW	4	150.0	600.0	0.98	612.2
			600.0	1.0	612.2
EBC-3 Capacity	665.11	kVA (800)			
EBC-3 Proposed Load	612.24	kVA			
EBC-3 Load	92.1%				
Utility Transformer Capacity	3750.00	kVA			
Utility Transformer Proposed Load	612.24	kVA			
Utility Transformer Load	16.3%				
Generator GS-3 Capacity	625.00	kVA			
Generator GS-3 Proposed Load	612.24	kVA			
Generator GS-3Load	98.0%				

Figure 22 Scenario 3 EBC-3 Capacity Calculation

Distribution Panel EBC-4: The addition of an 800A 480Y/277 (100% Rated) distribution panel will provide power to 4 depot chargers.

EBC-4 Panel schedule and feeders are shown on Appendix B Schedule 4.3.3.(4)

Scenario 3 Generator - EBC-4 / GS-4 capacity Calculation					
	Quantity	**kW**	**Quantity x kW**	**PF**	**Apparent Power kVA**
Depot Charger 150kW	4	150.0	600.0	0.98	612.2
			600.0	0.98	612.24
EBC-4 Capacity	665.11	kVA (800A)			
EBC-4 Proposed Load	612.24	kVA			
EBC-4 Load	92.1%				
Utility Transformer Capacity	3750.00	kVA			
Utility Transformer Proposed Load	612.24	kVA			
Utility Transformer Load	16.3%				
Generator GS-4 Capacity	625.00	kVA			
Generator GS-4 Proposed Load	612.24	kVA			
Generator GS-4 Load	98.0%				

Figure 23 Scenario 3 EBC-4 Capacity Calculation

Distribution Panel EBC-5:

The addition of a new 250A 480Y/277 distribution panel will provide power to the RTU-AC unit, three rooftop exhaust fans, and the existing EF-23. This configuration provides dedicated backup power to HVAC equipment from GS-5.

EBC-5 Panel schedule and feeders are shown on Appendix B Schedule 4.3.3.(5)

Scenario 3 - Proposed EBC-5 / GS-5 Capacity Calculation					
	Quantity	**kW**	**Quantity x kW**	**PF**	**Apparent Power kVA**
Additional RTU AC- Unit	1	133.4	133.4	0.98	136.1
Additional 3HP EF	3	6.1	18.3	0.836	21.9
Existing 1.5 HP EF-23	1	1.4	1.4	0.86	1.6
			153.1	0.97	158.22

EBC-5 Capacity	207.85	kVA (250A)
EBC-5 Proposed Load	158.22	kVA
EBC-5 Load	76.1%	
Utility Transformer Capacity	3750.00	kVA
Utility Transformer Proposed Load	158.22	kVA
Utility Transformer Load	4.2%	
Generator GS-5 Capacity	187.50	kVA
Generator GS-5 Proposed	158.22	kVA
Generator GS-5 Load	84.4%	

Figure 24 Scenario 3 EBC-5 Capacity Calculation

4.3.4 Mechanical Evaluation

Supplemental cooling will be required to maintain the prescribed 90-degree F space temperature.

The first stage of cooling will be accomplished by adding exhaust fans and associated intake openings in the exterior wall. Any time the ambient air temperature is 80 deg F or less, the “cooling” effect provided by the fans will suffice as the system will be sized to maintain a 10-degree differential between the space temperature and the ambient temperature. With sixteen chargers being proposed for the space, the resulting heat gain is approximately 580 MBH. To maintain the 10-degree differential, the fans will be required to move approximately 53,300 cfm. Considering that the existing EF-23 already exhausts 10,600 cfm, three additional fans at 14,200 cfm each are proposed. To accommodate the additional intake air, additional wall openings, totaling approximately 86 square feet, will be required based on an air velocity of 500 feet per minute. Each opening will include a motorized control damper and be protected with bird screen. The openings will be spaced evenly around the perimeter of the room. Variable frequency drives (VFDs) will be provided to allow the fans to reduce airflow during low load conditions.

Once the space temperature is no longer able to be maintained by the exhaust fans, supplemental cooling will be required. The exhaust fans will de-energize, the intake dampers will close, and a fully recirculating rooftop unit (RTU) will energize to accommodate the full cooling requirement (See calculations table below in figure 25). The RTU will be a packaged unit with a return damper, filters, direct expansion (DX) cooling coil, and a supply fan. The DX cooling will include variable speed/modulating compressor technology to provide better temperature control. This unit will be sized to maintain the desired 90-degree F setpoint. Based on the heat gain of the chargers as well as any perimeter heat gain and dehumidification of the space, the unit will be sized to deliver approximately 50 tons of sensible cooling and recirculate approximately 15,400 cfm.

Supply will be ducted throughout the space and be distributed via air devices near the floor with the unit’s return air opening being an open-ended duct terminated with bird screen just below the roof level. The low supply will allow for more effective cooling throughout the space.

The equipment operation and temperature control for the space will be integrated into the existing Siemens controls system.

If a space temperature setpoint of 100 degrees F (10 degrees above ambient) is acceptable, the exhaust fans can remove the heat associated with all 16 depot chargers in the space with no need of a supplemental RTU.

Equipment Heat Gain Assumptions for Charger Room (Scenario #1)

Equipment	Number	KVA	Total KVA	Efficiency	Total Heat Gain (MBH)	Required Vent. Air for 10 deg Delta (cfm)
Existing Chargers	2	150	300	93	71.7	13,950

	Air Volume (cfm)	Ambient Temperature (Deg F)	Cooling Capacity @ 90 Space Temp. (MBH)	Current Space Temperature (Deg F)
Existing Exhaust Fan (EF-23)	10,600	90	0	96.3

Existing exhaust fan not able to accommodate additional chargers. It is not anticipated that the current space temperature is maintained at 90 deg F with only two chargers.

Equipment Heat Gain Assumptions for Charger Room (Scenario #3 - Ambient Temperature Below 80 deg F)

Equipment	Number	KVA	Total KVA	Efficiency	Total Heat Gain (MBH)	Required Vent. Air for 10 deg Delta (80 deg F cfm SA/90 deg F space)
Chargers (Total)	16	150	**2400**	93	573.4	53,091

	Air Volume (cfm)	Fan Quantity	Required Exhaust Air Volume/Fan (cfm)
Required Ventilation Air	53,091		
Existing Exhaust Fan (EF-23)	10,600	1	10,600
New Exhaust Fans	42,491	3	14,164

Three (3) additional exhaust fans are required at approximately 14,200 cfm each to maintain space temperature at 90 deg F with 80 deg F ambient air.

Equipment Heat Gain Assumptions for Charger Room (Scenario #3 - Ambient Temperature Above 80 deg F)

Equipment	Number	KVA	Total KVA	Efficiency	Total Heat Gain (MBH)	Total Heat Gain (Tons)	Required Vent. Air for 35 deg Delta (55 deg F cfm SA/90 deg F space)
Chargers (Total)	16	150	**2400**	93	573.4	48	15,169

	Supply Air Volume @ 55 deg F (cfm)	Total Cooling Requirement (MBH)	Total Cooling Requirement (Tons)
RTU Requirements	15,169	573	47.8

Provide single 50 ton RTU to accommodate heat gain from chargers. Heat gain through envelope will be negligible because the design inside and ambient temperatures will be equal.

Figure 25 Scenario 3 HVAC Calculation

4.3.5 Fire Protection

The building is provided with an existing sprinkler system supplied from the city water supply. A fire pump system supplements the city water supply and feeds an 8" fire loop that serves the building. The Training Rm. and Bus Storage area is protected with a wet-pipe sprinkler system supplied from 8" sprinkler risers. Original record drawings indicate the systems were designed for Extra Hazard protection per NFPA 13. Hydraulic design criteria from available record documents is indicated below:

Area	Design Density	Remote Area	Hose Demand
Bus Storage	0.3 gpm/sq. ft.	5,000 sq. ft.	500 gpm
Tire Storage (Training Rm.)	0.35 gpm/sq. ft.	2,000 sq. ft.	500 gpm

The project scope will include modifications to the wet-pipe sprinkler system to accommodate new work conditions and coordinate with new utilities. All sprinkler work must maintain existing Extra Hazard level of protection in the project area. Sprinkler heads must be spaced 100 sq. ft. maximum and have 17/32" orifice to match existing.

The building is provided with an existing fire alarm system. Pull station devices are located at building exits and notification appliance coverage is provided within the area of work. The fire alarm system monitors the building fire suppression systems.

The project scope includes modifications to the fire alarm system. New duct smoke detection will be provided on the return air ductwork to comply with the International Mechanical Code. A fire alarm interface will be provided with the air handling unit starter for automatic shutdown controls. The system will be configured to automatically shutdown the new mechanical unit The existing ceiling mounted smoke detectors would need evaluated for spacing depending on the final air flow through the room.

4.3.6 Structural

Structural modifications will be needed to accommodate the proposed mechanical work in Room (101).

The roof of Room (101) is comprised of 1 1/2 inch metal deck and steel joists. Metal deck spans between steel joists, which are supported by steel columns, concrete masonry unit walls, and precast tee walls. The roof framing system was designed to support a 10 pound per square foot (psf) dead load and a 30 psf live load.

The existing roof framing does not have adequate capacity to support the weight of the proposed AHU and will require strengthening. Existing joists will be reinforced along their full length to increase their load carrying capacity and stiffness. Supplemental steel framing members beneath the footprint of the proposed unit will support the weight of the unit between joists instead of the metal deck, which was not designed to carry large loads.

The proposed rooftop AHU and fan units will require roof penetrations. Supplemental steel framing members will support the edge of metal deck at openings and will span between joists to distribute roof loads around the openings. Where the supplemental framing is supported by the existing joists, the joists will be locally reinforced to support the concentrated loads.

The proposed wall louvers will require openings in the exterior CMU wall. Steel lintels will span over the openings to support the weight of the CMU wall above the openings.

4.4 Scenario 4

4.4.1 Summary

Scenario 4 evaluated the electrical, structural, and infrastructure modifications required to provide a total of 30 150kW Depot Chargers, and 2 outdoor 450kW Pantograph Chargers at the East Liberty Garage.

East Liberty Garage has limited space within the facility for additional chargers so WRA met with Authority on site and evaluated the optimum location for the depot chargers and determined that locating an equipment platform outdoors would provide adequate space to house the units while keeping them out of the way of day to day operations within the facility. The proposed equipment platform would be two levels with 14 rectifiers per level.

See Appendix A Exhibit 4.4.1 –for East Liberty Site Plan Scenario 4.
See Appendix A Exhibit 4.4.2.1 –for East Liberty Equipment Layout Scenario 4.
See Appendix A Exhibit 4.4.2.2 –for East Liberty One Line Diagram Scenario 4.

4.4.2 Electrical

The charging scheme to implement 30 depot chargers and 2 pantograph chargers is achieved by utilizing two separate 23kV circuits from the utility for redundancy. Equipment fed from SWBD-1 will not utilize the two 23kV circuit redundant scheme, and uses generators for backup power.

Utility Additions and Modifications: A second dedicated 23kV circuit would need provided by the utility, which would serve as a redundant circuit to the existing dedicated BEB charging circuit. The two proposed utility medium voltage 23kV circuits would be provided overhead and transition to underground feeders terminating in the proposed outdoor walk-in MV switchgear. NEC requires a 7ft high perimeter fence around the switchgear with an additional 1ft barbed wire fence at the top. To save space and qualify for the 6ft clearance between the fence and equipment a locked gate must be provided on the perimeter fence to prevent unauthorized access. In addition to the fence bollards are proposed around the outside perimeter of the fence to prevent vehicle impacts.

Existing Outdoor Rated Switchboard - SWBD-1: The existing switchboard (SWBD-1) is rated for 4000A 480Y/277V supply with a 100% rated main circuit breaker. The intent for scenario 4 is to utilize the dedicated circuit from the MV switchgear to the (SWGR-1) dedicated 2500kVA transformer. The switchboard will provide power to a total of eight 150kW depot chargers and two 450kW pantograph chargers. The 8 depot chargers fed from SWBD-1 will rely on the utility power with redundancy provided by the two 500kW generators. The remaining pantograph chargers would not have an alternate power source or redundancy.

SWBD-1 Additions and Modifications: SWBD-1 will require the main circuit breaker be replaced with a 3000 amp 100% rated circuit breaker. There are adequate spare breakers to provide power to the additional 800A panel for panel EBC-2 (for 4 additional 150kW depot chargers) and two 450kW pantograph chargers.

Existing Standby Generator: The existing Kohler 500kW diesel generator (GS-1) is a pad mounted, outdoor rated, level II sound enclosure, genset with 24 hour sub base tank, and maintenance platform. GS-1 is connected to the 1200A ASCO NEMA 3R ATS located outdoor adjacent to SWBD-1 and switches between utility and generator power for panel EBC-1.

Generator Additions and Considerations: A second pad mounted diesel generator (GS-2) will be added to the electrical scheme to individually serve the correlating EBC-2 panelboard. The existing generator (GS-1) will provide emergency power to depot chargers BC-1 through BC-4. The proposed generator (GS-2) will provide power to depot chargers BC-5 through BC-8.

Generator GS-2 will mirror the same make, model, size, and options as the existing GS-1 for commonality of parts, service, and overall standardization. The 500kW genset powers an 800A distribution panel through an 800A automatic transfer switch. GS-2 will be located adjacent to the GE-1 generator and due to space constraints is located over the existing 8" fire suppression loop. The fire loop also interferes with the remaining electrical equipment and will require approximately 380 linear ft of fire line to be relocated.

MV Switchgear: One outdoor NEMA-3R rated walk-in enclosure is proposed for the medium voltage switchgear. The switchgear is rated for 1200A and will have one primary circuit from each section on each end of the switchgear. Each circuit will have a section for utility metering, main fuse OCPD, and feeders for each low voltage transformer.

Incoming utility power will enter overhead from the rear of the building, utilizing existing utility poles, then transitioning to underground duct banks to the switchgear. Primary circuits will be routed underground between the switchgear and each of the low voltage transformers for SWGR-1, SWGR-2 and SWBD-1.

Scenario 4 - Total Electrical Demand Calculation					
	Quantity	**kW**	**Quantity x kW**	**PF**	**Apparent Power kVA**
Existing Rectifier 150kW	2	150.0	300.0	0.98	306.1
Additional Rectifier 450kW	2	460.0	920.0	0.97	948.5
Additional Rectifier 150kW	28	150.0	4200.0	0.98	4285.7
			5420.0	0.98	5539.49

Total Proposed Load	5539.49	kVA
Total Transformer Capacity	6500.00	kVA ((2) 2000kVA (1) 2500 kVA)
Transformer Proposed Load	5539.49	kVA
Transformer Load	85%	

Figure 26 Scenario 4 Required Capacity Calculation

Scenario 4 - 23kV Primary Circuit Electrical Demand Calculation					
				Amps per Circ. Normal Operation	
	kVA	**kV**	**Total Amps**	**Circuit A**	**Circuit B**
Utility Demand Load	5,540	23	139.2	96.9	42.3

Scenario 4 - LV Electrical Branch Distribution				
	kVA	**V**	**Total Amps**	**MV Circuit**
SWGR-1 Load	1,684	480	2,026	A
SWGR-2 Load	1,684	480	2,026	B
SWBD-1 Load	2,172	480	2,614	A
Total:	**5,540**		**6,666**	

Figure 27 Scenario 4 Primary Circuit Load Calculation and Distribution

Scenario 4 will exceed the utilities available 72A spare capacity for the existing 23kV circuit. Utility coordination and studies will need performed for this scenario.

LV Switchgear(s): Two outdoor NEMA-3R rated walk-in switchgears will provide power to twenty two 150kW depot chargers. Each switchgear is rated for 3200A 480Y/277V and will be throat coupled between the transformer and switchgear buss. The switchgear is designed with a main-tie-main configuration with a transformer from each end and the tie in the middle. Under normal operation the tie would be in the open position to split and alleviate the required load on each utility circuit. Redundancy is provided from each end of the switchgear; In the event that one of the primary circuits are de-energized, the switchgear will automatically open the main circuit breaker on the failed circuit and close the main-tie breaker and provide power to the entire switchgear buss.

Outgoing branch circuit breakers will be 250A draw out breakers with conductors routed underground to their correlating 150kW depot charger located on the rectifier platform.

Scenario 4 - SWBD-1 Electrical Demand Calculation					
	Quantity	**kW**	**Quantity x kW**	**PF**	**Apparent Power kVA**
450kW Pantograph Rectifier	2	460.0	920.0	0.97	948.5
150kW Depot Charger Rectifier	8	150.0	1200.0	0.98	1224.5
			2120.0	0.98	2172.40
SWBD-1 Capacity		3325.54	kVA (4000A)		
SWBD-1 Proposed Load		2172.40	kVA		
SWBD-1 Load		65.3%			
Utility Transformer Capacity		2500.00	kVA		
Utility Transformer Proposed Load		2172.40	kVA		
Utility Transformer Load		87%			

Figure 28 Scenario 4 SWBD-1 Electrical Demand Calculation

Scenario 4 - SWGR-1 Electrical Demand Calculation					
	Quantity	**kW**	**Quantity x kW**	**PF**	**Apparent Power kVA**
Depot Charger Rectifier 150kW	11	150.0	1650.0	0.98	1683.7
			1650.0	0.98	1683.67
SWGR-1 Proposed Load		1683.67	kVA		
2000kVA Transformer Capacity		2000.00	kVA		
Transformer Proposed Load		1683.67	kVA		
Transformer Load		84%			

Figure 29 Scenario 4 SWGR-1 Electrical Demand Calculation

Scenario 4 - SWGR-2 Electrical Demand Calculation					
	Quantity	**kW**	**Quantity x kW**	**PF**	**Apparent Power kVA**
Depot Charger Rectifier 150kW	11	150.0	1650.0	0.98	1683.7
			1650.0	0.98	1683.67
SWGR-2 Proposed Load		1683.67	kVA		
2000kVA Transformer Capacity		2000.00	kVA		
Transformer Proposed Load		1683.67	kVA		
Transformer Load		84%			

Figure 30 Scenario 4 SWGR-2 Electrical Demand Calculation

4.4.3 Structural

The proposed charger equipment will be supported by a two-story open structural steel shelter comprised of steel beams, columns, and braces. At ground level the equipment will sit on a concrete slab and at the upper level platform on open steel grating. The upper level platform will be accessed by a set of staircases on each end of the equipment platform. Steel railing around the shelter perimeter will provide fall protection at the upper level platform. At the roof level, metal decking will provide the equipment with moderate shelter from the elements.

The structure will be designed for both gravity and other environmental loads such as snow, ice, wind, and seismic loads. Horizontal diagonal bracing members at the second platform and vertical diagonal bracing members will be provided to transfer lateral loads to the foundation and provide lateral stability. The metal deck will act as the roof diaphragm.

The equipment shelter foundation, consisting of a reinforced concrete structural slab supported on continuous spread footings, will be designed to support loading from the shelter framing and equipment atop the slab. It is assumed that a deep foundation will not be required for the shelter foundation.

Weather protection will be considered in the design of the shelter to protect the exposed structure from the elements. Means of protection will include galvanizing all steel, covering the metal deck with roofing, and sloping the roof and top of the concrete slab to prevent pooling.

Rainwater will be collected from the rooftop and routed underground to the nearest storm system drain line or catch basin.

5. Bus Layout and Dispenser options

5.1 Parking Configuration

Existing bus charging occurs in two parking spaces along the northern interior drive aisle. The Autority has expressed a preference that new electric buses are grouped in parking Lanes 24-22. These are the three lanes immediately adjacent to the Room 101. Parking lanes are configured with two lanes accessing a single twenty-one-foot-wide garage door. Lanes are delineated with lane striping. Ceiling height in the parking lanes is approximately seventeen feet. Parking in the garage is extremely tight, resulting in typical clearances between buses of eighteen to twenty-four inches. Where lanes are striped for egress or columns the spacing widens slightly to between twenty-four and thirty inches.

Figure 31 Aisle at Structural Columns

Figure 32 Egress Aisle Between Garage Doors

Figure 33 Egress Aisle at Wall

Figure 34 Buses Parked at Shared Garage Door

The parking arrangements for the first three scenarios attempted to meet two major operational factors. The first factor is finding space between lanes that is suitable for locating the charging dispenser. The second factor is creating lanes with adequate parking capacity that does not require mixing diesel fleet and electric bus fleet in the same lane. While it is possible for the route planning to account for both fuel types to park in a single lane, managing a returning mixed fleet that ensures that the space for charging is not occupied by a diesel bus is considered to be challenging, if not impossible, on a daily basis.

The fourth scenario will utilize overhead electric cord reels to extend the dispenser nozzle down to the bus. This scenario will be less dependent on available space between buses as the dispenser will be retracted out of the bus parking envelope when not in use.

The rectifier scenarios discussed previously indicate the following new charging stations:

	40’ buses	60’ buses
Scenario 1	2	0
Scenario 2	1	0
Scenario 3	6	8
Scenario 4	6	22

Figure 35 Anticipated Bus Fleet

Scenario 1: This scenario adds two bus chargers (BC) within a parking lane. The dispenser would be set at a protected location adjacent to a column and at a position that does not encroach on the egress path. Dispensers may be located at a wall or on a column if sufficient space exists to meet the minimum egress requirements after the dispenser and bollards are set in place. Figure 36 illustrates a layout of the chargers at a centrally located parking lane that does not have an adjacent egress path. Each parking lane accommodates four to six buses, which will require at least one lane to be a mixed fleet of diesel and electric. The site manager will be required to schedule the returning buses to allow the electric fleet to park in their designated locations. Dispensers could be located at the entrance or exit of the lane. The dispenser locations would be dependent on returning bus schedules and Port Authority bus movement policies. In rare cases it may be required to back a bus in the lane if returning buses are out of sequence due to unforeseen circumstances.

<u>Scenario 2:</u> This scenario is exactly the same as Scenario 1, with the exception that there is capacity for only one new charging dispenser.

For both Scenario 1 and Scenario 2 there is an advantage to moving the two existing dispensers in the drive through lane down to the parking area to create an electric only parking lane. The space vacated in those areas could be utilized for another function and mitigate some of the concerns of a mixed fuel lane if the diesel buses can be displaced to another location.

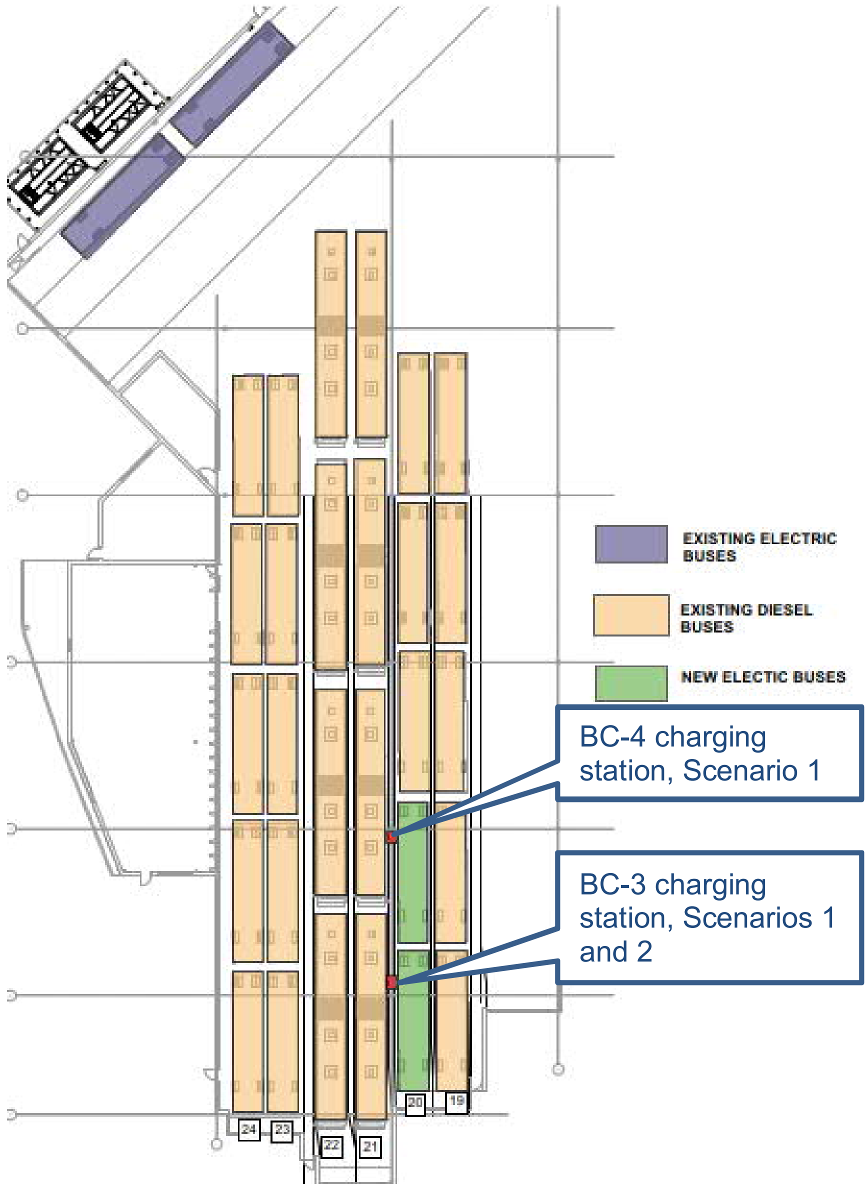


Figure 36 Scenario 1 and 2 Parking Arrangement

<u>Scenario 3</u> proposes parking electric buses in alternating lanes where there is space for the charging dispenser. Final configurations of the dispensers will be critical as they potentially will encroach on the required egress paths to exit doors. In this scenario the westernmost Lane 24 would be set up with charging for five 40’ buses. Charging dispensers would be located on the wall, curb-side of the bus. Lanes 22 and 20 would be set up for charging four 60’ articulated buses in each lane, with charging stations located along the interior egress path. Lanes 23, 21, and 19 would not allow space for floor mounted dispensers and will be configured for diesel bus parking. This scenario can accommodate one additional 40 foot bus, which is proposed for Lane 18. This has the potential to create a scheduling concern with one electric bus in a lane primarily used for diesel buses. If possible, an alternative that locates the electric bus up to the existing bus charging area should be considered, otherwise the bus starters will have to manage the incoming buses as necessary to support the charging operation.

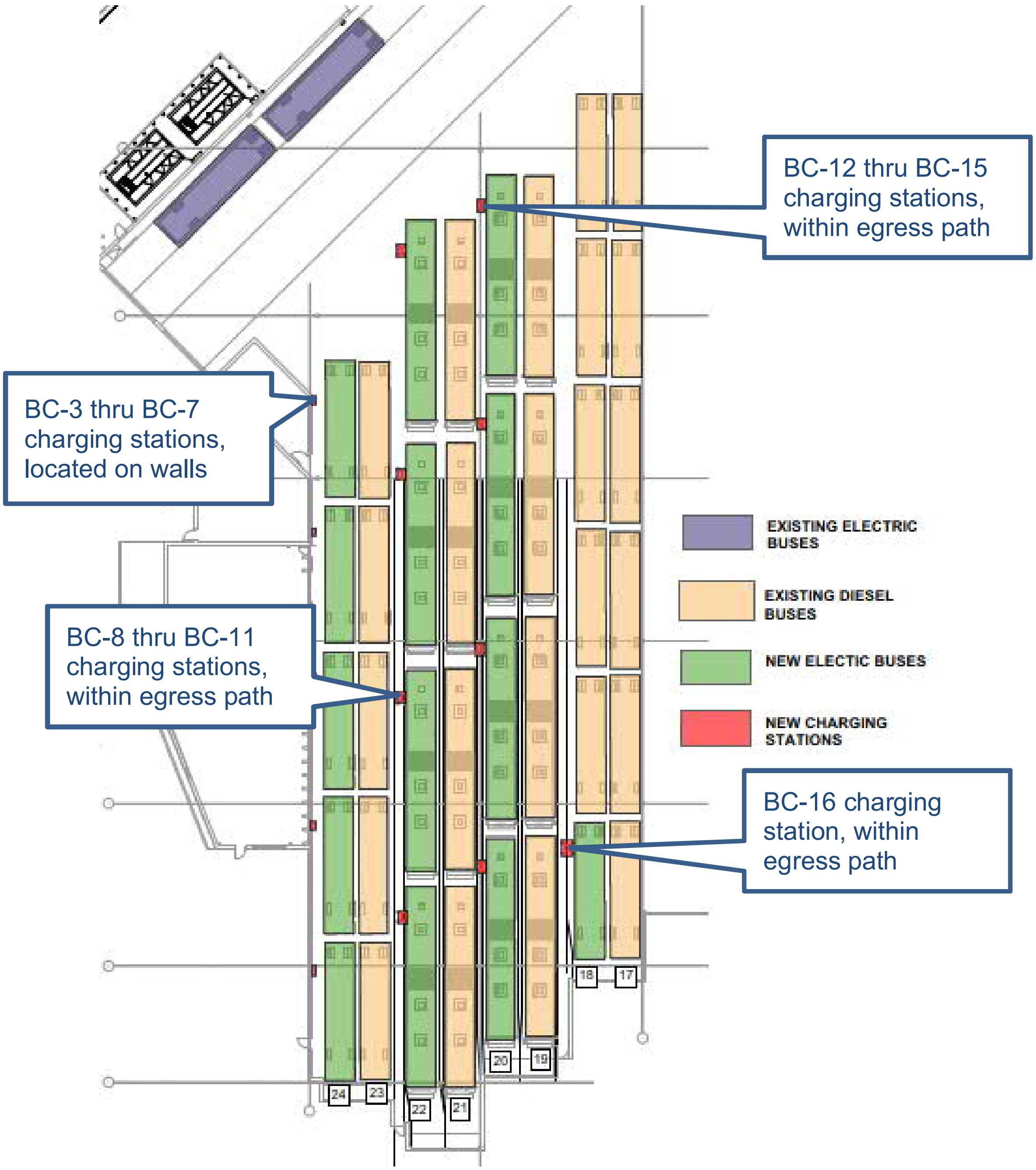


Figure 37 Scenario 3 Charger Layout Lanes 24,22,20,18

Scenario 4: This scenario adds chargers for twenty-eight electric buses. In this scenario the charging dispensers are mounted to the roof framing system. The dispenser cable is routed to a motorized cord reel that will be controlled by a local reel operator. Dispenser nozzles will be retained in the “up” position when not in use to protect them from damage and keep them out of egress paths when not in use. The cord reel operators will be grouped at easily accessible locations, generally at a wall or column and labeled to match the cord reel. This scenario provides for the full anticipated fleet of six 40 foot buses and twenty-two articulated buses. This particular fleet mix may require that one lane accommodates both types of buses, shown in Lane 24 in this scenario.

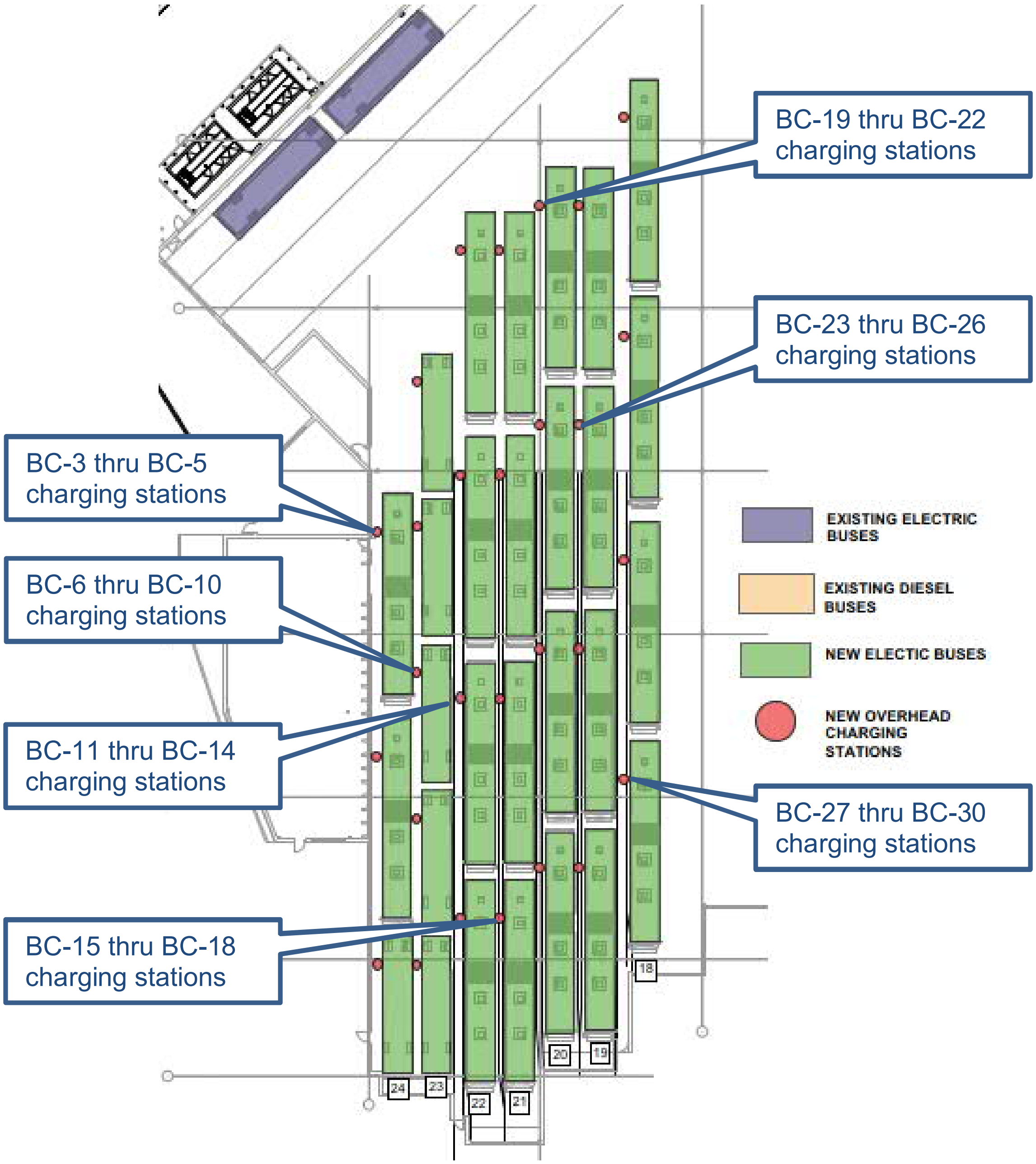


Figure 38 Scenario 4 Charger Layout Lanes 24 through18

5.2 Charger Dispenser Options

The locations of dispensers evaluated include options for floor-mounted and overhead-supported reel systems. The Autority has indicated that a goal for the charger dispenser locations is to place them where a driver can easily determine that the bus is charging and that the communication between bus and charger has occurred. The charging inlet on the buses is located at the rear of the bus on the curb side.

In evaluating the floor-mounted option, it is apparent the space between buses that share a garage door would not permit a charging station between the buses. The overall footprint of the dispenser with six inch diameter bollard protection would be approximately thirty inches deep by forty-two inches wide. The space between parked buses is approximately twenty-four inches or less, depending on the actual location of the bus as parked by the driver. The charging stations are located in drive lanes which are wide enough to accommodate the dispenser, the associated electrical and ethernet connections, are visibly accessible to the operator, and put the operator in a safer position when accessing the HMI console.

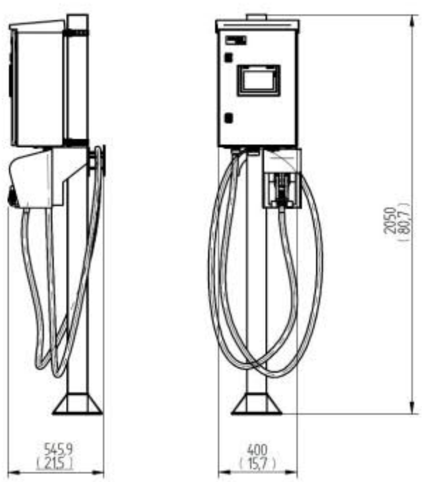


Figure 39 Pedestal Mounted Dispenser

An overhead reel charging system was evaluated for Scenario 4. The National Electric Code requires that cord lengths for electric vehicle charging be limited to twenty-five feet “unless equipped with a cable management system that is part of the listed electric vehicle supply equipment.” At this time ABB is the only manufacturer that is known to produce a ceiling mounted dispenser package. The upgraded cord package is approximately twenty-two feet long. With a dispenser box mounted at seventeen feet and strung over to a cord reel there will be little flexibility in the location of the reels relative to the bus charging ports. ABB only provides the dispenser box and works with third party suppliers for the motorized cord reel system. With current trends in the industry it is anticipated that Siemens and other manufacturers will have similar overhead systems in the near future. While suspending charging cables provides more flexibility to the location of the parking in the garage, it also presents an operational challenge. If the HMI console is located remotely where the operator cannot witness that the “handshake” between the bus and charger has actually occurred, there is a potential for the chargers to not initiate charging. ABB is currently working on a solution to address this concern by moving the status lights on the bottom of the dispenser control box where they are more readily visible (see Figure 41). This feature is currently available in European models and is being made available for the North American market in the near future, likely first or second quarter 2021. An HMI interface is located on the main rectifier which will provide more detailed information on the charging status.

Figure 40 Overhead Charging Reel

Figure 41 Overhead Dispensing Box with Status Light

In either scenario there will be at least some impact on the existing roof structure to support cables and conduit. The existing roof framing, designed to support a ten pound per square foot (psf) dead load and a thirty psf live load, does not have the capacity to support the proposed roof hung conduits and roof mounted chargers. Existing joists will be reinforced along their full length to increase their load carrying capacity and stiffness.

6. Engineers Rough Order of Magnitude Estimate of Probable Cost

The opinion of cost is based on the historical data for cost per square foot for facilities of this type. Additional factors specific to this site and project have been incorporated into the cost model.

Opinion of Probable Construction Cost Table

Anticipated design and construction management costs

Design fees should be budgeted at a range of 8% to 10% of construction for a project of this scope and complexity.

Construction management fees should be budgeted at a range of 5% to 7% based on partial on-site representation. If full time on-site representation is desired, a 10% fee should be anticipated.

Cost estimates are based on Port Authority provided values for rectified charging equipment; 150kW Depot chargers ($95,000 each) and 450kW Pantograph chargers ($1,000,000). Rectified charging equipment costs reflect material costs only and do not include contractor markups.

Scenario 1: *See Appendix C for Scenario 1 cost estimate*

Costs Associated with Required Building Improvements (G, H, E, P contracts):	$	34,000
Costs Associated with Rectifier Equipment (not including contractor markup):		
(2) 150kW Depot Chargers:	$	190,000
(1) 450kW Pantograph Charger:	$	1,000.000
Grand Total:	**$**	**1,224,000**

Scenario 2: *See Appendix C for Scenario 2 cost estimate*

Costs Associated with Required Building Improvements (G, H, E, P contracts):	$	17,000
Costs Associated with Rectifier Equipment (not including contractor markup):		
(1) 150kW Depot Charger:	$	95,000
(1) 450kW Pantograph Charger:	$	1,000,000
Grand Total:	**$**	**1,112,000**

Scenario 3: *See Appendix C for Scenario 3 cost estimate*

Costs Associated with Required Building Improvements (G, H, E, P contracts):	$	4,850,000
Costs Associated with Rectifier Equipment (not including contractor markup):		
(14) 150kW Depot Chargers:	$	1,330,000
(1) 450kW Pantograph Charger:	$	1,000,000
Grand Total:	**$**	**7,180,000**

Scenario 4: *See Appendix C for Scenario 4 cost estimate*

Costs Associated with Required Building Improvements (G, H, E, P contracts):	$	11,080,000
Costs Associated with Rectifier Equipment (not including contractor markup):		
(28) 150kW Depot Chargers:	$	2,660,000
(2) 450kW Pantograph Charger:	$	2,000,000
Grand Total:	**$**	**15,740,000**

7. Future Considerations

7.1 Electrical

Additional equipment or other electrical additions will require studies and evaluations beyond this report. Site verifications for physical space to accommodate chargers, dispensers, and electrical equipment. Load flow studies, harmonics mitigation, and coordination studies will need performed. Additional power requirements should be closely coordinated with the utility provider as additions are considered.

7.2 Industry Trends

WRA discussed the current trends of the industry with New Flyer as part of this evaluation. It was noted that the trend is moving away from active plug-in that requires an operator, to a more passive, automated system. In many garages they are seeing either inductive charging being introduced, or suspended pantographs within the garage. The advantage to these systems are that they can eliminate driver error or carelessness, reduce overall maintenance and operational costs, and improve operator safety. These options are more costly in terms of equipment and installation. An inductive system would require a slab replacement, while a pantograph system would likely require an independent structural frame to support the pantograph where the existing roof structure is not adequate. No additional research or costing was performed as a product of this report, however it is recommended that the Authority keep these trends in mind as it develops capital improvement projects at its garages that may support these systems or uses the opportunity to include infrastructure that will reduce the costs of future installations.

Appendix A – Exhibit Drawings

*SITE UTILITIES AND FENCE ARE APPROXIMATE

Whitman, Requardt & Associates, LLP
500 Grant Street, Pittsburgh, Pennsylvania 15219

NO.	DATE	DESCRIPTION
		REVISIONS

SIGNATURE | APPROVED | DATE

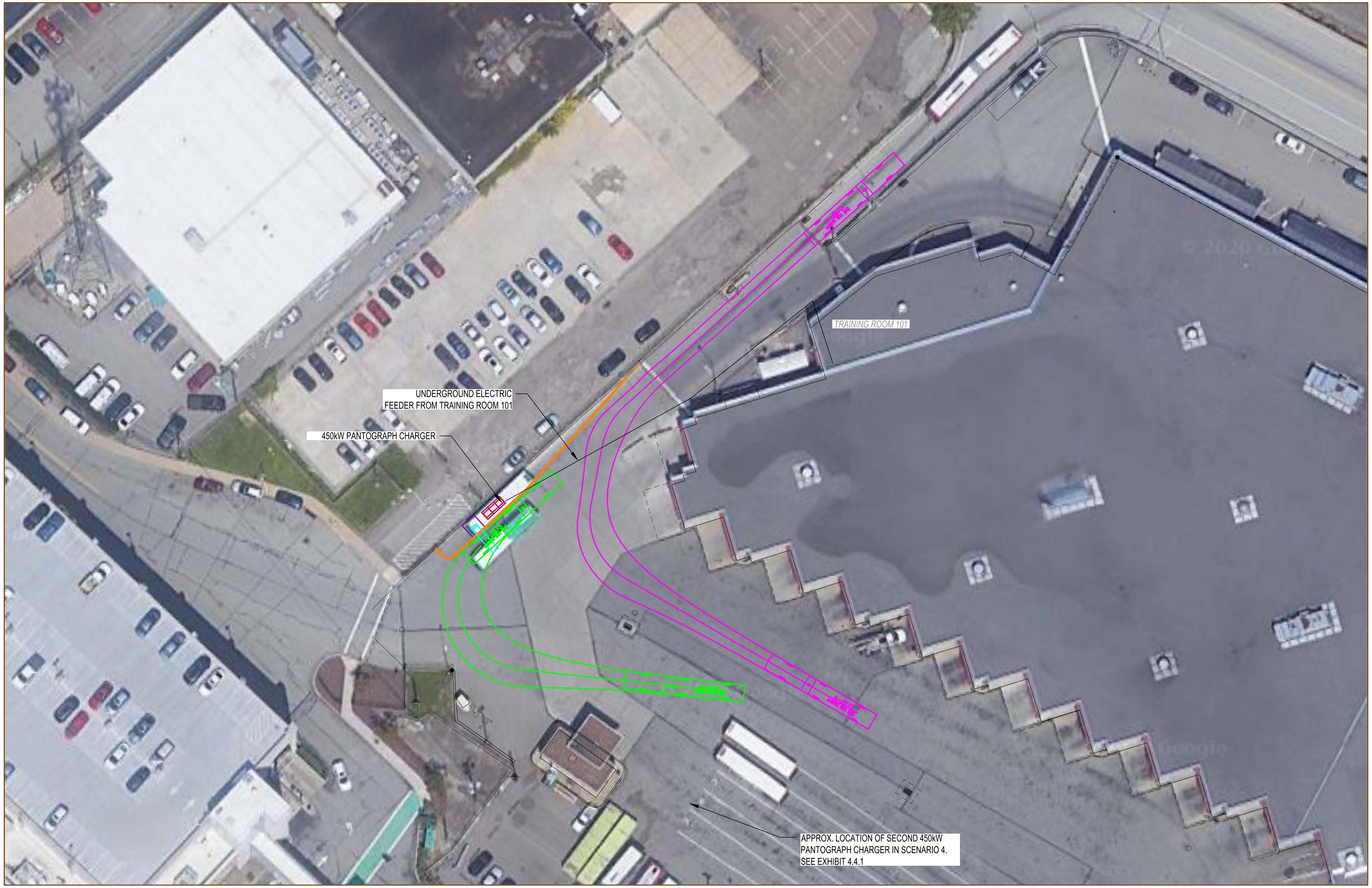
DESIGNED	MDB
DRAWN	MDB
CHECKED	
IN CHARGE	ECR
DATE	OCT 30, 2020
SCALE	AS NOTED

PORT AUTHORITY OF ALLEGHENY COUNTY
PITTSBURGH PENNSYLVANIA

EAST LIBERTY BEB IMPLEMENTATION PLAN
ELECTRICAL
SITE POWER PLAN

Port Authority
connecting people to life

CONTRACT NO.
DWG. NO. EXHIBIT 2.1.1
SHT.



1 / 3.2 EAST LIBERTY - 450KW PANTOGRAPH LOCATION
NTS

NO.	DATE	DESCRIPTION
	REVISIONS	

Whitman, Requardt & Associates, LLP
500 Grant Street, Pittsburgh, Pennsylvania 15219

SIGNATURE | APPROVED | DATE

DESIGNED	MDB
DRAWN	MDB
CHECKED	
IN CHARGE	ECR
DATE	OCT 30, 2020
SCALE	AS NOTED

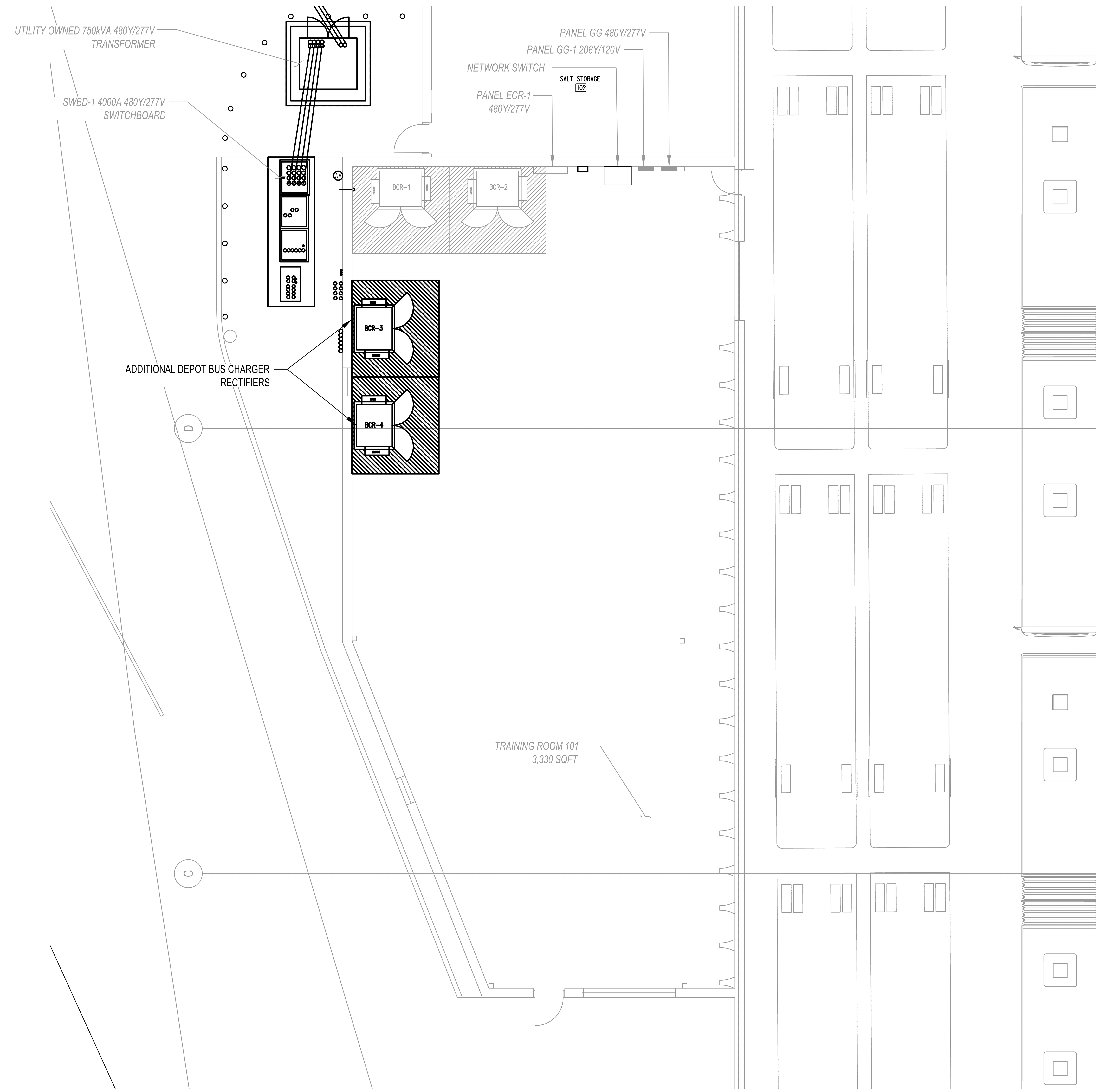
PORT AUTHORITY OF ALLEGHENY COUNTY
PITTSBURGH PENNSYLVANIA

EAST LIBERTY BEB IMPLEMENTATION PLAN
ELECTRICAL
450kW PANTOGRAPH LOCATION

Port Authority connecting people to life

CONTRACT NO.
DWG. NO. EXHIBIT 3.2.1 SHT.

PLOT DATE: 10/28/2020 8:37:57 AM PAGE SETUP: WRA-PDF (34X22) PLOT STYLE: WRA_2006.CTB PAPER SIZE:ANSI FULL BLEED D (34.00 X 22.00 INCHES)
FILENAME: N:\9025\9-021\CADD\90259021 PANTOGRAPH 3.2.1.DWG
$DATE$ $FILE$ $TIME$



1
4.1
EAST LIBERTY TRAINING ROOM 101 - SCENARIO 1
NTS

WRA
Whitman, Requardt & Associates, LLP
500 Grant Street, Pittsburgh, Pennsylvania 15219

NO.	DATE	DESCRIPTION

REVISIONS

SIGNATURE

APPROVED

DATE

DESIGNED	MDB
DRAWN	MDB
CHECKED	
IN CHARGE	ECR
DATE	OCT 30, 2020
SCALE	AS NOTED

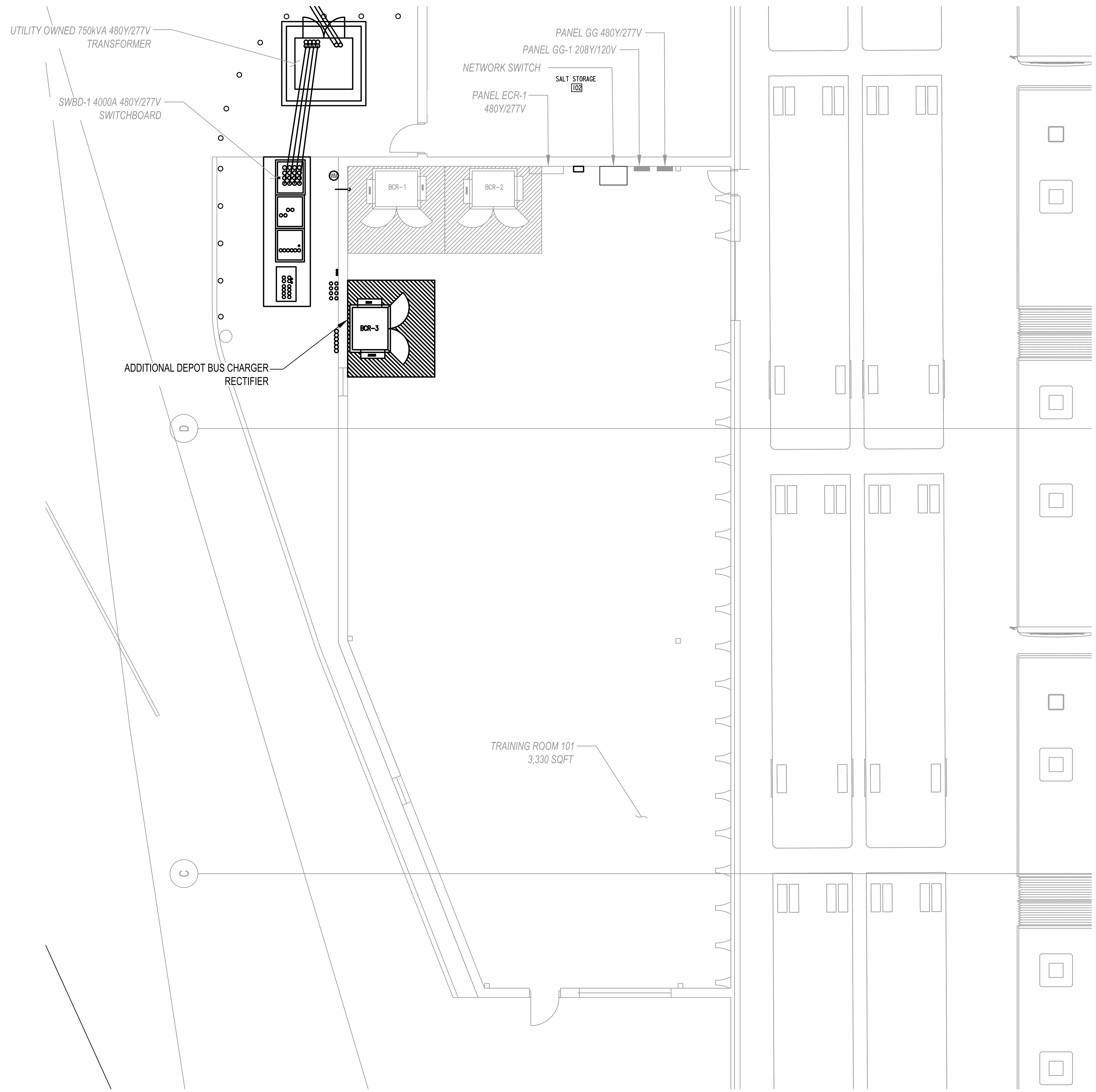
PORT AUTHORITY OF ALLEGHENY COUNTY
PITTSBURGH PENNSYLVANIA

EAST LIBERTY BEB IMPLEMENTATION PLAN
ELECTRICAL
TRAINING ROOM 101-SCENARIO 1

Port Authority
connecting people to life

CONTRACT NO.
DWG. NO. EXHIBIT 4.1.1
SHT.

*NOTE: THIS CONFIGURATION DOES NOT COMPLY TO PAAC'S 90°F DESIGN TEMPERATURE. SUPPLEMENTAL HVAC WOULD BE REQUIRED. THIS GRAPHIC SHOWS THE POSSIBLE LAYOUT WITH A 10°F DEGREE TEMPERATURE DIFFERENCE



1
4.2
EAST LIBERTY TRAINING ROOM 101 - SCENARIO 2
NTS

NO.	DATE	DESCRIPTION
		REVISIONS

WRA
Whitman, Requardt & Associates, LLP
500 Grant Street, Pittsburgh, Pennsylvania 15219

SIGNATURE
APPROVED
DATE

DESIGNED	MDB
DRAWN	MDB
CHECKED	
IN CHARGE	ECR
DATE	OCT 30, 2020
SCALE	AS NOTED

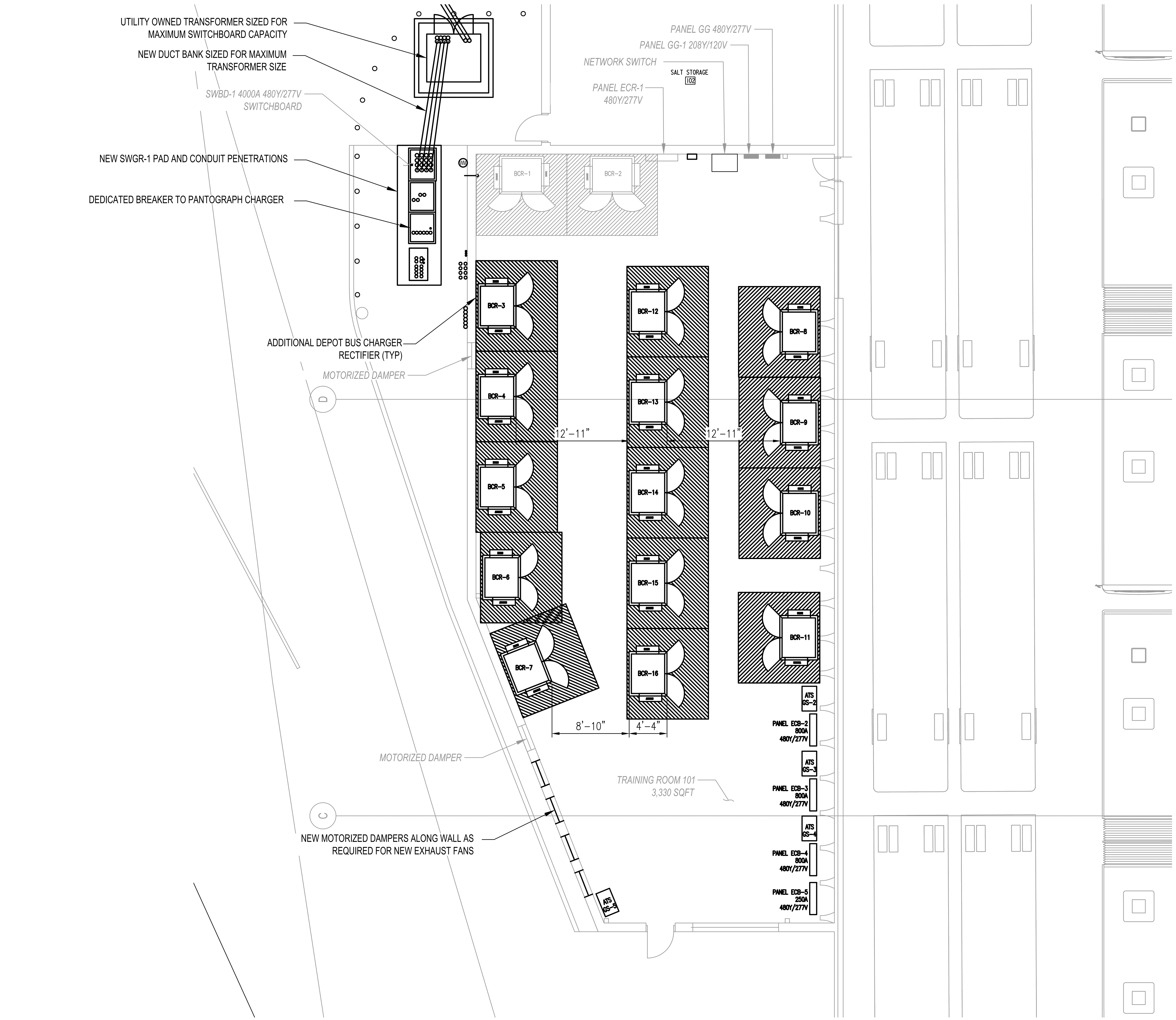
PORT AUTHORITY OF ALLEGHENY COUNTY
PITTSBURGH PENNSYLVANIA

EAST LIBERTY BEB IMPLEMENTATION PLAN
ELECTRICAL
TRAINING ROOM 101 - SCENARIO 2

Port Authority
connecting people to life

CONTRACT NO.
DWG. NO. EXHIBIT 4.2.1
SHT.

PLOT DATE: 10/27/2020 2:06:39 PM PAGE SETUP: WRA-PDF (34X22) PLOT STYLE: WRA_2006.CTB PAPER SIZE:ANSI FULL BLEED D (34.00 X 22.00 INCHES)
$TIME$
$DATE$
$FILE$
FILENAME: N:\90259-03\CADD\9025903E2-01 MDB.DWG



1 / 4.3 EAST LIBERTY TRAINING ROOM 101 - SCENARIO 3
NTS

NO.	DATE	DESCRIPTION
		REVISIONS

Whitman, Requardt & Associates, LLP
500 Grant Street, Pittsburgh, Pennsylvania 15219

SIGNATURE — APPROVED — DATE

DESIGNED	MDB
DRAWN	MDB
CHECKED	
IN CHARGE	ECR
DATE	OCT 30, 2020
SCALE	AS NOTED

PORT AUTHORITY OF ALLEGHENY COUNTY
PITTSBURGH PENNSYLVANIA

EAST LIBERTY BEB IMPLEMENTATION PLAN
ELECTRICAL
TRAINING ROOM 101 - SCENARIO 3

Port Authority
connecting people to life

CONTRACT NO.
DWG. NO. EXHIBIT 4.3.1
SHT.

1 / 4.3 EAST LIBERTY GENERATOR LAYOUT SCENARIO 3
NTS

WRA Whitman, Requardt & Associates, LLP
500 Grant Street, Pittsburgh, Pennsylvania 15219

NO.	DATE	DESCRIPTION

REVISIONS

SIGNATURE | APPROVED | DATE

DESIGNED	MDB
DRAWN	MDB
CHECKED	
IN CHARGE	ECR
DATE	OCT 30, 2020
SCALE	AS NOTED

PORT AUTHORITY OF ALLEGHENY COUNTY
PITTSBURGH PENNSYLVANIA

EAST LIBERTY BEB IMPLEMENTATION PLAN
ELECTRICAL
GENERATOR LAYOUT - SCENARIO 3

Port Authority
connecting people to life

CONTRACT NO.
DWG. NO. EXHIBIT 4.3.4
SHT.

WRA
Whitman, Requardt & Associates, LLP
500 Grant Street, Pittsburgh, Pennsylvania 15219

NO.	DATE	DESCRIPTION
REVISIONS		

SIGNATURE | APPROVED | DATE

DESIGNED MDB
DRAWN MDB
CHECKED
IN CHARGE ECR
DATE OCT 30, 2020
SCALE AS NOTED

PORT AUTHORITY OF ALLEGHENY COUNTY
PITTSBURGH PENNSYLVANIA

EAST LIBERTY BEB IMPLEMENTATION PLAN
ELECTRICAL
SITE POWER PLAN - SCENARIO 4

Port Authority
connecting people to life

CONTRACT NO.
DWG. NO. EXHIBIT 4.4.1
SHT.

1 / 4.4 EAST LIBERTY EQUIPMENT LAYOUT SCENARIO 4
NTS

NO.	DATE	DESCRIPTION	SIGNATURE	APPROVED / DATE
		REVISIONS		

Whitman, Requardt & Associates, LLP
500 Grant Street, Pittsburgh, Pennsylvania 15219

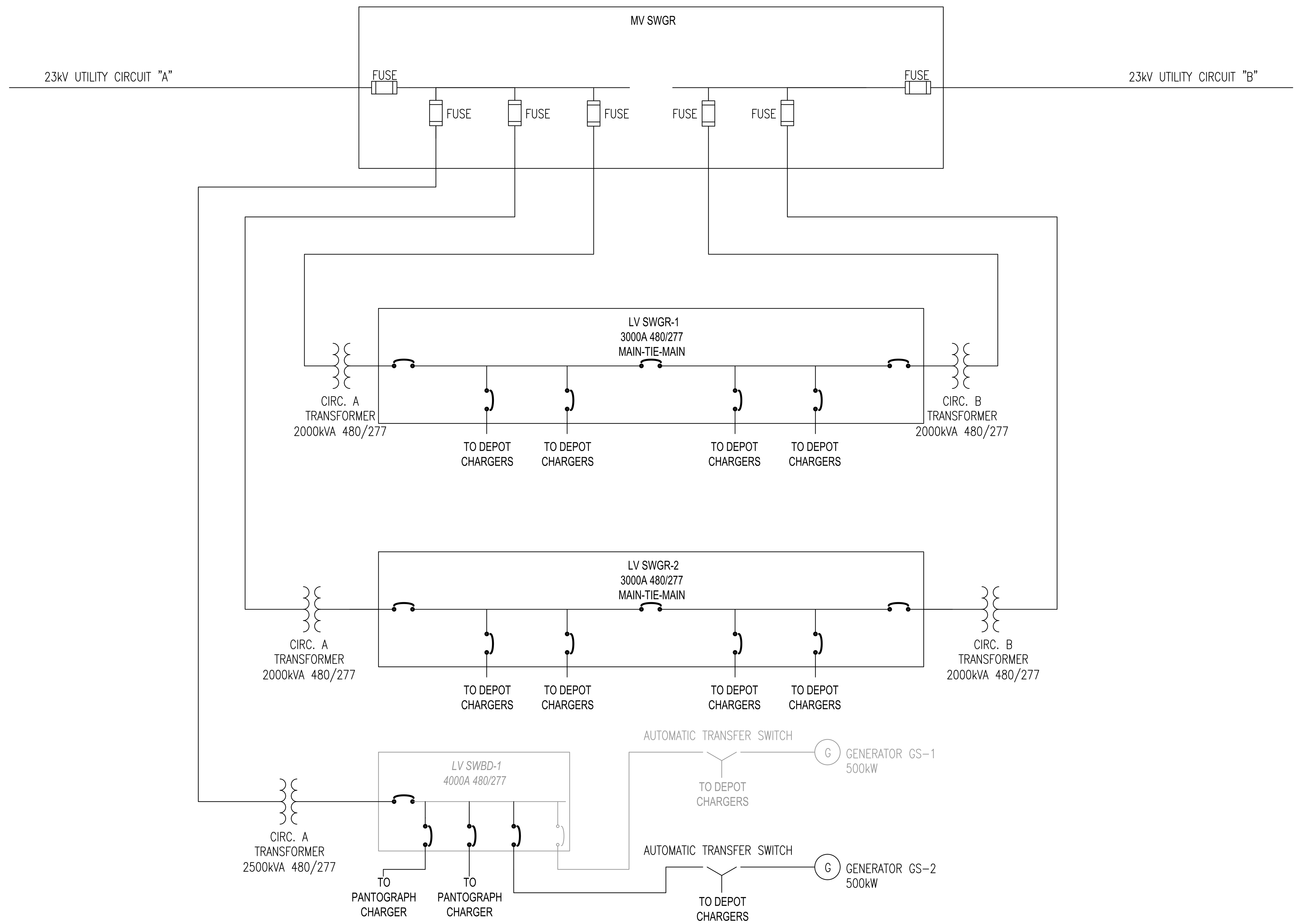
DESIGNED	MDB
DRAWN	MDB
CHECKED	
IN CHARGE	ECR
DATE	OCT 30, 2020
SCALE	AS NOTED

PORT AUTHORITY OF ALLEGHENY COUNTY
PITTSBURGH PENNSYLVANIA

EAST LIBERTY BEB IMPLEMENTATION PLAN
ELECTRICAL
EQUIPMENT LAYOUT - SCENARIO 4

Port Authority
connecting people to life

CONTRACT NO.
DWG. NO. EXHIBIT 4.4.2.1
SHT.



1 / 4.4 EAST LIBERTY SINGLE LINE SCENARIO 4
NTS

PLOT DATE: 10/30/2020 2:14:59 PM PAGE SETUP: WRA-PDF (34X22) PLOT STYLE: WRA_2006.CTB PAPER SIZE:ANSI FULL BLEED D (34.00 X 22.00 INCHES)
FILENAME: N:\90259-031\CADD\90259031E2-01 SC4 MDB.DWG
$DATE$ $FILE$ $TIME$

Whitman, Requardt & Associates, LLP
500 Grant Street, Pittsburgh, Pennsylvania 15219

NO.	DATE	DESCRIPTION
		REVISIONS

SIGNATURE | APPROVED | DATE

DESIGNED	MDB
DRAWN	MDB
CHECKED	
IN CHARGE	ECR
DATE	OCT 30, 2020
SCALE	AS NOTED

PORT AUTHORITY OF ALLEGHENY COUNTY
PITTSBURGH PENNSYLVANIA

EAST LIBERTY BEB IMPLEMENTATION PLAN
ELECTRICAL
ONE LINE DIAGRAM - SCENARIO 4

Port Authority
connecting people to life

CONTRACT NO.
DWG. NO. EXHIBIT 4.4.2.2
SHT.

Appendix B - Schedules

PANEL EBC-1- SCENARIO 1

MOUNTING:	SURFACE	VOLTAGE:	480/277	PH-GRD VOLTAGE:	277	ACCESSORIES:	-
MCB OR MLO:	MCB	PHASE:	3	PH-PH VOLTAGE:	480	ACCESSORIES:	-
MCB FRAME SIZE:	1200	BUS MATERIAL:	CU	SOURCE EQUIPMENT:	SWBD-1	ACCESSORIES:	-
MCB TRIP AMPS:	1200	BUS RATING:	1200	SOURCE LOCATION:	Outodoor SWBD-1	ACCESSORIES:	-
MCB MAX KVA RATING:	798	AVAILABLE KAIC:	35	PANEL LOCATION:	Training Room 101	ACCESSORIES:	-
SPARE KVA:	186	SPARE PERCENT:	23%				

LOAD DESCRIPTION	CONDUIT SIZE (INCHES)	COND TYPE	(NO. WIRE) SIZE	EGC SIZE	WIRE INSUL TYPE	KAIC	CB AMPS/POLES	POLE #	LOAD AMPS	LOAD AMPS	POLE #	CB AMPS/POLES	KAIC	WIRE INSUL TYPE	EGC SIZE	(NO. WIRE) SIZE	COND TYPE	CONDUIT SIZE (INCHES)	LOAD DESCRIPTION
BUS CHARGING RECTIFIER BCR-1	2-1/2"	GRC	250 KCMIL	#4	XHHW-2	35	250/3	1	184.1	184.1	2	250/3	35	XHHW-2	#4	250 KCMIL	GRC	2-1/2"	BUS CHARGING RECTIFIER BCR-2
								3	184.1	184.1	4								
								5	184.1	184.1	6								
BUS CHARGING RECTIFIER BCR-3	**2-1/2"**	**GRC**	**250 KCMIL**	**#4**	**XHHW-2**	**35**	**250/3**	7	184.1	184.1	8	**250/3**	**35**	**XHHW-2**	**#4**	**250 KCMIL**	**GRC**	**2-1/2"**	**BUS CHARGING RECTIFIER BCR-4**
								9	184.1	184.1	10								
								11	184.1	184.1	12								
SPACE								13	0.0	0.0	14								SPACE
SPACE								15	0.0	0.0	16								SPACE
SPACE								17	0.0	0.0	18								SPACE
SPACE								19	0.0	0.0	20								SPACE
SPACE								21	0.0	0.0	22								SPACE
SPACE								23	0.0	0.0	24								SPACE
SPACE								25	0.0	0.0	26								SPACE
SPACE								27	0.0	0.0	28								SPACE
SPACE								29	0.0	0.0	30								SPACE
SPACE								31	0.0	0.0	32								SPACE

LOAD SUMMARY PANEL:

LOAD CATEGORIES	CONNECTED KVA	DEMAND FACTOR	DEMAND KVA	TOTAL CONNECTED KVA	TOTAL CONNECTED AMPS	DEMAND KVA	DEMAND FACTOR	CONNECTED KVA	LOAD CATEGORIES
LIGHTING	0.0	100%	0.0	611.9	736.1	0.0	90%	0.0	MOTOR LOADS
RECEPTACLES (1ST 10KVA)	0.0	100%	0.0	TOTAL DEMAND KVA	TOTAL DEMAND AMPS	0.0	80%	0.0	HVAC
RECEPTACLES (BALANCE)	0.0	50%	0.0	611.9	736.1	611.9	100%	611.9	MISCELLANEOUS
A-PHASE KVA	204.0	PANEL SIZING = TOTAL DEMAND KVA X CONTINUOUS LOAD FACTOR X FUTURE LOAD FACTOR						736.4	A-PHASE AMPS
B-PHASE KVA	204.0	CONTINUOUS LOAD FACTOR:		1	611.9	KVA		736.4	B-PHASE AMPS
C-PHASE KVA	204.0	FUTURE LOAD FACTOR:		1	736.1	AMPS		736.4	C-PHASE AMPS

PANEL EBC-1- SCENARIO 2

MOUNTING:	SURFACE	VOLTAGE:	480/277	PH-GRD VOLTAGE:	277	ACCESSORIES:	-
MCB OR MLO:	MCB	PHASE:	3	PH-PH VOLTAGE:	480	ACCESSORIES:	-
MCB FRAME SIZE:	1200	BUS MATERIAL:	CU	SOURCE EQUIPMENT:	SWBD-1	ACCESSORIES:	-
MCB TRIP AMPS:	1200	BUS RATING:	1200	SOURCE LOCATION:	Outodoor SWBD-1	ACCESSORIES:	-
MCB MAX KVA RATING:	798	AVAILABLE KAIC:	35	PANEL LOCATION:	Training Room 101	ACCESSORIES:	-
SPARE KVA:	339	SPARE PERCENT:	42%				

LOAD DESCRIPTION	CONDUIT SIZE (INCHES)	COND TYPE	(NO. WIRE) SIZE	EGC SIZE	WIRE INSUL TYPE	KAIC	CB AMPS/POLES	POLE #	LOAD AMPS	LOAD AMPS	POLE #	CB AMPS/POLES	KAIC	WIRE INSUL TYPE	EGC SIZE	(NO. WIRE) SIZE	COND TYPE	CONDUIT SIZE (INCHES)	LOAD DESCRIPTION
BUS CHARGING RECTIFIER BCR-1	2-1/2"	GRC	250 KCMIL	#4	XHHW-2	35	250/3	1	184.1	184.1	2	250/3	35	XHHW-2	#4	250 KCMIL	GRC	2-1/2"	BUS CHARGING RECTIFIER BCR-2
								3	184.1	184.1	4								
								5	184.1	184.1	6								
BUS CHARGING RECTIFIER BCR-3	**2-1/2"**	**GRC**	**250 KCMIL**	**#4**	**XHHW-2**	**35**	**250/3**	7	184.1	0.0	8								SPACE
								9	184.1	0.0	10								SPACE
								11	184.1	0.0	12								SPACE
SPACE								13	0.0	0.0	14								SPACE
SPACE								15	0.0	0.0	16								SPACE
SPACE								17	0.0	0.0	18								SPACE
SPACE								19	0.0	0.0	20								SPACE
SPACE								21	0.0	0.0	22								SPACE
SPACE								23	0.0	0.0	24								SPACE
SPACE								25	0.0	0.0	26								SPACE
SPACE								27	0.0	0.0	28								SPACE
SPACE								29	0.0	0.0	30								SPACE
SPACE								31	0.0	0.0	32								SPACE

LOAD SUMMARY PANEL:

LOAD CATEGORIES	CONNECTED KVA	DEMAND FACTOR	DEMAND KVA	TOTAL CONNECTED KVA	TOTAL CONNECTED AMPS	DEMAND KVA	DEMAND FACTOR	CONNECTED KVA	LOAD CATEGORIES
LIGHTING	0.0	100%	0.0	459.0	552.1	0.0	90%	0.0	MOTOR LOADS
RECEPTACLES (1ST 10KVA)	0.0	100%	0.0	TOTAL DEMAND KVA	TOTAL DEMAND AMPS	0.0	80%	0.0	HVAC
RECEPTACLES (BALANCE)	0.0	50%	0.0	459.0	552.1	459.0	100%	459.0	MISCELLANEOUS
A-PHASE KVA	153.0	PANEL SIZING = TOTAL DEMAND KVA X CONTINUOUS LOAD FACTOR X FUTURE LOAD FACTOR						552.3	A-PHASE AMPS
B-PHASE KVA	153.0	CONTINUOUS LOAD FACTOR:		1	459.0	KVA		552.3	B-PHASE AMPS
C-PHASE KVA	153.0	FUTURE LOAD FACTOR:		1	552.1	AMPS		552.3	C-PHASE AMPS

APPENDIX B - SCHEDULE 4.2.1(1)

PANEL EBC-1- SCENARIO 3

MOUNTING:	SURFACE	VOLTAGE:	480/277	PH-GRD VOLTAGE:	277	ACCESSORIES:	-
MCB OR MLO:	MCB	PHASE:	3	PH-PH VOLTAGE:	480	ACCESSORIES:	-
MCB FRAME SIZE:	1200	BUS MATERIAL:	CU	SOURCE EQUIPMENT:	SWBD-1 / ATS	ACCESSORIES:	-
MCB TRIP AMPS:	800	BUS RATING:	1200	SOURCE LOCATION:	Outodoor SWBD-1	ACCESSORIES:	-
MCB MAX KVA RATING:	665	AVAILABLE KAIC:	35	PANEL LOCATION:	Training Room 101	ACCESSORIES:	-
SPARE KVA:	53	SPARE PERCENT:	8%				

LOAD DESCRIPTION	CONDUIT SIZE (INCHES)	COND TYPE	(NO. WIRE) SIZE	EGC SIZE	WIRE INSUL TYPE	KAIC	CB AMPS/POLES	POLE #	LOAD AMPS	LOAD AMPS	POLE #	CB AMPS/POLES	KAIC	WIRE INSUL TYPE	EGC SIZE	(NO. WIRE) SIZE	COND TYPE	CONDUIT SIZE (INCHES)	LOAD DESCRIPTION
BUS CHARGING RECTIFIER BCR-1	2-1/2"	GRC	250 KCMIL	#4	XHHW-2	35	250/3	1	184.1	184.1	2	250/3	35	XHHW-2	#4	250 KCMIL	GRC	2-1/2"	BUS CHARGING RECTIFIER BCR-2
								3	184.1	184.1	4								
								5	184.1	184.1	6								
BUS CHARGING RECTIFIER BCR-3	**2-1/2"**	**GRC**	**250 KCMIL**	**#4**	**XHHW-2**	**35**	**250/3**	7	184.1	184.1	8	**250/3**	**35**	**XHHW-2**	**#4**	**250 KCMIL**	**GRC**	**2-1/2"**	**BUS CHARGING RECTIFIER BCR-4**
								9	184.1	184.1	10								
								11	184.1	184.1	12								
SPACE								13	0.0	0.0	14								SPACE
SPACE								15	0.0	0.0	16								SPACE
SPACE								17	0.0	0.0	18								SPACE
SPACE								19	0.0	0.0	20								SPACE
SPACE								21	0.0	0.0	22								SPACE
SPACE								23	0.0	0.0	24								SPACE
SPACE								25	0.0	0.0	26								SPACE
SPACE								27	0.0	0.0	28								SPACE
SPACE								29	0.0	0.0	30								SPACE
SPACE								31	0.0	0.0	32								SPACE

LOAD SUMMARY PANEL:

LOAD CATEGORIES	CONNECTED KVA	DEMAND FACTOR	DEMAND KVA	TOTAL CONNECTED KVA	TOTAL CONNECTED AMPS	DEMAND KVA	DEMAND FACTOR	CONNECTED KVA	LOAD CATEGORIES
LIGHTING	0.0	100%	0.0	611.9	736.1	0.0	100%	0.0	MOTOR LOADS
RECEPTACLES (1ST 10KVA)	0.0	100%	0.0	TOTAL DEMAND KVA	TOTAL DEMAND AMPS	0.0	80%	0.0	HVAC
RECEPTACLES (BALANCE)	0.0	50%	0.0	611.9	736.1	611.9	100%	611.9	MISCELLANEOUS
A-PHASE KVA	204.0	PANEL SIZING = TOTAL DEMAND KVA X CONTINUOUS LOAD FACTOR X FUTURE LOAD FACTOR						736.4	A-PHASE AMPS
B-PHASE KVA	204.0	CONTINUOUS LOAD FACTOR:	1		611.9	KVA		736.4	B-PHASE AMPS
C-PHASE KVA	204.0	FUTURE LOAD FACTOR:	1		736.1	AMPS		736.4	C-PHASE AMPS

	POLE #	LOAD AMPS	LOAD AMPS	POLE #	
1 POLE BREAKER	1	0.0	0.0	2	1 POLE BREAKER
2 POLE BREAKER	1	0.0	0.0	2	2 POLE BREAKER
	3	0.0	0.0	4	
3 POLE BREAKER	1	0.0	0.0	2	3-POLE BREAKER
	3	0.0	0.0	4	
	5	0.0	0.0	6	

PANEL EBC-2- SCENARIO 3

MOUNTING:	SURFACE	VOLTAGE:	480/277	PH-GRD VOLTAGE:	277	ACCESSORIES:	-
MCB OR MLO:	MCB	PHASE:	3	PH-PH VOLTAGE:	480	ACCESSORIES:	-
MCB FRAME SIZE:	800	BUS MATERIAL:	CU	SOURCE EQUIPMENT:	SWBD-1	ACCESSORIES:	-
MCB TRIP AMPS:	800	BUS RATING:	800	SOURCE LOCATION:	Outodoor SWBD-1	ACCESSORIES:	-
MCB MAX KVA RATING:	665	AVAILABLE KAIC:	35	PANEL LOCATION:	Training Room 101	ACCESSORIES:	-
SPARE KVA:	53	SPARE PERCENT:	8%				

LOAD DESCRIPTION	CONDUIT SIZE (INCHES)	COND TYPE	(NO. WIRE) SIZE	EGC SIZE	WIRE INSUL TYPE	KAIC	CB AMPS/POLES	POLE #	LOAD AMPS	LOAD AMPS	POLE #	CB AMPS/POLES	KAIC	WIRE INSUL TYPE	EGC SIZE	(NO. WIRE) SIZE	COND TYPE	CONDUIT SIZE (INCHES)	LOAD DESCRIPTION
BUS CHARGING RECTIFIER BCR-5	**2-1/2"**	**GRC**	**250 KCMIL**	**#4**	**XHHW-2**	**35**	**250/3**	1	184.1	184.1	2	**250/3**	**35**	**XHHW-2**	**#4**	**250 KCMIL**	**GRC**	**2-1/2"**	**BUS CHARGING RECTIFIER BCR-6**
								3	184.1	184.1	4								
								5	184.1	184.1	6								
BUS CHARGING RECTIFIER BCR-7	**2-1/2"**	**GRC**	**250 KCMIL**	**#4**	**XHHW-2**	**35**	**250/3**	7	184.1	184.1	8	**250/3**	**35**	**XHHW-2**	**#4**	**250 KCMIL**	**GRC**	**2-1/2"**	**BUS CHARGING RECTIFIER BCR-8**
								9	184.1	184.1	10								
								11	184.1	184.1	12								
SPACE								13	0.0	0.0	14								SPACE
SPACE								15	0.0	0.0	16								SPACE
SPACE								17	0.0	0.0	18								SPACE
SPACE								19	0.0	0.0	20								SPACE
SPACE								21	0.0	0.0	22								SPACE
SPACE								23	0.0	0.0	24								SPACE
SPACE								25	0.0	0.0	26								SPACE
SPACE								27	0.0	0.0	28								SPACE
SPACE								29	0.0	0.0	30								SPACE
SPACE								31	0.0	0.0	32								SPACE

LOAD SUMMARY PANEL:

LOAD CATEGORIES	CONNECTED KVA	DEMAND FACTOR	DEMAND KVA	TOTAL CONNECTED KVA	TOTAL CONNECTED AMPS	DEMAND KVA	DEMAND FACTOR	CONNECTED KVA	LOAD CATEGORIES
LIGHTING	0.0	100%	0.0	611.9	736.1	0.0	100%	0.0	MOTOR LOADS
RECEPTACLES (1ST 10KVA)	0.0	100%	0.0	TOTAL DEMAND KVA	TOTAL DEMAND AMPS	0.0	100%	0.0	HVAC
RECEPTACLES (BALANCE)	0.0	50%	0.0	611.9	736.1	611.9	100%	611.9	MISCELLANEOUS
A-PHASE KVA	204.0	PANEL SIZING = TOTAL DEMAND KVA X CONTINUOUS LOAD FACTOR X FUTURE LOAD FACTOR						736.4	A-PHASE AMPS
B-PHASE KVA	204.0	CONTINUOUS LOAD FACTOR:	1		611.9	KVA		736.4	B-PHASE AMPS
C-PHASE KVA	204.0	FUTURE LOAD FACTOR:	1		736.1	AMPS		736.4	C-PHASE AMPS

APPENDIX B - SCHEDULE 4.3.3(2)

PANEL EBC-3- SCENARIO 3

MOUNTING:	SURFACE	VOLTAGE:	480/277	PH-GRD VOLTAGE:	277	ACCESSORIES:	-
MCB OR MLO:	MCB	PHASE:	3	PH-PH VOLTAGE:	480	ACCESSORIES:	-
MCB FRAME SIZE:	800	BUS MATERIAL:	CU	SOURCE EQUIPMENT:	SWBD-1	ACCESSORIES:	-
MCB TRIP AMPS:	800	BUS RATING:	800	SOURCE LOCATION:	Outodoor SWBD-1	ACCESSORIES:	-
MCB MAX KVA RATING:	665	AVAILABLE KAIC:	35	PANEL LOCATION:	Training Room 101	ACCESSORIES:	-
SPARE KVA:	53	SPARE PERCENT:	8%				

LOAD DESCRIPTION	CONDUIT SIZE (INCHES)	COND TYPE	(NO. WIRE) SIZE	EGC SIZE	WIRE INSUL TYPE	KAIC	CB AMPS/POLES	POLE #	LOAD AMPS	LOAD AMPS	POLE #	CB AMPS/POLES	KAIC	WIRE INSUL TYPE	EGC SIZE	(NO. WIRE) SIZE	COND TYPE	CONDUIT SIZE (INCHES)	LOAD DESCRIPTION
BUS CHARGING RECTIFIER BCR-9	**2-1/2"**	**GRC**	**250 KCMIL**	**#4**	**XHHW-2**	**35**	**250/3**	1	184.1	184.1	2	**250/3**	**35**	**XHHW-2**	**#4**	**250 KCMIL**	**GRC**	**2-1/2"**	**BUS CHARGING RECTIFIER BCR-10**
								3	184.1	184.1	4								
								5	184.1	184.1	6								
BUS CHARGING RECTIFIER BCR-11	**2-1/2"**	**GRC**	**250 KCMIL**	**#4**	**XHHW-2**	**35**	**250/3**	7	184.1	184.1	8	**250/3**	**35**	**XHHW-2**	**#4**	**250 KCMIL**	**GRC**	**2-1/2"**	**BUS CHARGING RECTIFIER BCR-12**
								9	184.1	184.1	10								
								11	184.1	184.1	12								
SPACE								13	0.0	0.0	14								SPACE
SPACE								15	0.0	0.0	16								SPACE
SPACE								17	0.0	0.0	18								SPACE
SPACE								19	0.0	0.0	20								SPACE
SPACE								21	0.0	0.0	22								SPACE
SPACE								23	0.0	0.0	24								SPACE
SPACE								25	0.0	0.0	26								SPACE
SPACE								27	0.0	0.0	28								SPACE
SPACE								29	0.0	0.0	30								SPACE
SPACE								31	0.0	0.0	32								SPACE

LOAD SUMMARY PANEL:

LOAD CATEGORIES	CONNECTED KVA	DEMAND FACTOR	DEMAND KVA	TOTAL CONNECTED KVA	TOTAL CONNECTED AMPS	DEMAND KVA	DEMAND FACTOR	CONNECTED KVA	LOAD CATEGORIES
LIGHTING	306.0	100%	306.0	611.9	736.1	0.0	100%	0.0	MOTOR LOADS
RECEPTACLES (1ST 10KVA)	0.0	100%	0.0	TOTAL DEMAND KVA	TOTAL DEMAND AMPS	0.0	100%	0.0	HVAC
RECEPTACLES (BALANCE)	0.0	50%	0.0	611.9	736.1	306.0	100%	306.0	MISCELLANEOUS
A-PHASE KVA	204.0	PANEL SIZING = TOTAL DEMAND KVA X CONTINUOUS LOAD FACTOR X FUTURE LOAD FACTOR						736.4	A-PHASE AMPS
B-PHASE KVA	204.0	CONTINUOUS LOAD FACTOR:		1	611.9	KVA		736.4	B-PHASE AMPS
C-PHASE KVA	204.0	FUTURE LOAD FACTOR:		1	736.1	AMPS		736.4	C-PHASE AMPS

APPENDIX B - SCHEDULE 4.3.3(3)

PANEL EBC-4- SCENARIO 3

MOUNTING:	SURFACE	VOLTAGE:	480/277	PH-GRD VOLTAGE:	277	ACCESSORIES:	-
MCB OR MLO:	MCB	PHASE:	3	PH-PH VOLTAGE:	480	ACCESSORIES:	-
MCB FRAME SIZE:	800	BUS MATERIAL:	CU	SOURCE EQUIPMENT:	SWBD-1	ACCESSORIES:	-
MCB TRIP AMPS:	800	BUS RATING:	800	SOURCE LOCATION:	Outodoor SWBD-1	ACCESSORIES:	-
MCB MAX KVA RATING:	665	AVAILABLE KAIC:	35	PANEL LOCATION:	Training Room 101	ACCESSORIES:	-
SPARE KVA:	53	SPARE PERCENT:	8%				

LOAD DESCRIPTION	CONDUIT SIZE (INCHES)	COND TYPE	(NO. WIRE) SIZE	EGC SIZE	WIRE INSUL TYPE	KAIC	CB AMPS/POLES	POLE #	LOAD AMPS	LOAD AMPS	POLE #	CB AMPS/POLES	KAIC	WIRE INSUL TYPE	EGC SIZE	(NO. WIRE) SIZE	COND TYPE	CONDUIT SIZE (INCHES)	LOAD DESCRIPTION
BUS CHARGING RECTIFIER BCR-13	**2-1/2"**	**GRC**	**250 KCMIL**	**#4**	**XHHW-2**	**35**	**250/3**	1	184.1	184.1	2	**250/3**	**35**	**XHHW-2**	**#4**	**250 KCMIL**	**GRC**	**2-1/2"**	**BUS CHARGING RECTIFIER BCR-14**
								3	184.1	184.1	4								
								5	184.1	184.1	6								
BUS CHARGING RECTIFIER BCR-15	**2-1/2"**	**GRC**	**250 KCMIL**	**#4**	**XHHW-2**	**35**	**250/3**	7	184.1	184.1	8	**250/3**	**35**	**XHHW-2**	**#4**	**250 KCMIL**	**GRC**	**2-1/2"**	**BUS CHARGING RECTIFIER BCR-16**
								9	184.1	184.1	10								
								11	184.1	184.1	12								
SPACE								13	0.0	0.0	14								SPACE
SPACE								15	0.0	0.0	16								SPACE
SPACE								17	0.0	0.0	18								SPACE
SPACE								19	0.0	0.0	20								SPACE
SPACE								21	0.0	0.0	22								SPACE
SPACE								23	0.0	0.0	24								SPACE
SPACE								25	0.0	0.0	26								SPACE
SPACE								27	0.0	0.0	28								SPACE
SPACE								29	0.0	0.0	30								SPACE
SPACE								31	0.0	0.0	32								SPACE

LOAD SUMMARY PANEL:

LOAD CATEGORIES	CONNECTED KVA	DEMAND FACTOR	DEMAND KVA	TOTAL CONNECTED KVA	TOTAL CONNECTED AMPS	DEMAND KVA	DEMAND FACTOR	CONNECTED KVA	LOAD CATEGORIES
LIGHTING	306.0	100%	306.0	611.9	736.1	0.0	100%	0.0	MOTOR LOADS
RECEPTACLES (1ST 10KVA)	0.0	100%	0.0	TOTAL DEMAND KVA	TOTAL DEMAND AMPS	0.0	100%	0.0	HVAC
RECEPTACLES (BALANCE)	0.0	50%	0.0	611.9	736.1	306.0	100%	306.0	MISCELLANEOUS
A-PHASE KVA	204.0	PANEL SIZING = TOTAL DEMAND KVA X CONTINUOUS LOAD FACTOR X FUTURE LOAD FACTOR						736.4	A-PHASE AMPS
B-PHASE KVA	204.0	CONTINUOUS LOAD FACTOR:		1	611.9	KVA		736.4	B-PHASE AMPS
C-PHASE KVA	204.0	FUTURE LOAD FACTOR:		1	736.1	AMPS		736.4	C-PHASE AMPS

PANEL EBC-5- SCENARIO 3

MOUNTING:	SURFACE	VOLTAGE:	480/277	PH-GRD VOLTAGE:	277	ACCESSORIES:	-
MCB OR MLO:	MCB	PHASE:	3	PH-PH VOLTAGE:	480	ACCESSORIES:	-
MCB FRAME SIZE:	250	BUS MATERIAL:	CU	SOURCE EQUIPMENT:	SWBD-1	ACCESSORIES:	-
MCB TRIP AMPS:	250	BUS RATING:	250	SOURCE LOCATION:	Outodoor SWBD-1	ACCESSORIES:	-
MCB MAX KVA RATING:	208	AVAILABLE KAIC:	35	PANEL LOCATION:	Training Room 101	ACCESSORIES:	-
SPARE KVA:	64	SPARE PERCENT:	31%				

LOAD DESCRIPTION	CONDUIT SIZE (INCHES)	COND TYPE	(NO. WIRE) SIZE	EGC SIZE	WIRE INSUL TYPE	KAIC	CB AMPS/POLES	POLE #	LOAD AMPS	LOAD AMPS	POLE #	CB AMPS/POLES	KAIC	WIRE INSUL TYPE	EGC SIZE	(NO. WIRE) SIZE	COND TYPE	CONDUIT SIZE (INCHES)	LOAD DESCRIPTION
NEW 3HP EF	**3/4"**	**GRC**	**12**	**12**	**THHN**	**35**	**20/3**	1	4.8	159.0	2	**200/3**	**35**	**XHHW-2**	**#6**	**2/0**	**GRC**	**2"**	**RTU-AC UNIT**
								3	4.8	159.0	4								
								5	4.8	159.0	6								
NEW 3HP EF	**3/4"**	**GRC**	**12**	**12**	**THHN**	**35**	**20/3**	7	4.8	0.0	8	**20/3**	**35**	**THHN**	**#12**	**#12**	**GRC**	**3/4"**	**EF-23 (1.5 HP)**
								9	4.8	0.0	10								
								11	4.8	0.0	12								
NEW 3HP EF	**3/4"**	**GRC**	**12**	**12**	**THHN**	**35**	**20/3**	13	4.8	0.0	14								SPACE
								15	4.8	0.0	16								SPACE
								17	4.8	0.0	18								SPACE
SPACE								19	0.0	0.0	20								SPACE
SPACE								21	0.0	0.0	22								SPACE
SPACE								23	0.0	0.0	24								SPACE
SPACE								25	0.0	0.0	26								SPACE
SPACE								27	0.0	0.0	28								SPACE
SPACE								29	0.0	0.0	30								SPACE
SPACE								31	0.0	0.0	32								SPACE

LOAD SUMMARY PANEL:

LOAD CATEGORIES	CONNECTED KVA	DEMAND FACTOR	DEMAND KVA	TOTAL CONNECTED KVA	TOTAL CONNECTED AMPS	DEMAND KVA	DEMAND FACTOR	CONNECTED KVA	LOAD CATEGORIES
LIGHTING	0.0	100%	0.0	144.1	173.3	12.0	100%	12.0	MOTOR LOADS
RECEPTACLES (1ST 10KVA)	0.0	100%	0.0	TOTAL DEMAND KVA	TOTAL DEMAND AMPS	132.1	100%	132.1	HVAC
RECEPTACLES (BALANCE)	0.0	50%	0.0	144.1	173.3	0.0	100%	0.0	MISCELLANEOUS
A-PHASE KVA	48.0	PANEL SIZING = TOTAL DEMAND KVA X CONTINUOUS LOAD FACTOR X FUTURE LOAD FACTOR						173.4	A-PHASE AMPS
B-PHASE KVA	48.0	CONTINUOUS LOAD FACTOR:		1	144.1	KVA		173.4	B-PHASE AMPS
C-PHASE KVA	48.0	FUTURE LOAD FACTOR:		1	173.3	AMPS		173.4	C-PHASE AMPS

Appendix C - Estimates

COST ESTIMATE SUMMARY - BASE BID

PROJECT NAME:	East Liberty Battery Electric Bus Implementation Plan-Scenario 1	CLIENT: Port Authority of Allegheny County	ESTIMATED BY: WRA
PROJECT LOCATION:	Pittsburgh Pennsylvania	DESIGN SUBMISSION: Final Report	WORK ORDER NUMBER: 90259.031

DIVISION NO.	DIVISION TITLE	DIRECT (BARE) COSTS MATERIAL COST	LABOR COST	EQUIPMENT COST	TOTAL DIVISION COST	MARKED UP COST TOTAL DIVISION COST	PERCENTAGE OF TOTAL
01	GENERAL REQUIREMENTS	$ -	$ -	$ -	$ -	$ -	0%
02	EXISTING CONDITIONS	$ -	$ -	$ -	$ -	$ -	0%
03	CONCRETE	$ 615	$ 348	$ 1	$ 964	**$ 2,250**	7%
04	MASONRY	$ -	$ -	$ -	$ -	$ -	0%
05	METALS	$ -	$ -	$ -	$ -	$ -	0%
06	WOOD, PLASTIC AND COMPOSITES	$ -	$ -	$ -	$ -	$ -	0%
07	THERMAL AND MOISTURE PROTECTION	$ -	$ -	$ -	$ -	$ -	0%
08	OPENINGS	$ -	$ -	$ -	$ -	$ -	0%
09	FINISHES	$ -	$ -	$ -	$ -	$ -	0%
10	SPECIALTIES	$ -	$ -	$ -	$ -	$ -	0%
11	EQUIPMENT	$ -	$ -	$ -	$ -	$ -	0%
12	FURNISHINGS	$ -	$ -	$ -	$ -	$ -	0%
13	SPECIAL CONSTRUCTION	$ -	$ -	$ -	$ -	$ -	0%
14	CONVEYING EQUIPMENT	$ -	$ -	$ -	$ -	$ -	0%
21	FIRE SUPPRESSION	$ -	$ -	$ -	$ -	$ -	0%
22	PLUMBING	$ -	$ -	$ -	$ -	$ -	0%
23	HEATING, VENTILATING & AIR COND.	$ -	$ -	$ -	$ -	$ -	0%
26	ELECTRICAL	$ 10,511	$ 3,770	$ -	$ 14,281	**$ 32,020**	93%
27	COMMUNICATIONS	$ -	$ -	$ -	$ -	$ -	0%
28	ELECTRONIC SAFETY & SECURITY	$ -	$ -	$ -	$ -	$ -	0%
31	EARTHWORK	$ -	$ -	$ -	$ -	$ -	0%
32	EXTERIOR IMPROVEMENTS	$ -	$ -	$ -	$ -	$ -	0%
33	UTILITIES	$ -	$ -	$ -	$ -	$ -	0%
34	TRANSPORTATION	$ -	$ -	$ -	$ -	$ -	0%
35	WATERWAY & MARINE CONSTR.	$ -	$ -	$ -	$ -	$ -	0%
41	MATERIAL PROC. & HAND. EQUIP.	$ -	$ -	$ -	$ -	$ -	0%
44	POLLUTION CONTROL EQUIPMENT	$ -	$ -	$ -	$ -	$ -	0%
46	WATER AND WASTEWATER EQUIPMENT	$ -	$ -	$ -	$ -	$ -	0%
48	ELECTRICAL POWER GENERATION	$ -	$ -	$ -	$ -	$ -	0%
	SUBTOTAL DIRECT COSTS	$ 11,126	$ 4,118	$ 1	$ 15,245		100%
	SUBCONTRACTOR MARKUP	$ 2,875	$ 3,533	$ 0	$ 6,408		
	SUBTOTAL	$ 14,001	$ 7,650	$ 1	$ 21,652		
	PRIME CONTRACTOR MARKUP	$ 8,159	$ 4,458	$ 1	$ 12,618		
	BASE BID TOTAL COSTS	**$ 22,161**	**$ 12,108**	**$ 2**	**$ 34,271**	**$ 34,271**	

COST ESTIMATE SUMMARY - BASE BID

PROJECT NAME:	East Liberty Battery Electric Bus Implementation Plan-Scenario 2	CLIENT: Port Authority of Allegheny County	ESTIMATED BY: WRA
PROJECT LOCATION:	Pittsburgh Pennsylvania	DESIGN SUBMISSION: Final Report	WORK ORDER NUMBER: 90259.031

DIVISION NO.	DIVISION TITLE	DIRECT (BARE) COSTS				MARKED UP COST	PERCENTAGE OF TOTAL
		MATERIAL COST	LABOR COST	EQUIPMENT COST	TOTAL DIVISION COST	TOTAL DIVISION COST	
01	GENERAL REQUIREMENTS	$ -	$ -	$ -	$ -	**$ -**	0%
02	EXISTING CONDITIONS	$ -	$ -	$ -	$ -	**$ -**	0%
03	CONCRETE	$ 308	$ 174	$ 0	$ 482	**$ 1,125**	7%
04	MASONRY	$ -	$ -	$ -	$ -	**$ -**	0%
05	METALS	$ -	$ -	$ -	$ -	**$ -**	0%
06	WOOD, PLASTIC AND COMPOSITES	$ -	$ -	$ -	$ -	**$ -**	0%
07	THERMAL AND MOISTURE PROTECTION	$ -	$ -	$ -	$ -	**$ -**	0%
08	OPENINGS	$ -	$ -	$ -	$ -	**$ -**	0%
09	FINISHES	$ -	$ -	$ -	$ -	**$ -**	0%
10	SPECIALTIES	$ -	$ -	$ -	$ -	**$ -**	0%
11	EQUIPMENT	$ -	$ -	$ -	$ -	**$ -**	0%
12	FURNISHINGS	$ -	$ -	$ -	$ -	**$ -**	0%
13	SPECIAL CONSTRUCTION	$ -	$ -	$ -	$ -	**$ -**	0%
14	CONVEYING EQUIPMENT	$ -	$ -	$ -	$ -	**$ -**	0%
21	FIRE SUPPRESSION	$ -	$ -	$ -	$ -	**$ -**	0%
22	PLUMBING	$ -	$ -	$ -	$ -	**$ -**	0%
23	HEATING, VENTILATING & AIR COND.	$ -	$ -	$ -	$ -	**$ -**	0%
26	ELECTRICAL	$ 5,256	$ 1,885	$ -	$ 7,140	**$ 16,010**	93%
27	COMMUNICATIONS	$ -	$ -	$ -	$ -	**$ -**	0%
28	ELECTRONIC SAFETY & SECURITY	$ -	$ -	$ -	$ -	**$ -**	0%
31	EARTHWORK	$ -	$ -	$ -	$ -	**$ -**	0%
32	EXTERIOR IMPROVEMENTS	$ -	$ -	$ -	$ -	**$ -**	0%
33	UTILITIES	$ -	$ -	$ -	$ -	**$ -**	0%
34	TRANSPORTATION	$ -	$ -	$ -	$ -	**$ -**	0%
35	WATERWAY & MARINE CONSTR.	$ -	$ -	$ -	$ -	**$ -**	0%
41	MATERIAL PROC. & HAND. EQUIP.	$ -	$ -	$ -	$ -	**$ -**	0%
44	POLLUTION CONTROL EQUIPMENT	$ -	$ -	$ -	$ -	**$ -**	0%
46	WATER AND WASTEWATER EQUIPMENT	$ -	$ -	$ -	$ -	**$ -**	0%
48	ELECTRICAL POWER GENERATION	$ -	$ -	$ -	$ -	**$ -**	0%
	SUBTOTAL DIRECT COSTS	$ 5,563	$ 2,059	$ 0	$ 7,622		100%
	SUBCONTRACTOR MARKUP	$ 1,438	$ 1,766	$ 0	$ 3,204		
	SUBTOTAL	$ 7,001	$ 3,825	$ 1	$ 10,826		
	PRIME CONTRACTOR MARKUP	$ 4,080	$ 2,229	$ 0	$ 6,309		
	BASE BID TOTAL COSTS	**$ 11,080**	**$ 6,054**	**$ 1**	**$ 17,135**	**$ 17,135**	

COST ESTIMATE SUMMARY - BASE BID

PROJECT NAME:	East Liberty Battery Electric Bus Implementation Plan-Scenario 3	CLIENT: Port Authority of Allegheny County	ESTIMATED BY: WRA
PROJECT LOCATION:	Piittsburgh Pennsylvania	DESIGN SUBMISSION: Final Report	WORK ORDER NUMBER: 90259.031

DIVISION NO	DIVISION TITLE	DIRECT (BARE) COSTS				MARKED UP COST	PERCENTAGE OF TOTAL
		MATERIAL COST	LABOR COST	EQUIPMENT COST	TOTAL DIVISION COST	TOTAL DIVISION COST	
01	GENERAL REQUIREMENTS	$ -	$ -	$ -	$ -	**$ -**	0%
02	EXISTING CONDITIONS	$ -	$ 8,500	$ 1,785	$ 10,285	**$ 28,551**	1%
03	CONCRETE	$ 90,619	$ 41,760	$ 200	$ 132,580	**$ 303,693**	6%
04	MASONRY	$ -	$ -	$ -	$ -	**$ -**	0%
05	METALS	$ 67,678	$ 110,438	$ 15,835	$ 193,951	**$ 491,100**	10%
06	WOOD, PLASTIC AND COMPOSITES	$ -	$ -	$ -	$ -	**$ -**	0%
07	THERMAL AND MOISTURE PROTECTION	$ -	$ -	$ -	$ -	**$ -**	0%
08	OPENINGS	$ -	$ -	$ -	$ -	**$ -**	0%
09	FINISHES	$ -	$ -	$ -	$ -	**$ -**	0%
10	SPECIALTIES	$ -	$ -	$ -	$ -	**$ -**	0%
11	EQUIPMENT	$ -	$ -	$ -	$ -	**$ -**	0%
12	FURNISHINGS	$ -	$ -	$ -	$ -	**$ -**	0%
13	SPECIAL CONSTRUCTION	$ -	$ -	$ -	$ -	**$ -**	0%
14	CONVEYING EQUIPMENT	$ -	$ -	$ -	$ -	**$ -**	0%
21	FIRE SUPPRESSION	$ 5,994	$ 64,402	$ -	$ 70,396	**$ 201,326**	4%
22	PLUMBING	$ -	$ -	$ -	$ -	**$ -**	0%
23	HEATING, VENTILATING & AIR COND.	$ 169,720	$ 77,056	$ -	$ 246,777	**$ 564,639**	12%
26	ELECTRICAL	$ 1,041,289	$ 391,599	$ 4,793	$ 1,437,681	**$ 3,235,104**	67%
27	COMMUNICATIONS	$ -	$ -	$ -	$ -	**$ -**	0%
28	ELECTRONIC SAFETY & SECURITY	$ 1,139	$ 3,941	$ -	$ 5,079	**$ 13,856**	0%
31	EARTHWORK	$ -	$ 3,525	$ 2,991	$ 6,517	**$ 16,324**	0%
32	EXTERIOR IMPROVEMENTS	$ -	$ -	$ -	$ -	**$ -**	0%
33	UTILITIES	$ -	$ -	$ -	$ -	**$ -**	0%
34	TRANSPORTATION	$ -	$ -	$ -	$ -	**$ -**	0%
35	WATERWAY & MARINE CONSTR.	$ -	$ -	$ -	$ -	**$ -**	0%
41	MATERIAL PROC. & HAND. EQUIP.	$ -	$ -	$ -	$ -	**$ -**	0%
44	POLLUTION CONTROL EQUIPMENT	$ -	$ -	$ -	$ -	**$ -**	0%
46	WATER AND WASTEWATER EQUIPMENT	$ -	$ -	$ -	$ -	**$ -**	0%
48	ELECTRICAL POWER GENERATION	$ -	$ -	$ -	$ -	**$ -**	0%
	SUBTOTAL DIRECT COSTS	$ 1,376,440	$ 701,221	$ 25,604	$ 2,103,265		100%
	SUBCONTRACTOR MARKUP	$ 355,672	$ 601,608	$ 6,616	$ 963,896		
	SUBTOTAL	$ 1,732,112	$ 1,302,829	$ 32,221	$ 3,067,161		
	PRIME CONTRACTOR MARKUP	$ 1,009,413	$ 759,242	$ 18,777	$ 1,787,432		
	BASE BID TOTAL COSTS	**$ 2,741,525**	**$ 2,062,071**	**$ 50,998**	**$ 4,854,593**	**$ 4,854,593**	

COST ESTIMATE SUMMARY - BASE BID

PROJECT NAME:	East Liberty Battery Electric Bus Implementation Plan-Scenario 4	CLIENT: Port Authority of Allegheny County	ESTIMATED BY: WRA
PROJECT LOCATION:	Piittsburgh Pennsylvania	DESIGN SUBMISSION: Final Report	WORK ORDER NUMBER: 90259.031

DIVISION NO	DIVISION TITLE	DIRECT (BARE) COSTS MATERIAL COST	LABOR COST	EQUIPMENT COST	TOTAL DIVISION COST	MARKED UP COST TOTAL DIVISION COST	PERCENTAGE OF TOTAL
01	GENERAL REQUIREMENTS	$ -	$ -	$ -	$ -	**$ -**	0%
02	EXISTING CONDITIONS	$ -	$ 8,500	$ 1,785	$ 10,285	**$ 28,551**	0%
03	CONCRETE	$ 107,988	$ 62,245	$ 8,701	$ 178,934	**$ 415,459**	4%
04	MASONRY	$ -	$ -	$ -	$ -	**$ -**	0%
05	METALS	$ 216,419	$ 132,551	$ 27,113	$ 376,083	**$ 874,845**	8%
06	WOOD, PLASTIC AND COMPOSITES	$ -	$ -	$ -	$ -	**$ -**	0%
07	THERMAL AND MOISTURE PROTECTION	$ -	$ -	$ -	$ -	**$ -**	0%
08	OPENINGS	$ -	$ -	$ -	$ -	**$ -**	0%
09	FINISHES	$ -	$ -	$ -	$ -	**$ -**	0%
10	SPECIALTIES	$ -	$ -	$ -	$ -	**$ -**	0%
11	EQUIPMENT	$ -	$ -	$ -	$ -	**$ -**	0%
12	FURNISHINGS	$ -	$ -	$ -	$ -	**$ -**	0%
13	SPECIAL CONSTRUCTION	$ -	$ -	$ -	$ -	**$ -**	0%
14	CONVEYING EQUIPMENT	$ -	$ -	$ -	$ -	**$ -**	0%
21	FIRE SUPPRESSION	$ 5,994	$ 64,402	$ -	$ 70,396	**$ 201,326**	2%
22	PLUMBING	$ -	$ -	$ -	$ -	**$ -**	0%
23	HEATING, VENTILATING & AIR COND.	$ 169,720	$ 77,056	$ -	$ 246,777	**$ 564,639**	5%
26	ELECTRICAL	$ 3,855,796	$ 346,215	$ 41,713	$ 4,243,724	**$ 8,780,977**	79%
27	COMMUNICATIONS	$ -	$ -	$ -	$ -	**$ -**	0%
28	ELECTRONIC SAFETY & SECURITY	$ 1,139	$ 3,941	$ -	$ 5,079	**$ 13,856**	0%
31	EARTHWORK	$ -	$ 57,008	$ 17,940	$ 74,948	**$ 203,376**	2%
32	EXTERIOR IMPROVEMENTS	$ -	$ -	$ -	$ -	**$ -**	0%
33	UTILITIES	$ -	$ -	$ -	$ -	**$ -**	0%
34	TRANSPORTATION	$ -	$ -	$ -	$ -	**$ -**	0%
35	WATERWAY & MARINE CONSTR.	$ -	$ -	$ -	$ -	**$ -**	0%
41	MATERIAL PROC. & HAND. EQUIP.	$ -	$ -	$ -	$ -	**$ -**	0%
44	POLLUTION CONTROL EQUIPMENT	$ -	$ -	$ -	$ -	**$ -**	0%
46	WATER AND WASTEWATER EQUIPMENT	$ -	$ -	$ -	$ -	**$ -**	0%
48	ELECTRICAL POWER GENERATION	$ -	$ -	$ -	$ -	**$ -**	0%
	SUBTOTAL DIRECT COSTS	$ 4,357,056	$ 751,918	$ 97,252	$ 5,206,227		100%
	SUBCONTRACTOR MARKUP	$ 1,125,863	$ 645,103	$ 25,130	$ 1,796,096		
	SUBTOTAL	$ 5,482,920	$ 1,397,021	$ 122,382	$ 7,002,323		
	PRIME CONTRACTOR MARKUP	$ 3,195,251	$ 814,134	$ 71,320	$ 4,080,705		
	BASE BID TOTAL COSTS	**$ 8,678,170**	**$ 2,211,156**	**$ 193,702**	**$ 11,083,028**	**$ 11,083,028**	