



ZERO EMISSION BUS PROJECT UPDATE

METROPOLITAN AREA PLANNING (MAP) FORUM
2020 SPRING MEETING

JUNE 19, 2020

FLEET CONSIDERATIONS



12 Years of Service

Continuous Operation

20% Spare Ratio

Service at Night

16 Hours of Service Daily

Buy America Requirements

Altoona Tested

PROJECT PARTNERSHIPS



PROTERRA

Manufacturer

- Greenville, South Carolina
- Los Angeles, California
- 400+ Buses Deployed
- 120 Properties
- 43 States/Provinces



CTDOT/CTTRANSIT

Technical /Funding

- Specification Development
- Facility Improvement Guidance
- Rate and Route Modeling/Review
- Match Funding – Vehicles
- Match Funding – Charging and Infrastructure



WENDEL

Architect / Engineer

- Rate Analysis
- Switchgear Design/CMS
- Charging Infrastructure Design
- Fire Suppression
- Construction Management Services



CTE

Technical Support/Non Profit

- Project Management
- Route Modeling
- Rate Modeling
- Specification Development
- Post Deployment

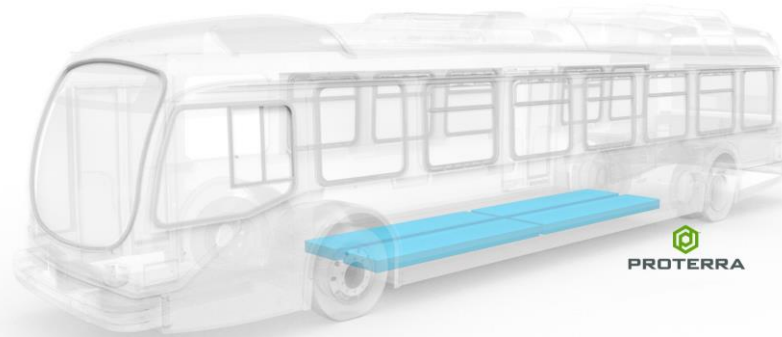
TWO ROUTE MODELING ITERATIONS – ENERGY, RANGE AND ENDURANCE



ITERATION 1

- Four Configurations
- Routes Selected By Type
- Not Selected By Block
- Vehicle Did Not Have Range for Selected Blocks

- Predict Energy Use by Route
- Predict Range by Route (Distance)
- Predict Endurance by Route (Time)
- Predict Impact of Diesel Fired Heat on Range/Endurance



ITERATION 2

- Proterra 40' E2 ProDrive 440 kWh
- Routes Re-Selected by Blocking
- Not Comparable to Diesel (Range)
- Sufficient Number of Blocks for Deployment
- Next Generation – Improved Range
- **Project Splits Into Two Phases**

ROUTE MODELING (RESULTS – NEW BATTERY)

Block	Route(s)	Distance (mi)	Duration (h:mm)	Electric Heat ⚡		Auxiliary Heat 🔌	
				Nominal	Strenuous	Nominal	Strenuous
115	10	53*	4:57	✓	✓	✓	✓
119	10	59*	5:45	✓	✓	✓	✓
129	10	173*	16:59	✗	✗	✓	✗
131	10	164*	16:11	✗	✗	✓	✗
153	10	50*	4:43	✓	✓	✓	✓
155	10	45*	4:04	✓	✓	✓	✓
109	13	47*	4:08	✓	✓	✓**	✓**
121	13	144*	13:09	✓	✗	✓**	✗**
147	13	90*	8:09	✓	✓	✓**	✓**
135	4, 19x	60.5	3:26	✓	✓	✓	✓
145	19x	73.9	3:25	✓	✓	✓	✓

* Distance approximated based on collected data

** Values reported for 40'. Diesel heat not available on the 35' bus planned for Route 13

BUS SPECIFICATION DEVELOPMENT



PROTERRA CATALYST E2

- 40' 40+14 Passengers
- 440 kW Battery Pack
- Depot Charging
- Specification Based on A Number of Specifications



CONCERNS

- Weight
- Rider Capacity
- Composite Body
- Variations From Typical Bus
- Negotiating Specifications

SELECT SPECIFICATION ELEMENTS

- Catalyst E2 ProDrive 440kW
- Two Charge Ports
- Depot Charging, No On-Street Charging
- 40 Seated, No Less Than 14 Standing
- Trapeze AVL Communication System W/APCs
- Seon Camera System
- ProTran Pedestrian Protection System
- Driver Barrier
- USB Ports At Seats

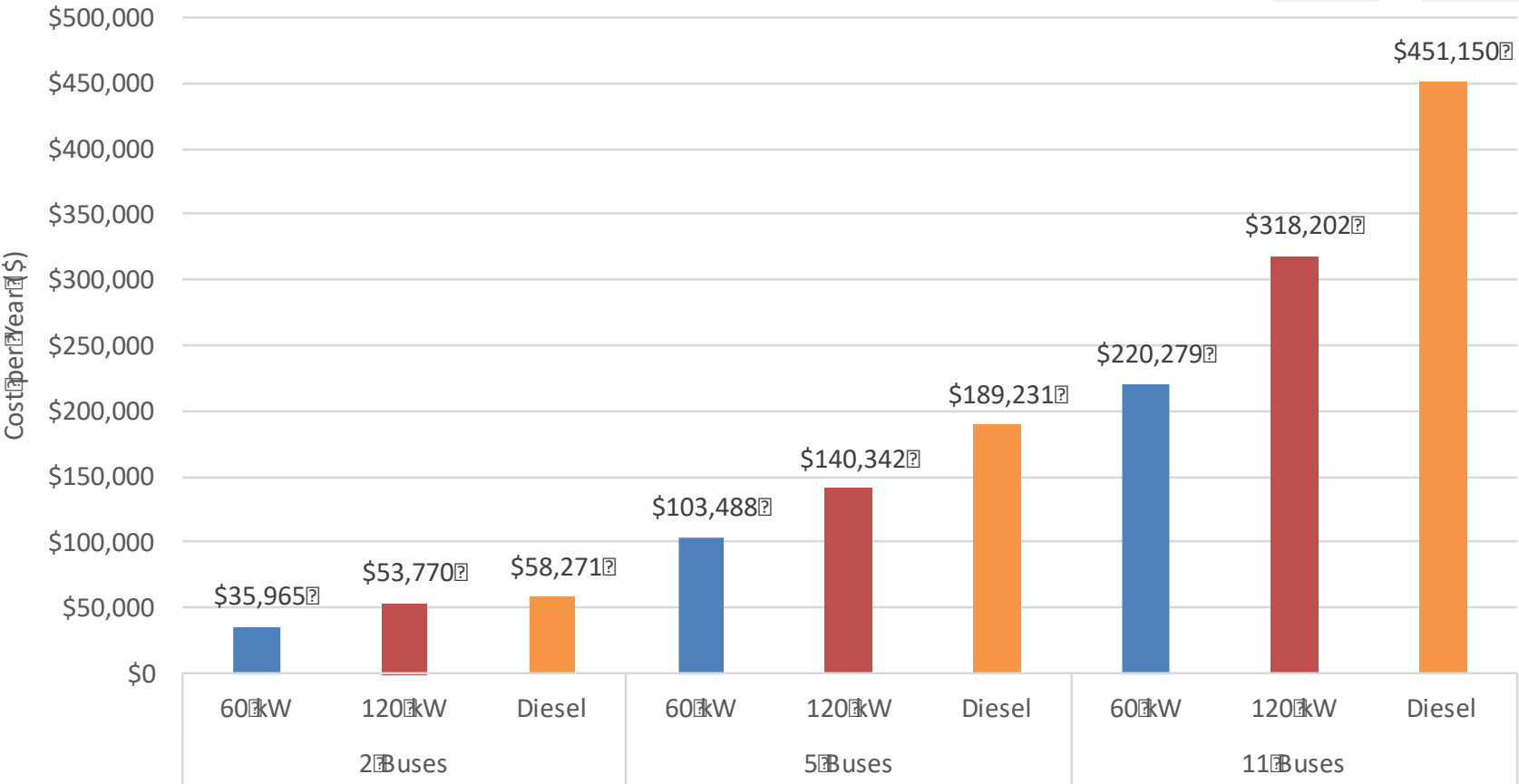


RATE MODELING AND BUS CHARGING STRATEGY

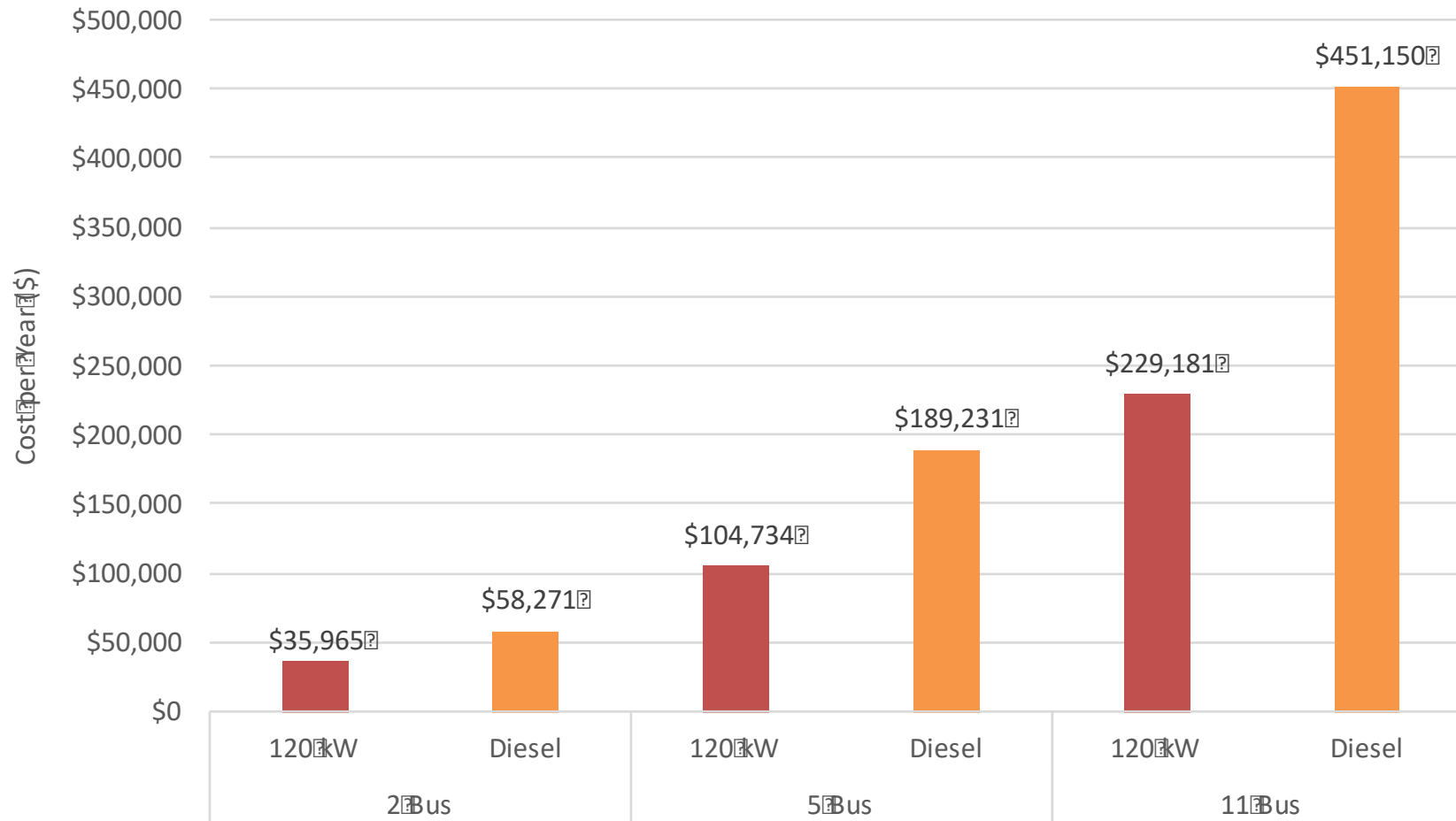
- Assumptions
 - 440 kWh pack for first two buses (service energy of 327 kWh)
 - 660 kWh pack for additional buses (service energy of 510 kWh)
 - Nominal efficiency (2.2 kWh/mi)
 - 60 kW and 125kW standard charger options
 - Diesel fuel economy from route data: 4 mpg
 - Five year diesel cost average: \$2.72
- Off-peak and shoulder charging vs. on-peak charging
- Simultaneous charging vs. staggered charging (125 kW charger)



ANNUAL COSTS (SIMULTANEOUS CHARGE)

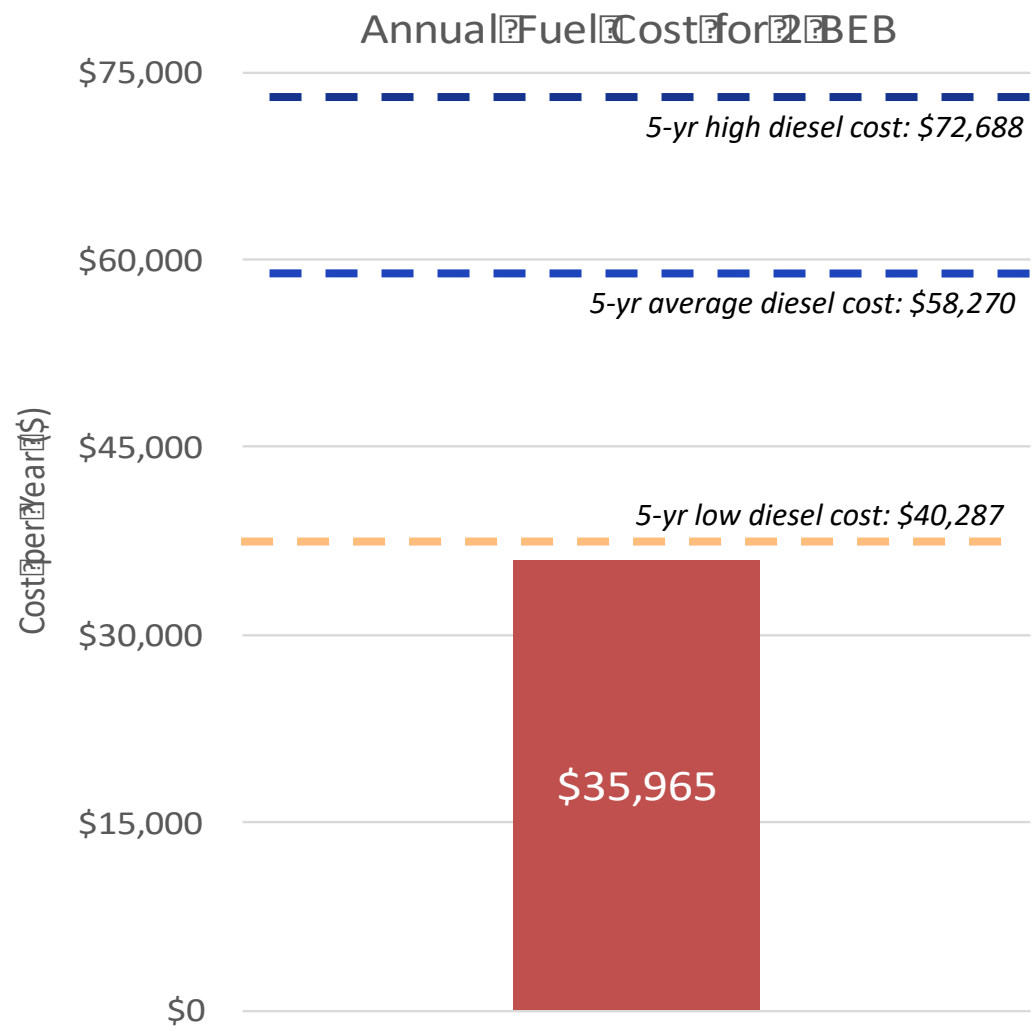


ANNUAL COSTS (STAGGERED CHARGE)



- 2 bus case: 1 bus charges, another bus charges
- 5 bus case: 3 buses charge, then 2 buses charge
- 11 bus case: 6 buses charge, then 5 buses charge

INITIAL DEPLOYMENT – PHASE 1



- Add two 440 kWh buses to service
- Assume 125 kW charger with staggered charging
- Assume off-peak or shoulder charging
- Average annual diesel cost is estimated at \$58,270

MAINTENANCE FACILITY

- Replacement Switchgear
- Installation of Charging Infrastructure
- Proterra 125 kW Chargers
- Capacity for 11 Buses
- Phase 1 – Two Chargers Installed
- Phase 2 – Three Additional
- Phase 3 – Six Additional



IMPACT

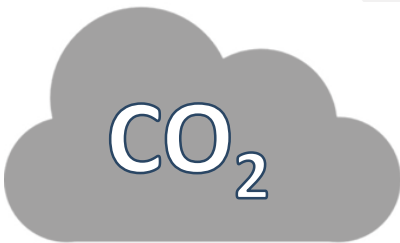
Estimated Annual Reduction in Diesel Fuel and Tailpipe Emissions:



Phase	Fleet Size	Annual Mileage	Diesel Gallons Reduced	GHG Tailpipe Emissions Reduced [lbs.]
1	2	85,264	24,361	559,182
2	5	276,889	79,111	1,815,906
3	11	660,139	188,611	4,329,351

IMPACT

What About the Power Plant?



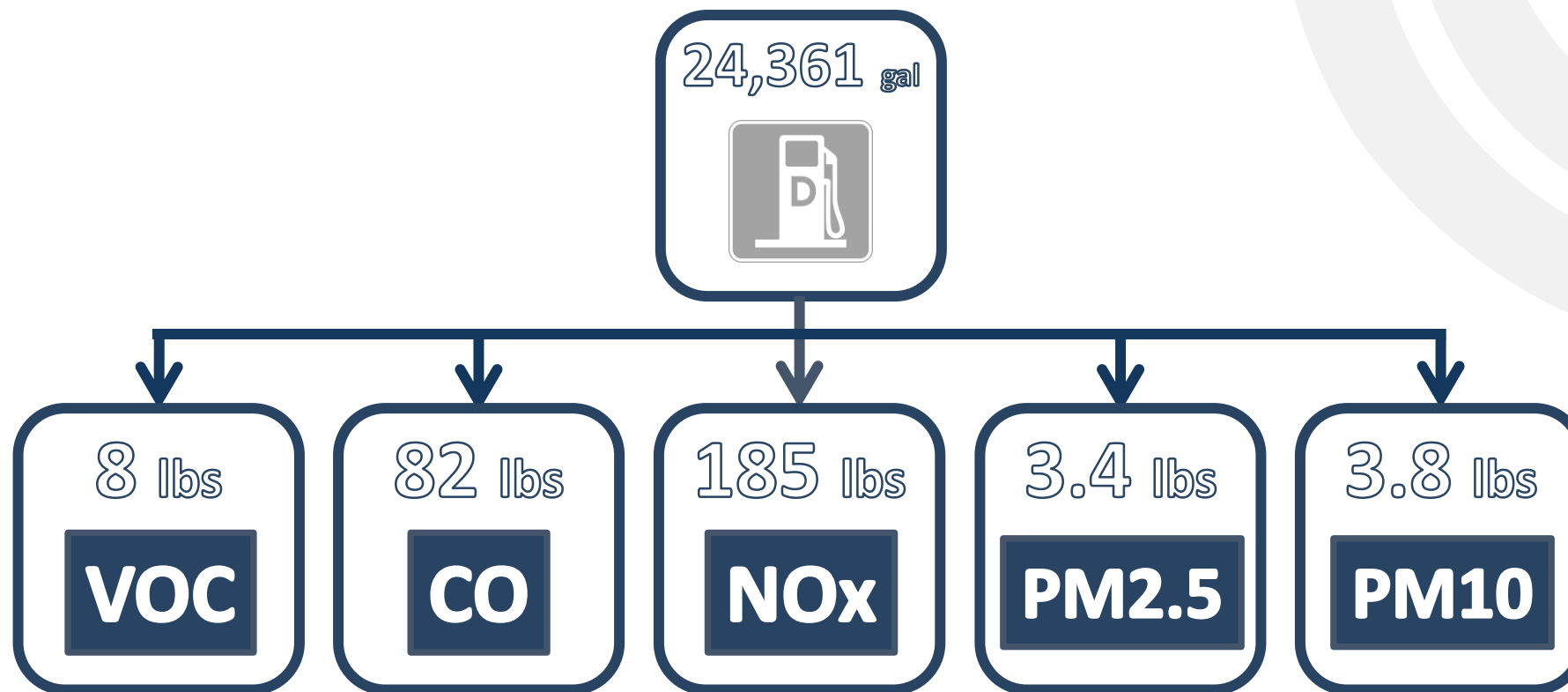
Phase	Fleet Size	Tailpipe Emissions Reduction [lbs. CO ₂]	Powerplant Emissions from Generation [lbs. CO ₂]	Net Emissions Reduction [lbs. CO ₂]
1	2	545,203	103,690	455,492
2	5	1,770,509	336,727	1,479,179
3	11	4,221,117	802,801	3,526,551

	Natural Gas	Nuclear**	Petroleum	Coal	Other
% of Total CT Power Generation	53.3%	42.3%	0.3%	0.2%	4.0%
% of Total CT Powerplant Emissions*	96.6%	0.0%	1.4%	1.1%	0.9%

*Based on EIA's 2016 Connecticut electric power industry emissions estimate by fuel source.

**Does not account for emissions during the mining/refining process.

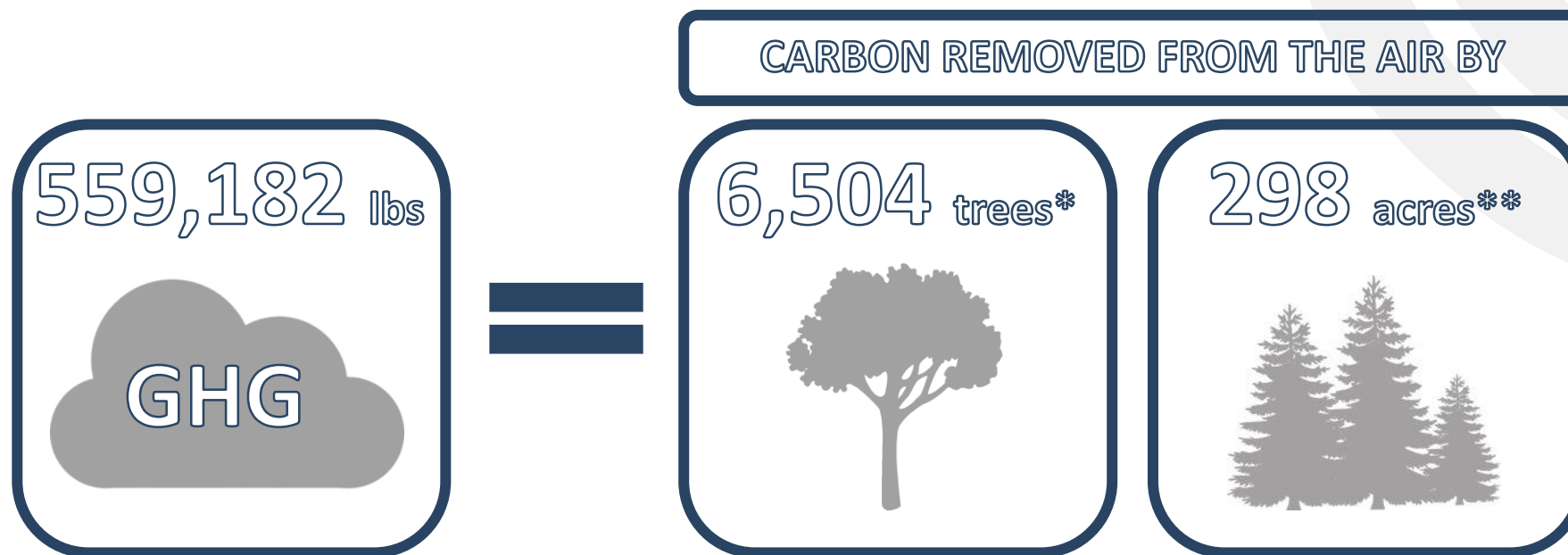
ADDITIONAL PHASE 1 IMPACTS



Notes/Assumptions

- Represents Phase 1 deployment (2 buses)

EMISSION REDUCTIONS IN PERSPECTIVE



Notes/Assumptions

- Represents Phase 1 deployment (2 buses)
- *Seedlings planted and grown for 10 years
- **Acres of US forests in 1 year

WORKFORCE DEVELOPMENT

- Operator Training – Depot Charge Buses, Four Hour Classes
- Maintenance Training – Sixteen Hours
- Charger Maintenance Training – Sixteen Hours
- Structural Composite Repair – Three Day Class
- Vendor Specific Training – TBD
- Post Deployment Training/Technical Support
- Working in High Voltage Environment
- Transitioning Maintenance Division



STATUS – ALMOST THERE!

- Switchgear Replaced
- Modeling Complete (Route and Rate)
- Specifications Complete
- Charging Infrastructure Designed/Installed
- Bus Production – Complete
- Final Inspection Underway
- Shipping





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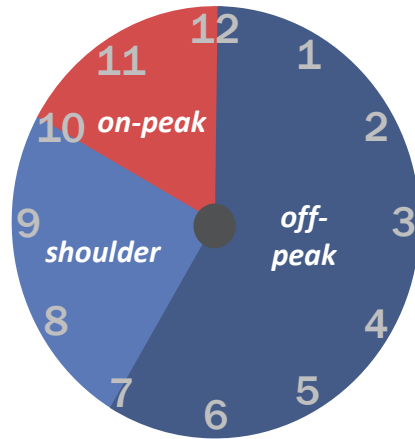
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CHARGING WINDOWS AND STRATEGY

**Midnight –
Noon**

Weekdays



Weekends



**Noon –
Midnight**

