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

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

- Predict Energy Use by Route
- Predict Range by Route (Distance)
- Predict Endurance by Route (Time)
- Predict Impact of Diesel Fired Heat on Range/Endurance
## ROUTE MODELING  
**RESULTS – NEW BATTERY**

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

* 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)

<table>
<thead>
<tr>
<th>Cost per Year ($)</th>
<th>60 kW</th>
<th>120 kW</th>
<th>Diesel</th>
<th>60 kW</th>
<th>120 kW</th>
<th>Diesel</th>
<th>60 kW</th>
<th>120 kW</th>
<th>Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Buses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 Buses</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## ANNUAL COSTS (STAGGERED CHARGE)

<table>
<thead>
<tr>
<th>Bus Case</th>
<th>120 kW</th>
<th>120 kW</th>
<th>120 kW</th>
<th>120 kW</th>
<th>120 kW</th>
<th>120 kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>diesel</td>
<td>$35,965</td>
<td>$58,271</td>
<td>$104,734</td>
<td>$189,231</td>
<td>$229,181</td>
<td>$451,150</td>
</tr>
</tbody>
</table>

- **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:

<table>
<thead>
<tr>
<th>Phase</th>
<th>Fleet Size</th>
<th>Annual Mileage</th>
<th>Diesel Gallons Reduced</th>
<th>GHG Tailpipe Emissions Reduced [lbs.]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>85,264</td>
<td>24,361</td>
<td>559,182</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>276,889</td>
<td>79,111</td>
<td>1,815,906</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>660,139</td>
<td>188,611</td>
<td>4,329,351</td>
</tr>
</tbody>
</table>
**IMPACT**

What About the Power Plant?

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>545,203</td>
<td>103,690</td>
<td>455,492</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>1,770,509</td>
<td>336,727</td>
<td>1,479,179</td>
</tr>
<tr>
<td>3</td>
<td>11</td>
<td>4,221,117</td>
<td>802,801</td>
<td>3,526,551</td>
</tr>
</tbody>
</table>

*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
ZERO EMISSION BUS PROJECT UPDATE

METROPOLITAN AREA PLANNING (MAP) FORUM
2020 SPRING MEETING

JUNE 19, 2020
CHARGING WINDOWS AND STRATEGY

**Weekdays**

- **Midnight – Noon**
  - 9:00 – 2:00: Off-peak
  - 8:00 – 9:00: Shoulder

- **Noon – Midnight**
  - 9:00 – 2:00: Off-peak
  - 8:00 – 9:00: Shoulder

**Weekends**

- 9:00 – 2:00: Off-peak
- 8:00 – 9:00: Shoulder

Legend:
- **On-peak**
- **Shoulder**
- **Off-peak**