Going Green
Electrification of the 16th St. Mall Shuttles

Summary

- 16th Street Mall Operation
- What was Replaced
- New RTD Electric Mall Shuttle Buses
- RTD Electric Bus Charging Operation
- Things to Consider
- Environmental Benefits

16th Street Mall Operations

- "Free" Shuttle service known as "Free Mall Ride"
- 1.4 miles long along 16th Street between Union Station and Civic Center Station
- Opened in 1982 from Broadway (Civic Center Station) to Market Street (Market Street Station)
- Designed by Pei Cobb Freed & Partners, with renowned architect I.M. Pei as design partner.

16th Street Mall Operations

- Bus stops at every intersection
- Runs 4:59 a.m. to 1:21 a.m. weekdays - slightly shorter on weekends and Holidays
- Shuttles run 90 sec headways during 2 peak times
- Average weekday ridership: 43,971/Day

16th Street Mall Operations

What was Replaced

What was Replaced

- Manufactured by Transteq in 2000
- 18 Seats
- Length: 45’
- Completely Low Floor
- One Wheelchair Securement area
- Right Hand Drive
- Three Passenger Doors and a Driver’s Door
- Two Drive Modes: On-Mall and Off-Mall
- CNG Generator Powering Electric Drive Motors

New RTD Electric Mall Shuttle Buses

- Manufactured by BYD in Lancaster, CA
- Length: 45’
- Curb Weight: about 30,000lbs
- Completely Low Floor
- Right Hand Drive
- Three Passenger Doors and a Driver’s Door
- Two Drive Modes: On-Mall and Off-Mall

RTD Electric Mall Shuttle Buses

- Zero Tailpipe Emissions – No Fuel-Fired Heater
- ADA Features:
  - Two Wheelchair Securement Areas
  - Manual Ramp
  - Kneeling

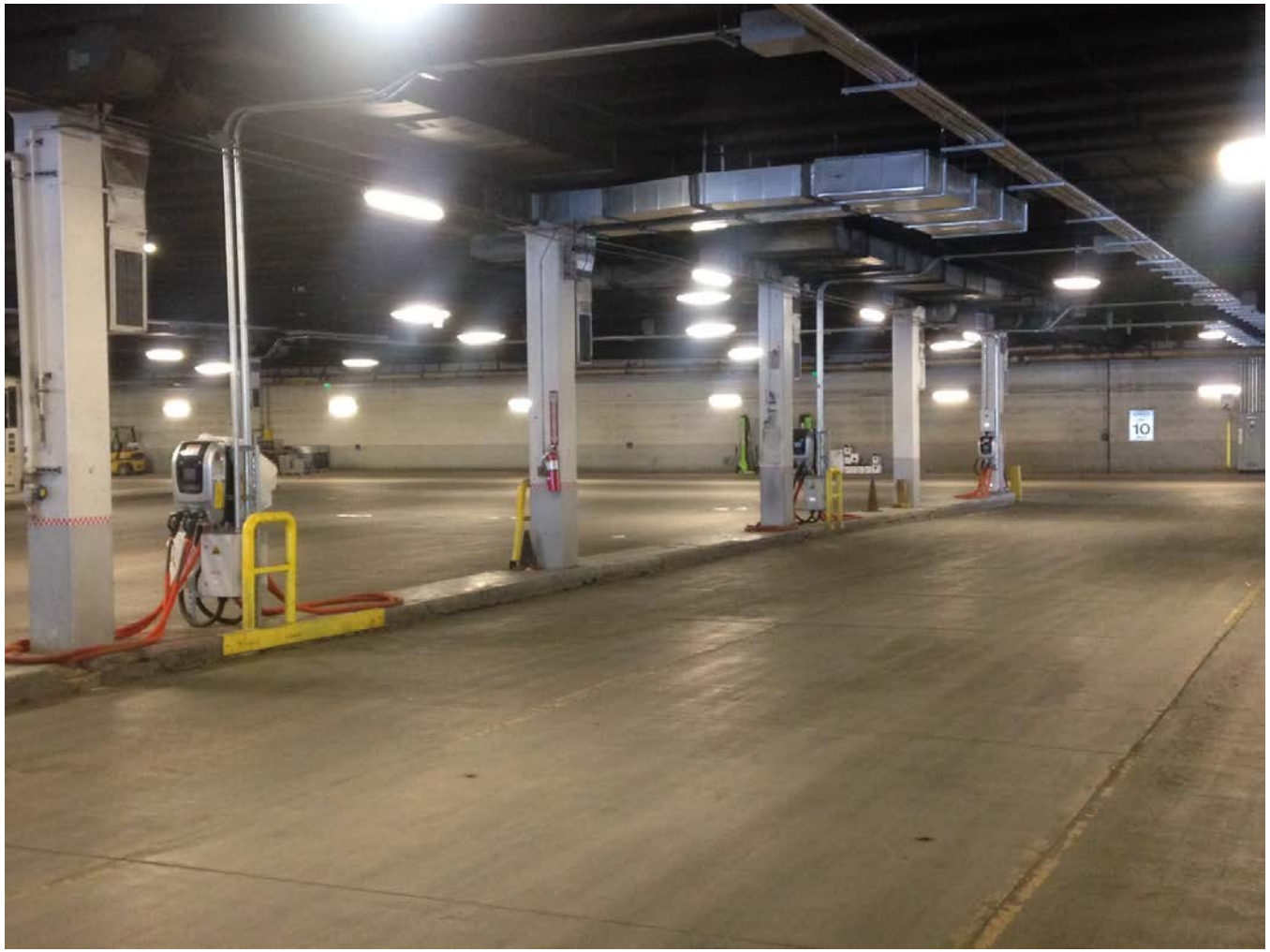
- Capacity without Wheelchairs: 107 (18 seated + 88 Standees + Driver)

RTD Electric Mall Shuttle Buses

- Battery Type: Lithium Iron Phosphate
- Battery Capacity: 292 kWh
- Battery Packs: 2 Each 540 VDC in Parallel
- No external heating or cooling of the batteries is required

RTD Electric Bus Charging Operation

- 30 Chargers – 10 on each island
- Charging Power: 100kWh, 480 VAC
- Charging Time from 20% to 100%: approximately 3.5 hours
- Separate transformer/metered service
- Equipment Field Certified by TuV and accepted by city inspector




WARNING

RTD Electric Bus Charging Operation

- Buses equipped with I/O Controls Health Alert Monitoring System
  - Reports Battery SOC and other data every three minutes via cellular network
- Buses are assigned to charging positions and run blocks based on their SOC
- Buses are plugged in and unplugged by Service and Cleaning personnel.
- Charging conditions are monitored remotely via the internet.

Things to Consider

- Usage – What is the Duty Cycle?
  - How much heating and cooling is required?
  - Hills?
  - Driver Behavior – Acceleration and Regeneration curves are programmable.
- Cost and Availability of Electricity
- Battery Capacity and Type of Charging
  - Tradeoff between battery capacity and on-route charging
  - Conductive
    - Fast, on route or in depot, moving parts -> maintenance
  - Inductive
    - Slower but no moving parts

Things to Consider

- Visually Impaired Pedestrians
  - We installed noise generators
- Maintenance
  - No perfect bus – How is the support from the OEM?
  - How long is the battery warranty? What are the parameters defining end of life?
  - Technician skill set somewhat different from diesel buses.

Things to Consider

- How electric buses impact service scheduling
- Vehicle blocks had to be reduced from 20hrs to 8hrs due to the unknown duty cycle of the new batteries, resulting in:
  - More buses to cover the same level of service
  - Additional relief drivers to cover the added vehicle blocks
  - Recharging cycle needed to be monitored

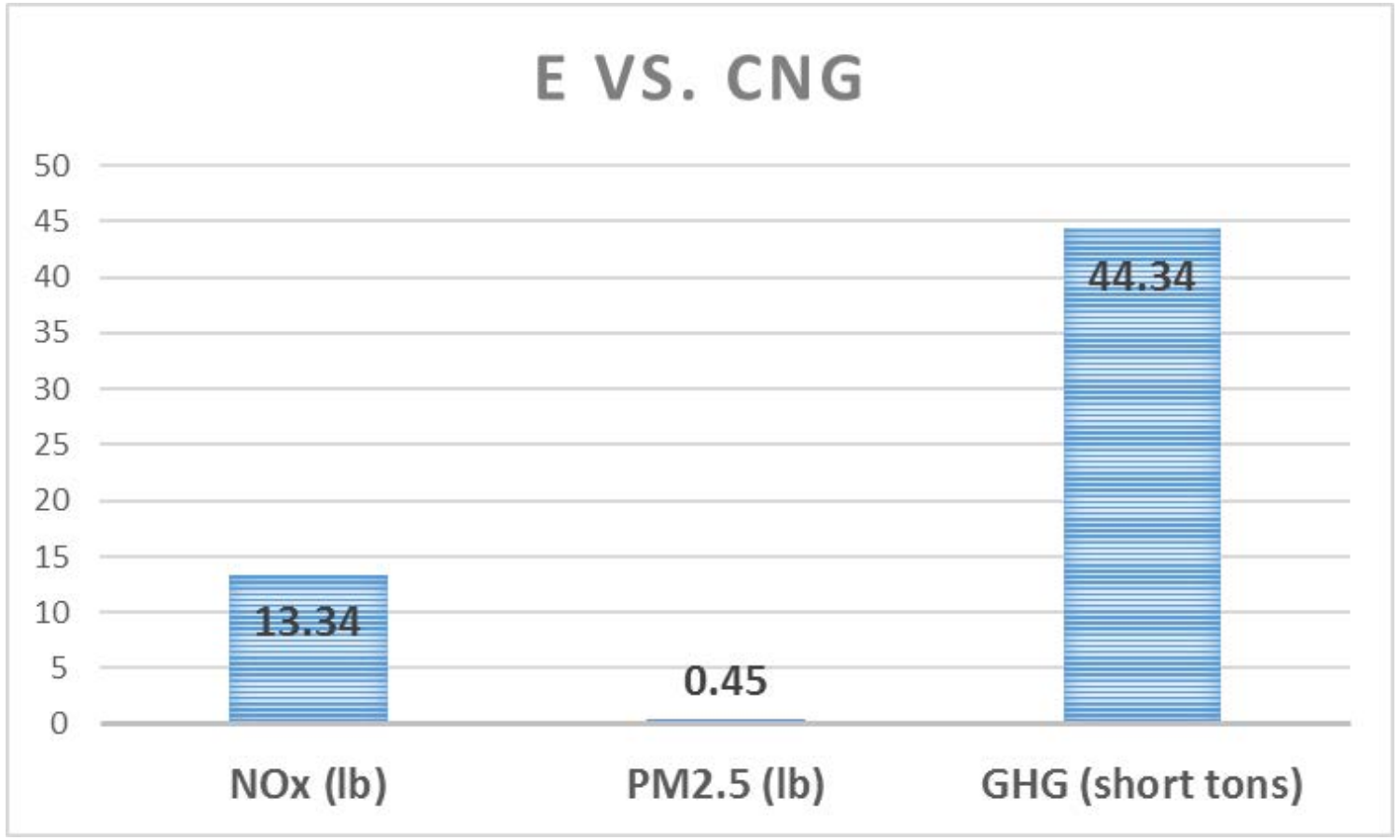
Environmental Benefits

- Annual Emissions Reduction per Bus*
  - Assumptions:
    - Western US Energy Production (WECC)
    - CNG MPDGE: 2.46
    - Electric MPDGE: 16.1
    - Annual Mileage: 12,700

- * Using the Heavy Duty Emissions Calculator from Argonne National Lab

Environmental Benefits

- Annual Emissions Reduction per Bus



Average Costs Apr 17 – Mar 18

- Maintenance Cost/Mile - $0.34
- Power Consumption (kWh) – 1,064,185
  - kWh Consumption Cost - $34,650
  - Demand Cost - $193,760 (76.1% of total electricity cost)
  - Total Power Cost - $254,643
- Operation Cost/Mile - $1.09

Questions ???