Alternative Fuel Buses / Carbon Neutrality

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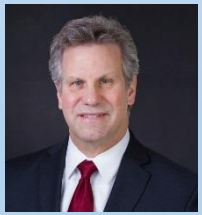

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Baseline Considerations

Energy planning
- Electricity is more efficient but installation costs are expensive

Charging protocol – on-route charging vs. depot charging

Level of sustainability

Maintenance facility retrofits
- Capital costs
- BEB test fleets

New maintenance facility construction
- Capital costs

Title VI considerations

Ways to Avoid Range Anxiety

Maximum distance travelled

- Battery technology
- Reduce deadheading

Evaluate energy consumption through modeling

Reduce deadheading

Recharge in outlying areas of service area

- Layover locations
- Operator driving habits affect SOC

Integrate SOC charge monitoring system at depot

Geographic location impact

- Emphasis on heat or air conditioning and hills

Energy density – 5% per year increase

Energy Use Planning

Engage your local electrical utility early to understand rate structures and charger reimbursement programs

- Demand charges
- Time of use charges
- Peak demand
- Rates by time of day
- Rebates/Funding for generating on-site power
- Emergency backup power

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

You are switching from ULSDF or CNG to electricity but you cannot conduct a bid for fuel supply; your local utility controls your fuel cost now

- Public Utilities Commission

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Energy Planning

Industry recognizes that the BEB technology horizon is now and are aligning themselves to provide turnkey solutions

- Power generation
- Inversion
- Mass energy storage
- Energy dispensing
- Vehicles
- Maintenance

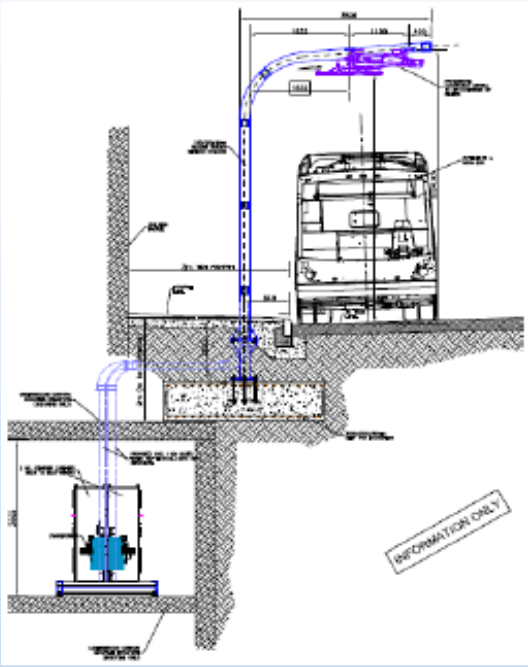
Energy Planning

Investigate innovations such as the use of sea container energy storage system which includes:

- Battery bank
- Fire suppression
- HVAC
- Inverters and electrical power in and out

Recharges during time of day when utility rates are lowest

Bus Charging Protocol



On-route charging

- Insufficient energy storage to operate bus throughout service day, have to recharge repeatedly
- Fast charge SAE J3105 overhead pantograph or
- SAE J2954 inductive wireless charging

Depot charging

- Sufficient onboard energy to operate bus through entire service day
- Buses will be charged upon returning to overnight parking facility

Buses are built to a specific protocol. It would be both expensive and very difficult to switch from one to another, if you learn the selected protocol is not working

- Different battery technologies

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Bus Charging Protocol

- Level of sustainability
  - Solar power supply – 100% sustainable
  - 6 acres = 1 Megawatt of energy production
  - 40’ sea container with batteries = 5 Megawatts
  - Use of batteries for energy storage, off utility grid
  - Transfer captured energy from battery bank to buses at night
  - Resale of excess energy to utility
- Reliance on utility for power
  - Does infrastructure support proposed charging demand?
- How do you backup utility during a power outage?
  - Generators/Batteries/Site constraints

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Battery Charging Technologies

Floor mounted SAE J1772 plug-in charging

- Capital cost
- Occupies space on bus storage floor
- Keeps high voltage at personnel level
- Obstructs bus storage facility
- Harder to implement with existing bus operations
- Be sure to specify charging plugs at both ends of the BEBs

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Battery Charging Technologies

Pantograph SAE J3105 roof charging

- Capital cost
- Removes charging equipment from floor or bus storage area
- Easier to implement with existing operations
- More cost effective for new facility design

Maintenance Facility Retrofits

Survey of existing electrical infrastructure at facility

Dedicated space requirements for transformers and switchgear

Decision on plug vs. pantograph

- Overhead space for pantograph
- Floor space for plug-in chargers and cables

Bus storage area

- Maintain existing bus storage
- Circulation patterns will change
- Existing fueling infrastructure needs to be maintained for non-BEB fleet

Bus Storage Area Impacts

Dedicated assignment for BEB subfleet parking

- For test fleet and/or phased conversion over time

Congestion throughout storage area with floor mounted chargers

Potential reduction in bus storage capability

- Sawtooth or charger access oriented parking consumes floor space
- Track parking (nose to tail) maximizes parking

Floor chargers require significant concrete trenching for power conduits & charger installations or electric power can be run through overhead conduits

Pantograph requires power conduits in facility roof

- More accurate bus parking for pantograph alignment and you
- must have sufficient overhead space

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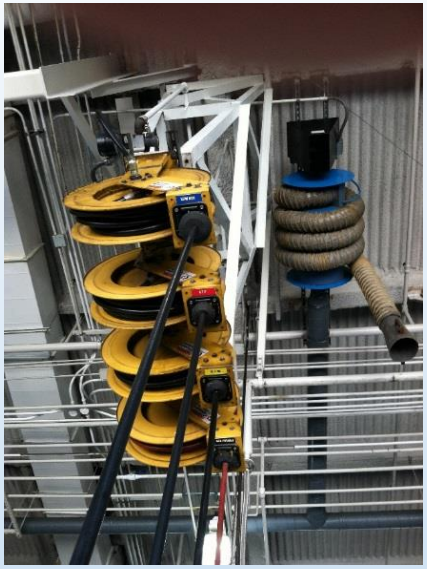
BEB Impact on Maintenance Facility



No engine oil changes, transmission fluid changes, charging air coolers

May still have rear axle gear oil changes

Reduction in overhead hose reels

Bus ECM update capability at maintenance bay

No filters to crush/dispose

No more waste engine disposal

Eliminate diesel fume extraction system

Potential reduction of ventilation requirements

Can add charging equipment in ceiling of maintenance bays for battery charging

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BEB Impact on Maintenance Facility

PM inspection changes

- Increase in bus PM mileage interval
- Decrease in brake inspections/work

Reduction in subcomponent rebuild space

Reduction in parts room space (full BEB fleet)

Future elimination of the fuel tank farm and monitoring system

Future elimination of bulk engine oil storage and distribution/dispensing plumbing systems

Cleaner shop and service lanes

Cleaner environment – no airborne exhaust

Equipment required to facilitate battery R&R

BEB Impact on Workforce

Integration

Operator training

- Safety
- Maximize regen opportunities
- Stay off accelerator

Mechanics training

- Safety
- Diagnostics

Facility manager and staff training

- Safety
- For test fleet

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Maintenance Facility Construction Costs

Reduction in space demands for systems and equipment

- By reducing the bus/bay ratio,
  you can reduce the number of maintenance bays required
- Makes most expensive part of facility less expensive

Cost of bus storage areas will escalate with addition of charging equipment

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Maintenance Facility Construction Costs

Available space for solar farm installation on roof of building

- Roof may need to be strengthened to support PV panels
- Canopies used in parking areas for PV can reduce impact of heat and snow on vehicles
- PV panels must be cleared of snow to remain effective

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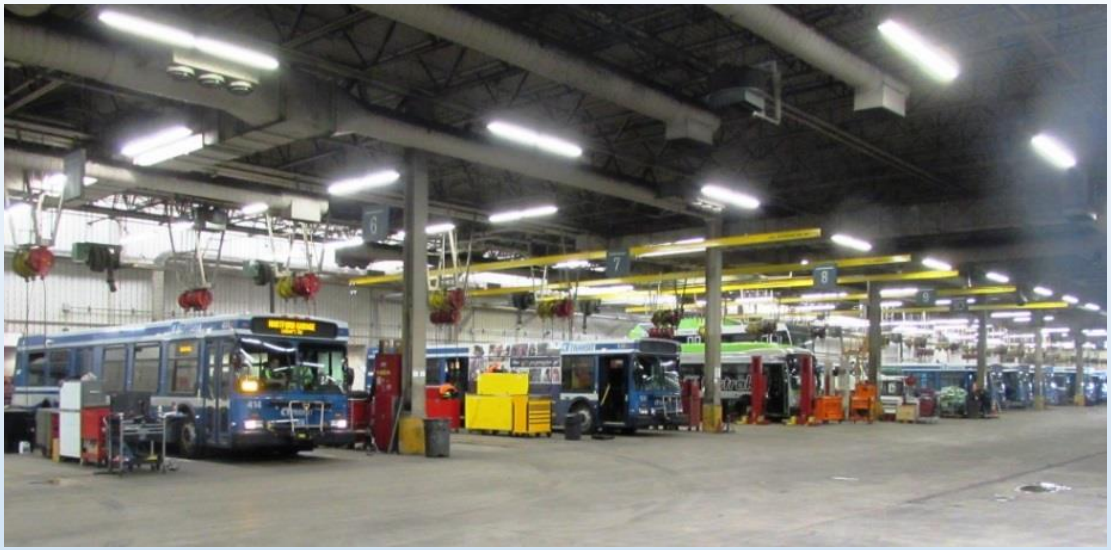
The Future is Bright



Changes in buses/bay – full BEB fleet

Current design parameters

- 8-12 buses per bay for larger operations
- 11-14 buses per bay for smaller fleet sizes
- BEB fleet estimate as many as 18 buses per maintenance bay

One bay savings could be $500,000

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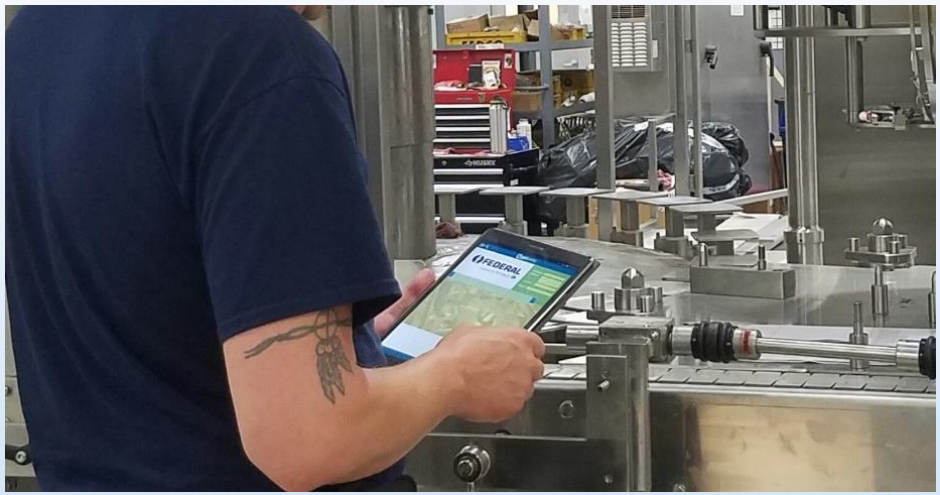
The Future is Bright

Environmental studies and clearance for new facility are simplified

- Quieter operations have less impact on neighboring areas
- No exhaust pipe emissions
- No fuel truck traffic
- Loudest component on the bus would be back-up alarm

The Future is Bright



Streamline servicing operations

- With proximity or swipe card-style fare collection you can eliminate first position of bus servicing lane as there are no fluids to check or fareboxes to empty
- Since refueling now occurs in bus storage, may want to rethink how you check bulbs, service windshield washer fluid, and tire checks
- Service lane is now just a wash rack
- We envision a service person walking through bus storage/charging area with an iPad recording low tire pressures and bad exterior lights for further maintenance action before next day's revenue service

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Thank You
Questions & Answers