POWERING THE FUTURE:
ELECTRIFYING & EXPANDING THE MBTA BUS NETWORK

WEDNESDAY, AUGUST 7TH, 2019

@ABetterCity #BEBBoston
EXECUTIVE VICE PRESIDENT, A BETTER CITY

KATE DINEEN

EXECUTIVE VICE PRESIDENT, A BETTER CITY

@ABetterCity BEBBoston
CAMRON GORGUINPOUR, PhD
Global Senior Manager, Electric Vehicles
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PRESENTATIONS

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WILLIAM WOLFGANG
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Conservation & Development Program Manager
Sierra Club, Massachusetts Chapter
MARC DeSHAMP
Project Manager, Transit and Rail, Bus Practice Lead
Jacobs
WORLD RESOURCES INSTITUTE: E-BUS BARRIERS & ENABLERS

Presented by:
Camron Gorguinpour, PhD
Senior Global Manager for Electric Mobility
OBJECTIVE: ACCELERATE THE TRANSITION TO ELECTRIC BUSES

- Still many barriers
- Growth concentrated in the global north
LEADING TO THE DEVELOPMENT OF A FRAMEWORK

- **Electric buses**
  - **0-1 Breakthrough**
  - **1-10 Test and pilot**
  - **10-100 Mass adoption, multiple routes**
  - **100-100% Fully electrify**
  - **Mature**

- **Countries and Regions**
  - Mexico
  - Brazil
  - India
  - Africa
  - Germany, South Korea
  - US
  - UK, France, Sweden, etc.
  - China
  - Shenzhen

**Countries and Regions**

- **Mexico**
- **Brazil**
- **India**
- **Africa**
- **Germany, South Korea**
- **US**
- **UK, France, Sweden, etc.**
- **China**
- **Shenzhen**
Despite global progress, electric bus adoption outside of China will be marginal in 2025.

**Estimated total # of e-buses in 2025:**

- **India**
  - 13,000
- **Latin America**
  - 16,000
- **China**
  - 1,200,000
WRI E-BUS PORTFOLIO

Tools
• E-bus cost-benefit calculator
• E-mobility infrastructure cost calculator
• E-mobility infrastructure analytic model
• (Coming Soon) E-bus operational data portal
• (Coming Soon) E-bus technical specification database

Technical Assistance Projects (Sample)
• Beijing
• Bogota
• Delhi
• Medellin
• Sao Paulo
• Santiago

Stay tuned for more

Recent Reports

WRI E-BUS REPORTS CONSIDERED 16 CASE STUDIES

Criteria:
- Stage of development
- Expert input
- City request
- “Interesting” features
CASE STUDY CITIES DISTRIBUTED ACROSS ADOPTION CURVE
CONSISTENT CASE STUDY METHODOLOGY

Interviews with local stakeholders through an in-depth questionnaire

INSTITUTIONAL
- Cost and finance

GOVERNANCE
- Social
- Environmental

TECHNOLOGY

OPERATIONS

Standardised case-study template
Pervasive Barriers to E-Bus Adoption

Common Challenges Across Regions

- Lack of knowledge
- Technical limitations
- Procurement Practices
- Non-Scalable Financing
- Institutional Limitations
- Pilot Paralysis

**Most common oversight:** Charging Infrastructure & Associated Real Estate
PLAN FOR MASS E-BUS ADOPTION

Consider the policy landscape

Perform an initial analysis

Launch a structured pilot project

Conduct a cost-benefit analysis

Set actionable and detailed targets
ACHIEVE MASS E-BUS ADOPTION

- Formalize and implement long-term infrastructure plan
- Create and execute e-bus procurement plan
- Provide training
- Plan for end of use
QUESTIONS?

Contact: Camron.Gorguinpour@wri.org
ERIK STOOTHOFF, PE. & WILLIAM WOLFGANG

OVERVIEW OF MBTA BUS ELECTRIFICATION & BUS MODERNIZATION PROGRAM: PILOT PROJECTS & PLANNING EFFORTS

@MBTA #BEBBoston
BUS FACILITIES MODERNIZATION PROGRAM

Erik J. Stoothoff, MBTA Chief Engineer

August 7, 2019
OVERVIEW OF FACILITY PROGRAM

1. The MBTA has a deferred investment need to address the condition and capacity of the bus maintenance facility network

2. We have a need to act with urgency to:
   • MEET THE FUNCTIONAL NEED OF OUR CURRENT BUS NETWORK
   • ADDRESS THE WORKING CONDITIONS WITHIN OUR GARAGE INFRASTRUCTURE
   • EXPAND OUR INFRASTRUCTURE TO FACILITATE NETWORK-WIDE MODERNIZATION AND REDESIGN

3. We need to prepare our infrastructure for future fleet electrification and other modern technologies

4. Each facility needs investment

5. Near term action is necessary while the entire strategy is developed

6. Multiple projects will be executed concurrently and include the committed $25M annual investment in our bus maintenance facilities
BUS FACILITY POLICY AND PRINCIPLES

- Prioritize safety and health
- Increase fleet reliability and resiliency
- Minimize operating and maintenance costs of the bus system
  - MINIMIZE THE USE OF SMALL AND SPECIALTY GARAGES
  - MINIMIZE DEADHEAD MILES
- Build overall capacity and capability to exceed existing, and meet future demand and technology
- Bring facilities to a state of good repair in 13 years while:
  - ENABLING FACILITIES TO CONTINUE SUPPORTING REVENUE FLEET
  - ENSURING FACILITIES ACCOMMODATE A MODERNIZED FLEET
    - Each facility will be designed to accommodate future electrification of bus fleet
    - Each facility will maximize indoor fleet storage
- Minimize impact on current bus system operations
- The program will be a phased approach: End-state quantity and location of facilities is not known yet, but will develop over time along with other MBTA, MassDOT, and Municipal initiatives
MBTA BUS FACILITIES MODERNIZATION PROGRAM (RECAP FROM MARCH 4, 2019)

- MBTA's Bus Garage Infrastructure consists of 10 Maintenance Garages, including Everett Heavy Maintenance
- MBTA Garages have a bus capacity ranging from 28 to 254
- Current Facilities Status
  - At or beyond capacity
  - Average age 54 years
  - Some functionally obsolete (e.g. capacity, ceiling heights, door heights)
- Action: Develop an executable bus facility modernization/replacement program
  - Locations/Permitting
  - Emerging Propulsion Technologies
  - Battery Charging
  - Utility Requirements
  - Bus Storage
  - Maintenance Improvements

All garages are near or above capacity, and are beyond their useful life or are functionally obsolete.

Intent is to re-use all facility sites that can support the future plan
## BUS MAINTENANCE FACILITIES - OVER CAPACITY

<table>
<thead>
<tr>
<th>Facility</th>
<th>Year Built</th>
<th>Bus Count</th>
<th>Maint. Capacity*</th>
<th>% of Maint. Capacity</th>
<th>Storage Capacity</th>
<th>% Storage Capacity</th>
<th>Condition Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albany Street</td>
<td>1941</td>
<td>116</td>
<td>35</td>
<td>333%</td>
<td>116</td>
<td>100%</td>
<td>2.7</td>
</tr>
<tr>
<td>Arborway</td>
<td>2004</td>
<td>118</td>
<td>52</td>
<td>226%</td>
<td>118</td>
<td>100%</td>
<td>3.1</td>
</tr>
<tr>
<td>Cabot</td>
<td>1975</td>
<td>180</td>
<td>104</td>
<td>172%</td>
<td>160</td>
<td>111%</td>
<td>2.8</td>
</tr>
<tr>
<td>Charlestown</td>
<td>1975</td>
<td>254</td>
<td>157</td>
<td>162%</td>
<td>310</td>
<td>82%</td>
<td>2.5</td>
</tr>
<tr>
<td>Everett Heavy Maintenance</td>
<td>1947</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2.6</td>
</tr>
<tr>
<td>Fellsway</td>
<td>1925</td>
<td>76</td>
<td>52</td>
<td>146%</td>
<td>74</td>
<td>102%</td>
<td>2.4</td>
</tr>
<tr>
<td>Lynn</td>
<td>1936</td>
<td>89</td>
<td>87</td>
<td>102%</td>
<td>99</td>
<td>90%</td>
<td>2.7</td>
</tr>
<tr>
<td>North Cambridge</td>
<td>1979</td>
<td>28</td>
<td>35</td>
<td>80%</td>
<td>32</td>
<td>88%</td>
<td>3.2</td>
</tr>
<tr>
<td>Quincy</td>
<td>1930</td>
<td>86</td>
<td>70</td>
<td>124%</td>
<td>90</td>
<td>95%</td>
<td>2.4</td>
</tr>
<tr>
<td>Southampton</td>
<td>2002</td>
<td>104</td>
<td>76</td>
<td>137%</td>
<td>101</td>
<td>103%</td>
<td>3.6</td>
</tr>
</tbody>
</table>

*Based on prior study ratio of 8.7 buses per maintenance bay (40-foot buses)
FUTURE BUS FACILITY CAPACITY

The optimal fleet size is difficult to predict at this time:

- **ONGOING TRANSPORTATION INITIATIVES; BETTER BUS PROJECT AND NETWORK REDESIGN ARE NOT YET COMPLETED**

- **THE INTENT IS TO MAXIMIZE FACILITY CAPACITY AND FLEXIBILITY FOR FLEET TYPE AT EACH SITE UNTIL THE WORK IS COMPLETE TO DEVELOP THE TARGET SIZE OF THE MBTA BUS FLEET**

- **MUNICIPAL PARTNERSHIPS W/ DEDICATED BUS LANES, QUEUE JUMPS, AND SIGNAL PRIORITY WILL INFLUENCE FLEET NEEDS**

- **REPLACEMENT OF DIESEL BUSES WITH BATTERY ELECTRIC BUSES IS NOT CURRENTLY A 1 FOR 1. ADDITIONAL REPLACEMENT VEHICLES ARE NECESSARY DUE TO:**
  - Travel range
  - Refuel/Recharge time
  - Energy consumption due to HVAC

Current working target necessary for progressing the planning for maintenance

- For planning purposes, assume an the need to support an increasing fleet size
- Subject to further refinement following Network Redesign, Better Bus Project, and Bus technology advancements
BUS FACILITY MODERNIZATION STRATEGY

Strategy: Develop a sequence of investments to address the need

1. Prioritize garage construction to meet the needs of the fleet and workforce
   • MOST URGENT NEEDS ARE AT THE QUINCY AND ALBANY FACILITIES
   • EXPAND CAPACITY AT SOUTHAMPTON FACILITY
   • CURRENT FLEET OF TROLLEY BUSES ARE BEYOND THEIR USEFUL LIFE: CONSIDER ALTERNATIVES FOR
     CONVERSION OF NORTH CAMBRIDGE FACILITY TO SUPPORT A BATTERY ELECTRIC BUS FLEET. ADDED
     BENEFIT IS THE ELIMINATION OF OVERHEAD CatenARY SYSTEM (OCS) INFRASTRUCTURE.

2. Build additional capacity throughout the Modernization Program
   • TO PROVIDE CAPACITY (SWING SPACE) TO CARRY OUT THE MODERNIZATION PROGRAM
   • TO CREATE THE CAPACITY FOR FUTURE GROWTH
   • BUILD APPROPRIATE REGIONALIZATION OF FACILITIES

3. Address past commitments
4. Accelerate facility modernization through alternative procurement methods such as Design Build contracting
5. Incorporate future bus fleet conversion to battery electric technology in facility designs
6. Engage in community outreach
7. Engage Real Estate team in developing strategy for land planning and acquisitions
8. Engage design community to develop standards for future facilities, and full program
Desire is to move bus procurement schedule to a more steady-state 100+ buses per year

- SIMPLIFIES BUS COMMISSIONING
- OFFERS A MORE PREDICTABLE AND MANAGEABLE FLEET LIFE-CYCLE MAINTENANCE PROGRAM

Challenge is sustaining the Quincy and Albany bus operations during the facility replacement timeline

- Replacement of 192 40 ft. ECD buses will begin this summer, when complete, the average fleet age will decrease to 6.2 years old, and the average age of non-electric buses drops to 5.6 years old.
- The 11 and 13 year old fleets of 40 ft. Diesel buses are the only buses that can be serviced by the Albany and Quincy Garage due to height restrictions
- The 11 and 13 year old fleets cannot be replaced until the Albany and Quincy Garages are replaced with facilities that can support modern buses

Current Fleet Consists of:
Fleet size = 1017, Average Age = 9 years
Non-Electric Fleet size = 957, Average Age = 8.6 years

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantity</td>
<td>175</td>
<td>150</td>
<td>45</td>
<td>60</td>
<td>25</td>
<td>155</td>
<td>155</td>
<td>192</td>
<td>32</td>
<td>28</td>
</tr>
<tr>
<td>Age</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>5</td>
<td>9</td>
<td>11</td>
<td>13</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Bus Height</td>
<td>11'-1&quot;</td>
<td>10'-10&quot;</td>
<td>10'-10&quot;</td>
<td>10'-10&quot;</td>
<td>10'-8&quot;</td>
<td>10'-3&quot;</td>
<td>10'-3&quot;</td>
<td>10'-6&quot;</td>
<td>11'-3&quot;</td>
<td>11'-10&quot;</td>
</tr>
</tbody>
</table>

Only buses that fit in Albany and Quincy
MOST URGENT NEEDS: QUINCY GARAGE REPLACEMENT

• Functionally Obsolete – The existing building structure cannot be rehabilitated to meet MBTA needs
• Critical height restrictions: Unable to accommodate any new buses being purchased
• Inefficient work space configuration and site layout
• Other areas of concern are:
  • Condition of floors
  • Deterioration of roof and walls
• Current Capacity is 90 buses, need to increase capacity to approx. 130 to 150 buses
• Supports the oldest buses in the MBTA fleet, which are due to be replaced starting in 2022
• Need to explore nearby alternative locations and real estate opportunities for future redevelopment of current site
MOST URGENT NEED: ALBANY GARAGE REPLACEMENT

- Functionally Obsolete – The existing building structure cannot be rehabilitated to meet MBTA needs
- Critical height restrictions: Unable to accommodate any new buses being purchased
- Inefficient work space configuration and site layout
- Other areas of concern are:
  - Condition of floors
  - Deterioration of roof and walls
- Current Capacity is 116 buses, need to increase capacity to approx. 130 buses
- Supports the oldest buses in the MBTA fleet, which are due to be replaced starting in 2022
- Need to explore nearby alternative locations and real estate opportunities for future redevelopment of current site
OPTION: SOUTHAMPTON GARAGE EXPANSION

- Southampton facility currently operating over capacity – built for 76 buses, now supporting over 100
- Need to expand to approximately double the existing usage
- Expansion would allow for an increase to the number of 60-foot buses in operation
- Provides capacity (swing space) to facilitate investments in other garages
- Provides for flexibility to maintain future vehicle technology
OPTION: NORTH CAMBRIDGE GARAGE CONVERSION TO BATTERY ELECTRIC FACILITY

• Upgrades required to support upcoming replacement of Electric Trolley Buses with battery buses
• Would allow removal of overhead catenary
• Many alternatives to be considered for the conversion to battery electric bus technology
  1. Convert current service to diesel buses while BEB facility is constructed
  2. Move maintenance of ETBs to Southampton and build outdoor temporary BEB storage and Charging station on maintenance building land
  3. Build separate BEB capable facility, then replace ETBs with BEBs, decommission, and build new BEB facility
MODERNIZATION PROGRAM PLAN

Phase 1 (0-5 Years)
• Increase Capacity by 150+ *(consistent with current capacity target)*
• Expand capacity at Southampton
• Address needs at Albany Street and Quincy Garages
• Modernize North Cambridge Garage to support battery electric service

Phase 2 (2-10 Years)
• Increase Capacity by 50+ *(subject to further fleet size study)*
• Determine strategy for Arborway and Cabot Garages
• Identify location for garage for expanded Silver Line fleet

Phase 3 (10-15 Years)
• Increase Capacity by as needed
• Determine strategy for Fellsway and Charlestown garages
• Determine strategy for potential additional garages

Site Selection Criteria
- Property Size. Must be able to accommodate anticipated fleet size
- Limits dead-head miles/Proximate to bus network
- Internal site circulation suited for buses
- Circulation to and from the site.
- Consistency with existing land use and zoning
- Environmental constraints
- Property availability
- Tenant Relocation
MBTA Bus Fleet Update / Plans
William G. Wolfgang, MBTA Vehicle Engineering

August 7, 2019
## Current MBTA Bus Fleet

MBTA bus fleet is currently made up of 922 40-foot and 107 60-foot buses of various propulsion technologies.

<table>
<thead>
<tr>
<th>Fleet Type</th>
<th>Year</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neoplan 40-ft Diesel</td>
<td>2003-04</td>
<td>193</td>
</tr>
<tr>
<td>Neoplan 60-ft Dual Mode</td>
<td>2004-06</td>
<td>32</td>
</tr>
<tr>
<td>Neoplan 40-ft Electric Trolley</td>
<td>2004</td>
<td>28</td>
</tr>
<tr>
<td>New Flyer 40-ft Diesel (base)</td>
<td>2006-07</td>
<td>155</td>
</tr>
<tr>
<td>New Flyer 40-ft Diesel (option)</td>
<td>2008-09</td>
<td>155</td>
</tr>
<tr>
<td>New Flyer 60-ft Hybrid</td>
<td>2010</td>
<td>25</td>
</tr>
<tr>
<td>New Flyer 40-ft Hybrid (option)</td>
<td>2014</td>
<td>60</td>
</tr>
<tr>
<td>New Flyer 40-ft Hybrid</td>
<td>2016-17</td>
<td>156</td>
</tr>
<tr>
<td>New Flyer 40-ft CNG</td>
<td>2016-17</td>
<td>175</td>
</tr>
<tr>
<td>New Flyer 60-ft Hybrid</td>
<td>2016-17</td>
<td>44</td>
</tr>
<tr>
<td>New Flyer 60-ft Ext Range Hybrid</td>
<td>2018</td>
<td>1</td>
</tr>
<tr>
<td>New Flyer 60-ft Battery Electric</td>
<td>2019</td>
<td>5</td>
</tr>
<tr>
<td>New Flyer 40-ft Hybrid*</td>
<td>2019-2020</td>
<td>194</td>
</tr>
</tbody>
</table>

*MBTA Vehicle Engineering is in-process of taking delivery of this fleet*
Life of an MBTA Bus

Procurement

- **Routine maintenance**
  - 0-1 years

- **6-8 years**
  - Mid-Life Overhaul

- **12-15 years**
  - Routine maintenance
  - Retirement

<table>
<thead>
<tr>
<th>New Bus Costs (approx.)*</th>
<th>Bus Overhauls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>155 New Flyer 40-foot Diesel</td>
</tr>
<tr>
<td></td>
<td>Completed 2017</td>
</tr>
<tr>
<td>Hybrid</td>
<td>32 Neoplan DMAs</td>
</tr>
<tr>
<td></td>
<td>Completed 2018</td>
</tr>
<tr>
<td>CNG</td>
<td>155 New Flyer 40-foot Diesel</td>
</tr>
<tr>
<td></td>
<td>Ongoing (95 delivered)</td>
</tr>
<tr>
<td>BEB</td>
<td>25 New Flyer 60-foot Hybrid</td>
</tr>
<tr>
<td></td>
<td>Pending Award</td>
</tr>
<tr>
<td></td>
<td>60 New Flyer 40-foot Hybrid</td>
</tr>
<tr>
<td></td>
<td>Program Development</td>
</tr>
</tbody>
</table>

*Note: Costs are for 40-foot buses
60-foot buses typically cost 40% more

New Bus Costs (approx.)*

- Diesel: $650k
- Hybrid: $750k
- CNG: $700k
- BEB: $850k

*Note: Costs are for 40-foot buses. 60-foot buses typically cost 40% more.
Bus Industry Overview

Trending towards advanced extended range hybrid and battery electric buses to reduce environment impacts and improve customer experience.

- Multiple bus manufactures capable of producing various propulsion types
- Reduced maintenance and operating costs
- Improved reliability and passenger amenities
- Electric bus infrastructure upgrades required
Path to a Zero Emissions Fleet

**2000:** Compressed Natural Gas (CNG) Buses

**2004:** Electric Trolley Bus (ETB) Fleet

**2004:** Dual Mode Articulated (DMA) - Silver Line Fleet

**2010:** 60’ Diesel Hybrid Fleet

**2015:** 40’ Diesel Hybrid Fleet

**2015:** 40’ Hydrogen Fuel Cell Bus

**2017-18:** 40’ Battery Electric Bus (BEB) Feasibility Study

**2019:** 60’ New Flyer XDE60 – Extended Range Hybrid Bus

**2019:** 60’ New Flyer XE60 – Prototype Battery Electric Buses
Future of MBTA Bus

In accordance with:
- Fleet and Facilities Plans
- Focus 40
- Better Bus Program

Key Objectives:
- Improve performance of advanced hybrid buses with extended engine-off operations (upwards of 30% fuel savings)
- Reduced GHG emissions
- Improved overall service, accessibility, and mobility
- Add passenger amenities and safety features

Upcoming plans include:
- 194 New Flyer hybrid buses – delivery commencing in August 2019 through 2020
- Continued evaluation of five New Flyer prototype battery electric buses
- Purchase of additional battery electric buses – RFI released to the industry
- Purchase of next fleet of advanced hybrid buses – RFI released to the industry
YOU MUST WALK BEFORE YOU CAN RUN:
GLOBAL PRACTICE OF HOW TO GET AN ELECTRIC BUS FLEET RUNNING
The Climate Emergency and Bus Electrification

August 2019

Michael Kodransky
Institute for Transportation and Development Policy
ITDP: global impact for 30+ years

125+ staff | 10+ offices | 7 countries
50+ cities with projects | $10M+ annual funding

ITDP Office
Current engagement

Mexico  US  Brazil  Africa  India  Indonesia  China
Transportation emissions soaring

Fastest-growing source of climate emissions

~25% of all GHG emissions

Single largest source of black carbon
All 3 required to limit climate change

Avoid
Shift +
Improve

Cars
Buses +
Bikes

2 Degree Scenario in Urban Transport

- BAU (w/ Automation)
- Avoid-Shift only
- Improve only
- Avoid-Shift + Improve
- 2 Degree Scenario
The extremes become the norm.
What is the connection between temperature and impact?

The extremes become the norm.
The coldest year in the future will be hotter than the hottest year in the past.
EVs currently 3% of global light duty vehicle sales

EVs expected to overtake conventional ICE light duty sales by 2040

Electric vehicle sales are growing quickly

Source: Bloomberg New Energy Finance
China expected to lead the EV market... with production in the US and Europe catching-up
E-buses expected to grow even faster

By 2040 80% of global municipal bus fleet is expected to be electric

Currently ~420,000 e-buses on the market

China also expected to lead e-bus market

Source: BloombergNEF's "Electric Vehicle Outlook 2019"
E-buses are the right focus for cities

Buses provide an accessible option to move more people sustainably

80% of buses use older, diesel engines and high sulfur fuel

Buses consume 30x more fuel than cars
3-Steps to Electrify Your Bus Fleet

**Set a Target**
- Define a vision with deadline and specific emissions and air quality goals
- Specify immediate emission reduction
- Develop a plan to achieve targets
- Engage with public to gain support

**Pilot a Program**
- Pick a controlled environment to test new technology on operations
- Test for range, recharging, weather conditions while minimizing variables
- Start making immediate improvements

**Implement with care**
- Finalize a transition plan based on conclusions from testing
- Align plan with expected vehicle renovation and turnover
- Implement incremental changes in overall fleet
Early leaders in bus electrification

China: 38,000+ electric buses, +9,500 each week

Shenzhen, China: full transit electrification
- 20% reduction in CO$_2$ emissions
- 75% reduction in black carbon

Latin American cities: with 50% power from renewables, well-poised to electrify bus fleets

Colombia: intends to reach 600,000 EVs by 2030, including 100% of its buses

Santiago, Chile: largest electric bus fleet in the Americas; transitioning to fully-electrified by 2050

India: plans to make 30% of bus fleet electric by 2030 with up to 60% subsidy provided
E-bikes & scooters are also important

One of the fastest growing transport markets

34 million E-bikes sold in 2017

Shared E-bikes are used 2x as much as pedal bikes

Cover short city distances and connect transit
Key success factors for electrification

**Government Mandates**
At the federal, state, and city levels to encourage adoption, especially for public buses and taxi fleets

**Charging Infrastructure**
By cities in the right locations to maximize charging flexibility and optimize time of day charging

**Subsidies & Financing**
At the federal and state levels to cover higher upfront capital costs, especially for buses which provide more public benefit

**Electricity Tariffs**
At the state level to set preferential prices to incentivize electrification and optimize time of day charging
Thank you!

Follow me on Twitter: @mkodransky
::: itdp.org ::: @ITPDUS :::
VEENA DHARMARAJ

WHY MBTA SHOULD RECHARGE ITS FLEET ELECTRIFICATION EFFORTS

@Sierra Club #BEBBoston
Why MBTA Should Recharge its Fleet Electrification Efforts
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  Public Health
  Economic
  Environmental

MBTA Bus Procurements

Opportunities to Lead
Sierra Club

Areas of Action

Organizing
Climate Action

Protecting
water, air, land
and wildlife

Acting for social
justice

Connecting
people to the
natural world

Founded by John Muir in 1892
Largest, most influential grassroots environmental organization in the country, 63 Chapters
130,000 members and supporters across the Commonwealth
Climate Emergency and Local Impacts

45% We need to reduce carbon emissions by 45% by 2030 to avoid mass extinctions, famines, displacement, and diseases

7.4 ft Boston is likely to experience 3.2 to 7.4 feet of relative sea level rise in the next 80 years because of climate change impacts

>40% Transportation is the largest source of emission in MA impacting climate change
Emission Reduction Strategies

• Stronger fuel efficiency and emission reduction standards
• Access to equitable transit options
• Safer bikeable and walkable communities
• Transition to electric vehicles

“Achieving the Commonwealth’s 2050 GWSA mandate will require the near-complete transition of our vehicle fleet to electric vehicles or other zero-emission vehicle (ZEV) technology. The Governor should establish a goal that by 2030, all cars, light duty trucks, and buses purchased with state resources will be ZEVs.”

- Governor’s Commission on the Future of Transportation, 2018
Public Health Impact

Inequitable exposure to vehicle pollution

- 34% - African Americans
- 26% - Latinos
- 36% - Asian Americans

Significant Health costs

- 109,000 asthma attacks
- 220,000 lost work days
- 2500 premature deaths

Potential to save $2.7 billion in public health

By transitioning all vehicle fleets to be powered by electricity Massachusetts will save almost $2.7 billion in public health by 2050.
Economically Attractive

- Saves ~$400,000 in lifetime fuel and maintenance costs
- Battery costs expected to account for 8% of bus price by 2030, down from around 26% in 2016
- Has four times the fuel efficiency
- Runs 250-300 miles on a single charge

Environment Friendly

- Eliminate 1,690 tons of carbon dioxide, 350 lbs of particulate matter, 10 tons of nitrogen oxides
- MBTA can avert ~55,000 tons of carbon emissions annually

Source: @MBTA
MBTA Bus Procurements

- Five 60 ft electric buses enter service on the Silverline
- Electric bus feasibility report
- Purchased 575 fossil fuel buses in the last 4 years, >50% of their fleet
- Plans to purchase over 700 buses in the next 5 years, only 35 electric
“We can wait for others and follow – at the expense of residents’ health – or lead and innovate, and reduce emissions as quickly as possible. I’d much rather do the latter.”

- Los Angeles Mayor Eric Garcetti
MBTA Should Be A Leader

Several cities including Los Angeles, New York, Seattle, and Martha’s Vineyard have committed to going 100% electric. And Denver, Philadelphia, Chicago and many others are adding more electric buses to their fleet.

- Commit to all electric bus purchases by 2030
- Lay out a clear pathway for a phased transition to 100% electric
- Equip garages for the next generation of bus technologies
- Have at least one garage fully operational for an electric bus fleet by 2020
GLEN BERKOWITZ & MARC DeSCHAMP

NEW MBTA BUS MAINTENANCE FACILITIES & EVOLVING BATTERY ELECTRIC TECHNOLOGY:

THE POTENTIAL FOR MIXED-USE, PUBLIC-PRIVATE DEVELOPMENT

@ABetterCity @JacobsConnects #BEBoston
New MBTA Bus Maintenance Facilities & Evolving Battery Electric Bus Technology

CASE STUDY: Albany Street Garage
TAKEAWAYS

1. Approximately $1 B financial challenge
2. BEB fleets in NE likely in 5-7 years
3. Joint-development benefits may help
   - Cost-effective procurement
   - Better neighborhood fit for facilities, not divest urban sites
   - Decarbonization and climate goals
NEED

Need  BEB  Multi-use  Next
BUS

33%

3.5
### $1B FUNDING NEED

<table>
<thead>
<tr>
<th>Facility</th>
<th>Age</th>
<th>Capacity</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Albany</td>
<td>76</td>
<td>116</td>
<td>2.7</td>
</tr>
<tr>
<td>2. Arborway</td>
<td>13</td>
<td>118</td>
<td>3.1</td>
</tr>
<tr>
<td>3. Cabot</td>
<td>42</td>
<td>180</td>
<td>2.8</td>
</tr>
<tr>
<td>4. Charlestown</td>
<td>42</td>
<td>254</td>
<td>2.0</td>
</tr>
<tr>
<td>5. Fellsway</td>
<td>92</td>
<td>76</td>
<td>2.4</td>
</tr>
<tr>
<td>6. Lynn</td>
<td>81</td>
<td>90</td>
<td>2.7</td>
</tr>
<tr>
<td>7. North Cambridge</td>
<td>38</td>
<td>28</td>
<td>3.2</td>
</tr>
<tr>
<td>8. Quincy</td>
<td>87</td>
<td>86</td>
<td>2.4</td>
</tr>
<tr>
<td>9. Southampton</td>
<td>15</td>
<td>98</td>
<td>3.6</td>
</tr>
<tr>
<td><strong>Fleet Average</strong></td>
<td><strong>49</strong></td>
<td><strong>1,046</strong></td>
<td><strong>2.8</strong></td>
</tr>
</tbody>
</table>

MBTA, INTEGRATED FLEET & FACILITIES PLAN, DEC. 2017
CHALLENGING LAYOUTS
“Achieving the Commonwealth’s [2040 goals] will require the near-complete transition of our vehicle fleet...buses...to electric vehicles.

“...by 2030, all...buses (as appropriate) purchased with state resources will be ZEVs
BEB CO$_2$ BENEFITS


Note: Power plant data as of 2016
<table>
<thead>
<tr>
<th>Type</th>
<th>Cost ($)</th>
<th>Year</th>
<th>Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>40' Proterra E2</td>
<td>950,000</td>
<td>2014</td>
<td>The City of Seneca</td>
</tr>
<tr>
<td>40' Proterra E2</td>
<td>789,000</td>
<td>2015</td>
<td>Foothill Transit</td>
</tr>
<tr>
<td>40' Proterra E2</td>
<td>797,882</td>
<td>2016</td>
<td>King County Metro</td>
</tr>
<tr>
<td>40' Proterra E2</td>
<td>784,000</td>
<td>2017</td>
<td>King County Metro</td>
</tr>
<tr>
<td>40' Proterra E2</td>
<td>700,000</td>
<td>2018</td>
<td>DC's National Mall</td>
</tr>
</tbody>
</table>
## $/BUS COMPARISON

<table>
<thead>
<tr>
<th>Type</th>
<th>Cost ($)</th>
<th>Year</th>
<th>Agency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>553,760</td>
<td>2015</td>
<td>MBTA</td>
</tr>
<tr>
<td>CNG</td>
<td>585,990</td>
<td>2015</td>
<td>MBTA</td>
</tr>
<tr>
<td>Diesel-Hybrid</td>
<td>769,000</td>
<td>2017</td>
<td>King County Metro</td>
</tr>
<tr>
<td>Diesel-Hybrid</td>
<td>736,927</td>
<td>2018</td>
<td>MBTA</td>
</tr>
<tr>
<td>BEB</td>
<td>784,000</td>
<td>2017</td>
<td>King County Metro</td>
</tr>
</tbody>
</table>
MBTA BEB INITIATIVES

- 5x 60-foot BEBs bought under FTA “Lo-No” grant program
- Support Silver Line service
- Evaluate technology in MBTA service / climate
- 40-foot BEB evaluation program anticipated
COLD IMPACTS RANGE

Tesla Model S

<table>
<thead>
<tr>
<th>Temperature</th>
<th>HVAC OFF</th>
<th>HVAC ON</th>
</tr>
</thead>
<tbody>
<tr>
<td>75º</td>
<td>239</td>
<td>148</td>
</tr>
<tr>
<td>20º</td>
<td>212</td>
<td>148</td>
</tr>
</tbody>
</table>

Note: % reductions compared to 75º
MAJOR DEVELOPMENTS
EXCHANGE SOUTH END

MBTA Albany St.

Mass. Ave. Connector
The Case Study is intended to demonstrate the viability of a concept. Not specific to the Albany Street Garage. This model could be adapted to any number of potential locations.
<table>
<thead>
<tr>
<th>Issue</th>
<th>Conventional Fleet</th>
<th>BEB Fleet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance</td>
<td>• Ventilation needed</td>
<td>• Ventilation not needed</td>
</tr>
</tbody>
</table>
| Vehicle Range & Cold Weather Performance | • 350+ miles                      | • 200-400 miles  
|                                      |                                     | • Cold weather impacts  
|                                      |                                     | • Indoor storage               |
| Fueling / Charging                   | • 10 minutes                        | • 2-5 hours to charge  
|                                      |                                     | • Strategic parking of buses  
|                                      |                                     | • Overhead / plug-in / inductive? |
| Power Infrastructure                 | • Established fuel supply chain and logistics | • Fleet power requirements under development  
<p>|                                      |                                     | • Backup generation required for redundancy? |
| Potential for Joint Development      | • Low                               | • High?                            |</p>
<table>
<thead>
<tr>
<th>Program</th>
<th>BEB Storage and Maintenance Facility</th>
<th>BEB Facility and TOD Mixed-Use Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Space</td>
<td>--</td>
<td>226,548 ft²</td>
</tr>
<tr>
<td>Retail Space</td>
<td>--</td>
<td>22,766 ft²</td>
</tr>
<tr>
<td>Transit Hub</td>
<td>--</td>
<td>12,232 ft²</td>
</tr>
<tr>
<td>Bus Maintenance &amp; Support</td>
<td>25,366 ft² (10 bays)</td>
<td>25,366 ft² (10 bays)</td>
</tr>
<tr>
<td>Indoor Bus Storage</td>
<td>80,975 ft² (94 buses)</td>
<td>80,975 ft² (94 buses)</td>
</tr>
<tr>
<td>Onsite Employee Parking</td>
<td>25,562 ft² (55 cars)</td>
<td>25,562 ft² (55 cars)</td>
</tr>
<tr>
<td>Underground Car Parking</td>
<td>63,222 ft² (68 cars)</td>
<td>63,222 ft² (68 cars)</td>
</tr>
</tbody>
</table>
## Conceptual Budget

<table>
<thead>
<tr>
<th>Program</th>
<th>Assumed Cost</th>
<th>BEB Storage and Maintenance Facility</th>
<th>BEB Facility and TOD Mixed-Use Development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus Storage</td>
<td>$42,000,000</td>
<td>$42,000,000</td>
<td>$42,000,000</td>
</tr>
<tr>
<td>Bus Maintenance</td>
<td>$20,000,000</td>
<td>$20,000,000</td>
<td>$20,000,000</td>
</tr>
<tr>
<td>Bus Electrification</td>
<td>$30,000,000</td>
<td>$30,000,000</td>
<td>$30,000,000</td>
</tr>
<tr>
<td>Apartment Tower</td>
<td>$255 / square foot</td>
<td>$30,000,000</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$92,000,000</strong></td>
<td><strong>$159,000,000</strong></td>
<td></td>
</tr>
</tbody>
</table>
MULTI-USE CONCEPT
1. Approximately $1 B financial challenge

2. BEB fleets in NE likely in 5-7 years

3. Joint-development benefits may help:
   - Cost-effective procurement
   - Better neighborhood fit for facilities, not divest urban sites
   - Decarbonization and climate goals
DISCUSSION
IN CLOSING

KATE DINEEN

EXECUTIVE VICE PRESIDENT, A BETTER CITY

@ABetterCity BEBBoston