



# Massachusetts Bay Transportation Authority

## MBTA Decarbonization Strategy

Presenter: Kat Eshel, Senior Director of Climate Policy and Planning  
MBTA Board of Directors - Safety, Health and Environment Subcommittee  
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# Summary and Purpose

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- Review the MBTA's role in supporting statewide climate goals, including as the largest provider of mass transportation and considering specific mandates set by the Legislature
- Provide update on progress toward emission reductions
- Summarize decarbonization strategies available to MBTA moving forward
- Provide an overview of the various modal approaches, with a specific focus on bus and rail
- Answer questions posed during December and February Board meetings



# The Legislature has set climate goals for the Commonwealth and the MBTA.

- The **Global Warming Solutions Act** (2008) requires the Commonwealth to set economy-wide greenhouse gas (GHG) emission reduction goals.
- Targets for the transportation sub-sector are set in the **Clean Energy and Climate Plan (CECP)**. From a 1990 baseline:
  - 18% by 2025
  - 34% by 2030
  - 86% by 2050
- The CECP outlines strategies to achieve those targets.

## MBTA-Specific Mandates

### **An Act Driving Clean Energy and Offshore Wind (2022)**

- Purchase only zero-emission passenger buses after 2030 and transition a 100% zero-emission passenger bus fleet by 2040
- Participate in the Electric Vehicle Intergovernmental Coordinating Council

### **An Act promoting a clean energy grid, advancing equity, and protecting ratepayers (2024):**

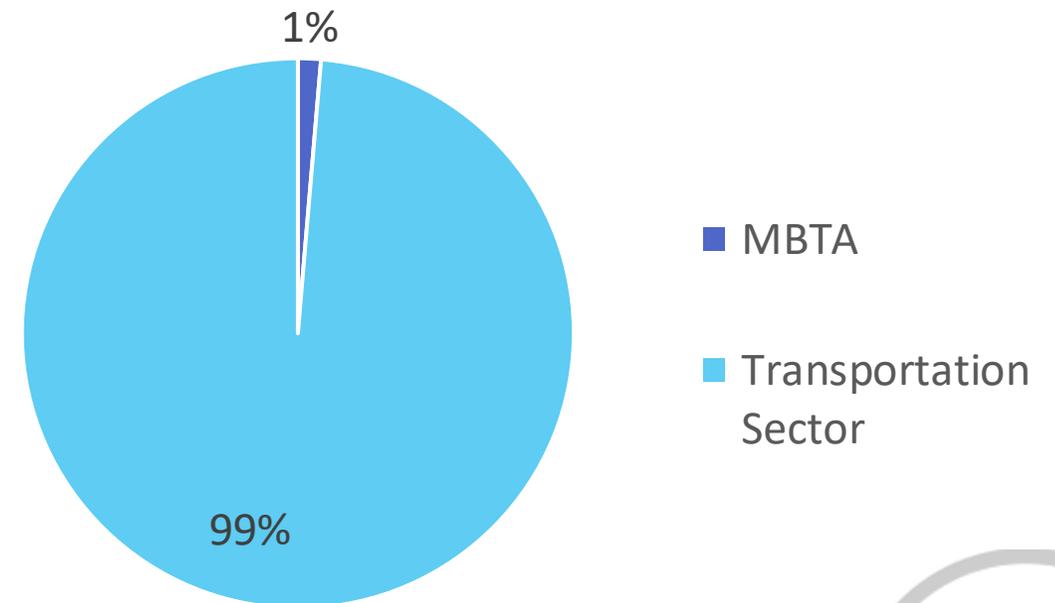
- Participate in the Embodied Carbon Intergovernmental Coordinating Council

# The MBTA is a climate solution for Massachusetts.

## Two ways to act on climate:

1. Provide low-carbon mass transportation services for the greater Boston region
2. Improve the sustainability of the MBTA as an organization

*Transportation is the largest source of emissions in Massachusetts. The MBTA accounts for 1-2% of transportation emissions, while accounting for ~10% of commuter trips in the Boston metro area.*



*2022 Transportation Subsector Emissions*



# Reliable service is our highest decarbonization priority.

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## **Frequent, reliable and accessible service that supports mode shift is the MBTA's most important contribution to state climate goals.**



Increasing service levels can increase the MBTA's organizational emissions, while delivering significant emissions reductions for the region.



Resilience and state of good repair investments help retain our existing ridership and all the avoided emissions their transit trips represent.



Electrification increases dependency on the regional power grid and can impact service reliability if there isn't commensurate investment in backup power facilities.



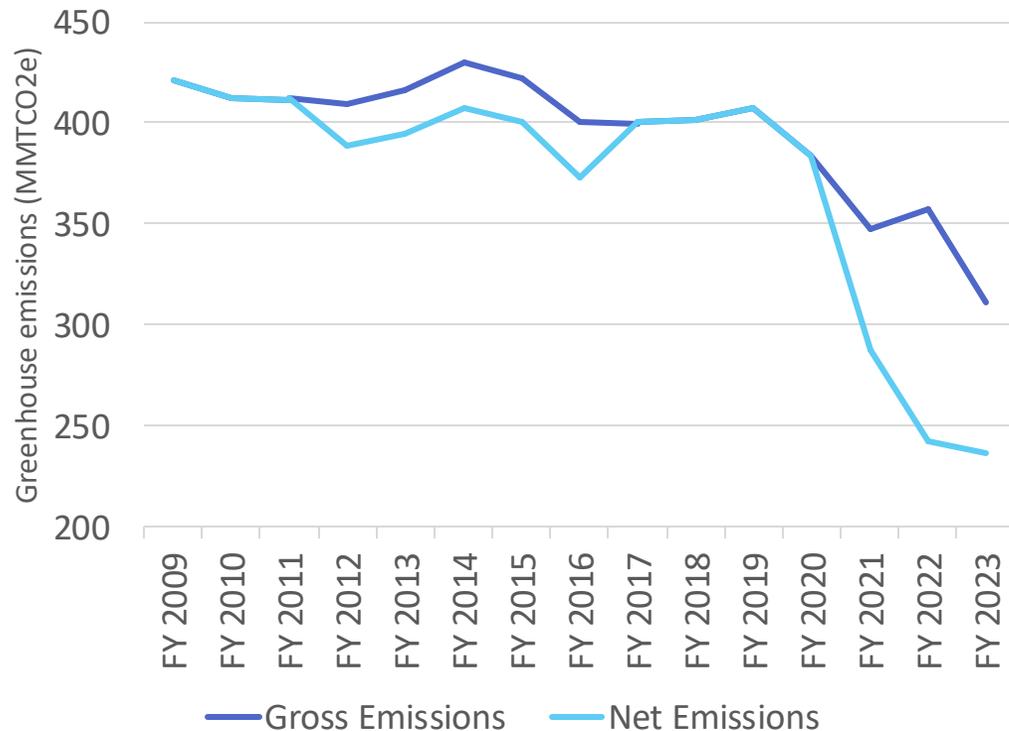
There can and will be short-term impacts to operations as the MBTA transitions to new technologies that are themselves rapidly evolving.



# The MBTA has led the way in reducing its emissions.

We cut our gross emissions by >25% and our net emissions by >40% since 2008, beyond the statewide targets for the transportation sector.

*Note: Net = Gross – Renewable Energy Credits*



## Examples of MBTA following best practice:

### Monitoring:

- Reduced emissions 44% and energy use 20% since 2009
- Adopted an Energy Enterprise Management System

### Efficiency:

- Improved bus fuel economy by 55% with hybrid buses
- Upcoming procurement of EPA Tier IV locomotives
- Invested \$22 million in energy efficiency projects, yielding \$17 million in annual savings

### Electrification/Fuel Switching:

- Fairmount Line BEMU Pilot
- Renewable diesel pilot

**Clean Electricity:** Purchased Renewable Energy Credits since 2021 to offset load.

# What are the MBTA's decarbonization levers?

## Rolling stock

~72% of gross emissions

- Vehicle efficiency
- Electrification
- Fuel switching

## Power

24% of gross emissions (rapid transit + facilities)\*

- Source
- Distributed generation and energy storage

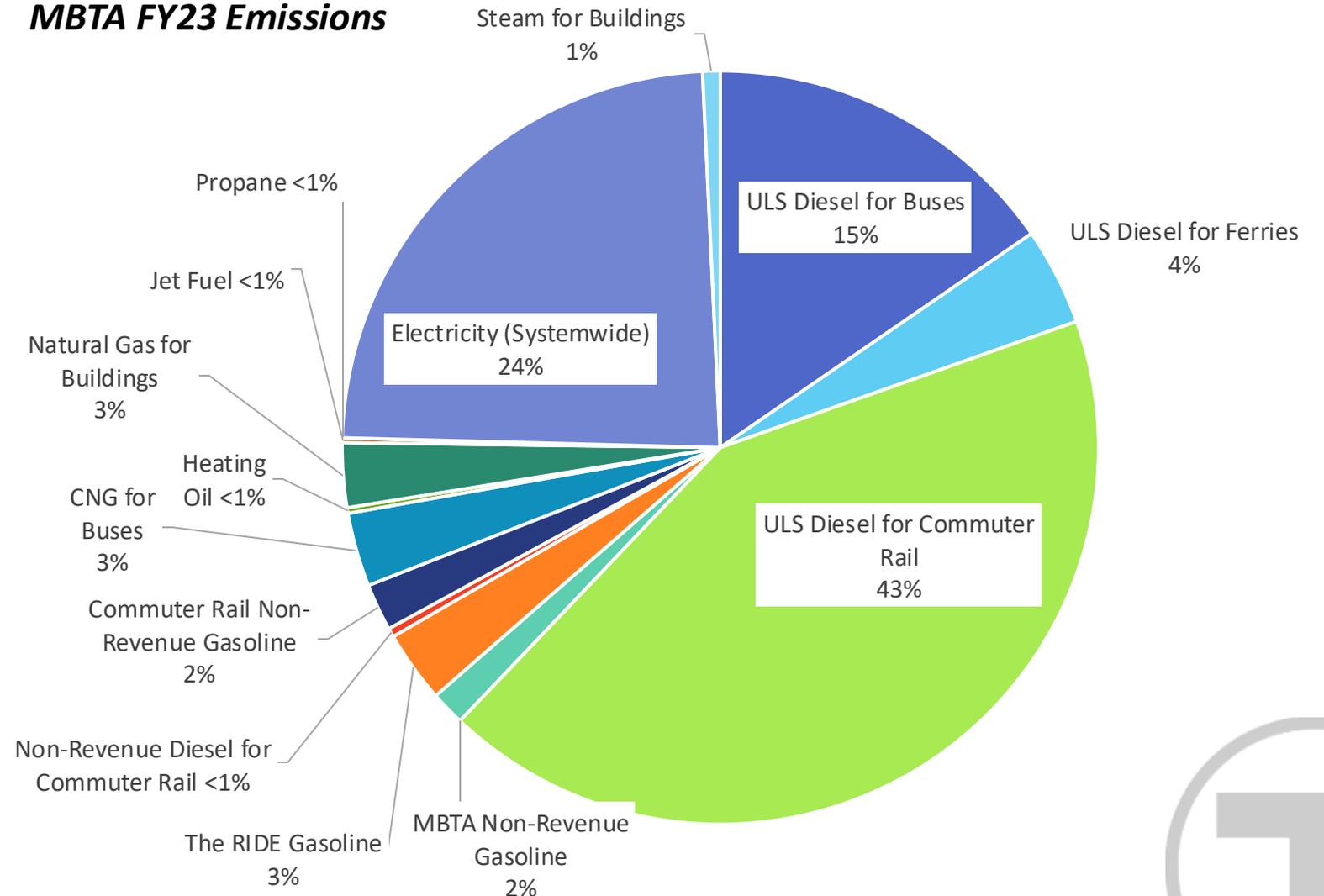
\* will include rolling stock in future years due to modernization initiatives

## Facilities

4% of gross emissions (steam and gas only)

- Standards for new facilities
- Retrofits of existing facilities

**MBTA FY23 Emissions**



# Our approach to decarbonize rolling stock (72% of MBTA's total emissions) varies by mode.



Bus

- Replace obsolete bus maintenance facilities to accommodate chargers and provide better working conditions for bus operations
- Transition fleet as diesel, CNG and hybrid vehicles reach end of life



Rail

- Run trains every 30 minutes or less in inner core and key corridors with high ridership
- Switch to Tier IV diesel locomotives for reliability
- Decarbonize rolling stock as funding and power infrastructure



Others

- Studies underway to assess feasibility, potential timelines, and energy needs
- Challenges include long-term property leases, reliability for long duty cycles and high energy density needs, limited electrified options



*As we increase electrical loads, we will need additional transmission and distribution capacity, including accompanying power infrastructure, whether by growing the power system or building our new connections and capacity with electric utilities.*





# Bus Modernization

Five years ago, we presented an integrated fleet and facility strategy.

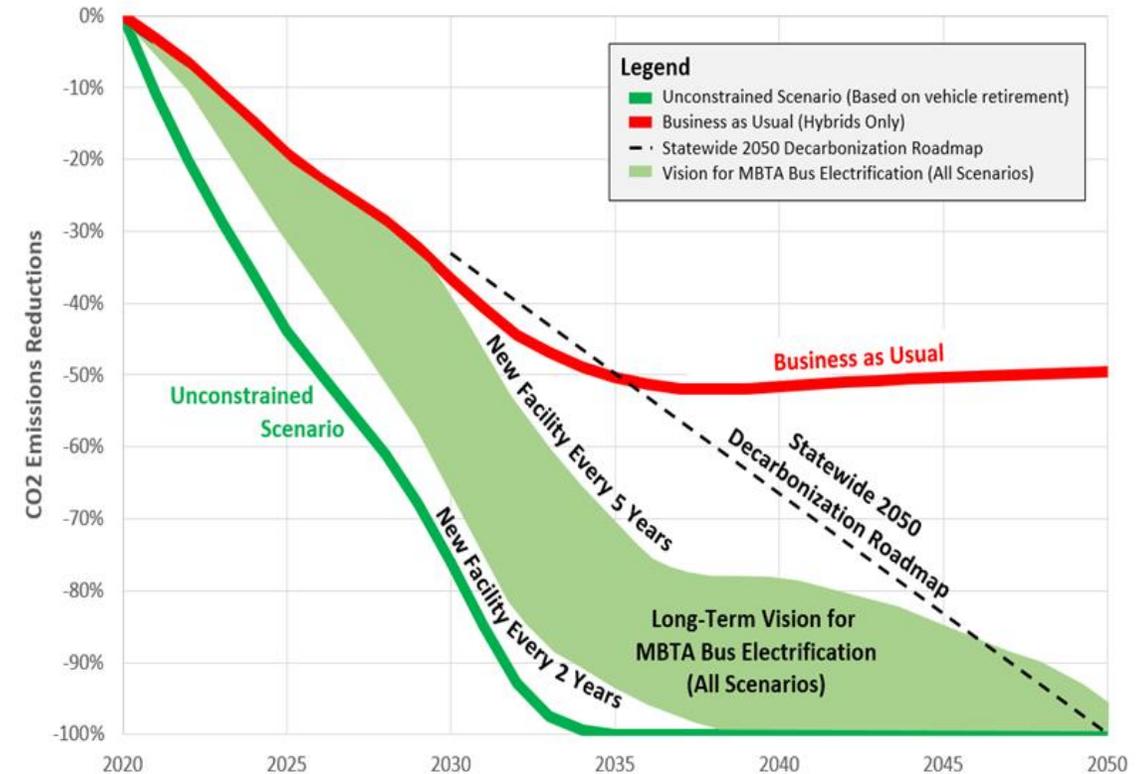
The fleet and facility modernization strategy was designed to support the Better Bus Project:

- Modernize obsolete bus facilities to support our workforce and accommodate new vehicle technologies;
- Allow for an increase in fleet size to position Bus Network Redesign the needs of growing ridership;
- Transition to a more uniform bus fleet.



# Why did the MBTA start to transition to BEBs?

- Massachusetts Climate Law enacted in August 2022 requires MBTA to purchase solely zero emission buses after 2029 and operate a fully electrify fleet by 2040.
- The MBTA Bus Electrification Plan was released in 2022.
  - At the time, many of our peer agencies were also adopting Battery-Electric Buses (BEBs).
  - Cost-benefit found that BEBs offered advantages over electric trolley buses (ETBs) and hydrogen fuel cell buses.
  - BEBs have no tailpipe emissions but are typically heavier and may cause more particulate pollution from tire and brake wear.



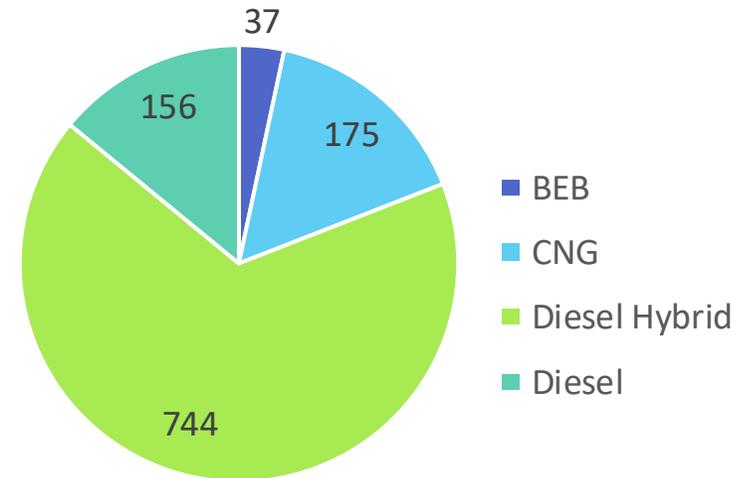
*Bus electrification and emissions scenario (2022). The MBTA's bus electrification plan took a phase approach predicated on sufficient resources to deliver a new bus facility every 2 years.*



# How much progress have we made toward the mandate?

- Battery-electric buses (BEBs) will start to operate out of the North Cambridge Garage in the summer service rating
  - Receipt of first 25 BEBs
  - Running limited test service out of Cabot/Charlestown garages, including monitoring cold weather performance
- Quincy bus facility on-track for Summer 2027 completion
  - Up to 100% BEB ready, 88 buses on order (can fit up to 120 buses)
- Arborway facility at 15% design
- Facility acquisition in Medford

Bus Engines (as of January 2026)



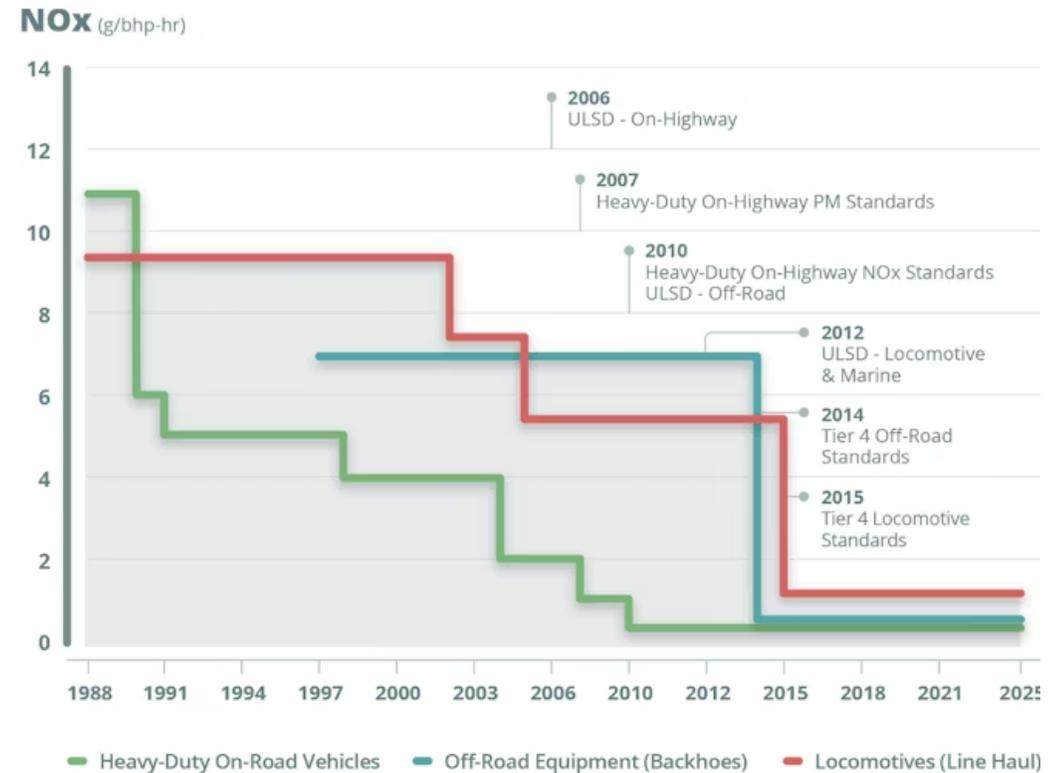
- 95 additional Battery Electric Buses (BEBs) on order to be delivered by 2027
- 150 diesel and diesel hybrid buses to be retired by 2027



# Industry Backdrop – Bus Technology Has Evolved Over Time

- The MBTA has shifted from diesel to ultra-low sulfur diesel.
- Hybrid buses offer significant improvements compared to conventional diesel buses (+55% fuel economy, -35% carbon emissions)
- New hybrid buses meet regulatory EPA Tier IV emission standards.
  - Standards apply to new buses and other types of heavy-duty vehicles
  - Improved air quality with reduced particulate matter and NOx emissions
- BEBs are an emerging and rapidly evolving technology.

Improvements in NOx emissions standards for heavy-duty vehicles



Source: U.S. EPA Office of Transportation and Air Quality (OTAQ)

Chart source: Engine Technology Forum



# Behind the Buses – Facilities In Need of Modernization

- Vehicle frames have changed, with critical equipment moving from undercarriage to roof, impacting facility design needs.
- Both diesel-hybrid and BEBs require maintenance from the side, back, and roof.
- We are designing to manage thermal failure risk
  - E.g., fire coating on steel, upsized water delivery systems

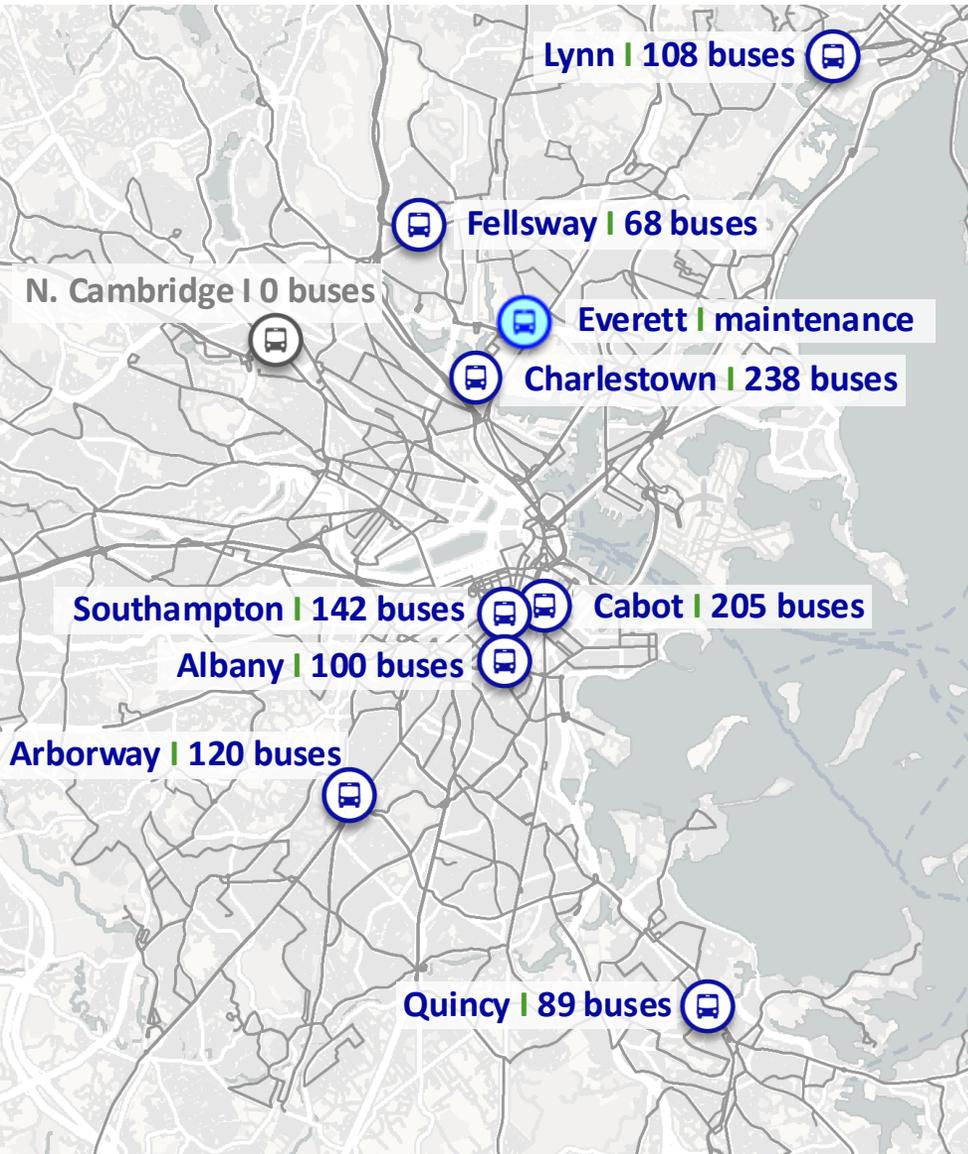
*STM (Société de transport de Montréal) photo (left) shows a section of the Legendre facility with BEB-ready and plug-in chargers*



*LA Metro photo (below) shows bus rooftop work and appropriate clearance*



# Bus Facility State of Good Repair

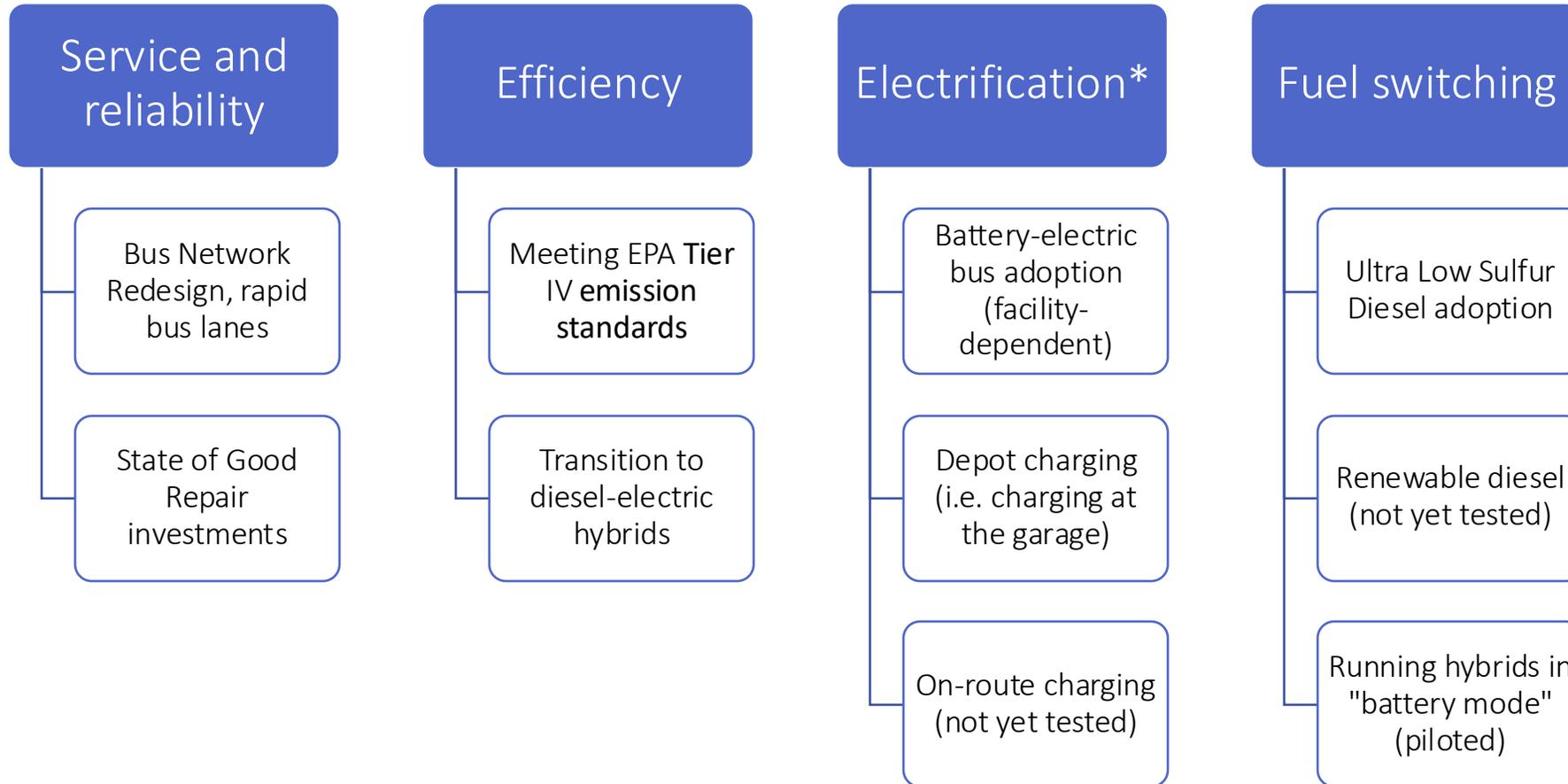


Nine depots and one central heavy maintenance facility service approximately 1,050 buses.

- 1904 – Quincy Opens (Streetcar)
- 1923 – Everett Opens (Orange Line)
- 1925 – Fellsway Opens, Quincy to Bus
- 1936 – Lynn Opens
- 1941 – Albany Opens
- 1975 – Cabot + Charlestown Open
- 1979 – North Cambridge Opens (ETBs)
- 2002 – Southamptton Opens (60-ft only)
- 2004 – Arborway (temporary facility)



# Bus modernization through a decarbonization lens (18% of emissions)



\* Switching to battery-electric buses is dependent on facility modernization. We can only buy and deploy BEBs buses if we have facilities that are equipped to store, charge and maintain them.



# We've advanced bus modernization initiatives.



## We're implementing Bus Network Redesign

- 20% YOY increase on Phase 1 routes

## We're investing in facilities

- Construction of North Cambridge and Quincy
- Arborway 15% design
- Acquisition of 440 Riverside Ave in Medford
- Charging added to Cabot, Charlestown

## We're investing in our fleet

- CNG overhauls will maintain fleet reliability until a new Arborway facility is completed.
- BEB procurements advance the legal mandate
- Hybrid procurements will modernize the fleet and maintain reliability while new facilities are underway

## Discretionary funding has been critical

- We have been successful in securing federal discretionary funding for BEB and hybrid bus procurements.



# Lessons learned

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- The incremental cost of BEB-facilities and of the BEBs themselves is significant, including life and safety upgrades. Federal and state funding has been critical to complete the investments made so far.
- The manufacturing community is small and been impacted by price shocks and supply chain disruptions, while demand for BEBs was growing rapidly.
- We're experiencing the growing pains of deploying new technology:
  - Getting local sign off on building safety systems has increased infrastructure buildout and costs.
  - We need to work with regulatory partners to approve auxiliary diesel heaters that other cold climate agencies use. The heaters have proven critical for cold weather operations.
  - We're anticipating reliability and service impacts.
  - We're in contact with peer agencies to learn from their experiences.





# Rail Modernization

# Six years ago, the MBTA launched a Rail Modernization initiative.

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**We released Rail Vision to assess potential pathways to transform the commuter rail system. Rail Modernization means:**

- Transitioning to a regional rail model to make more frequent all-day trips
- Making critical investments in the legacy system to improve service, frequency, reliability and accessibility
- Decarbonizing the rolling stock, which can deliver further service, frequency and reliability benefits, after undertaking enabling power and facility investments

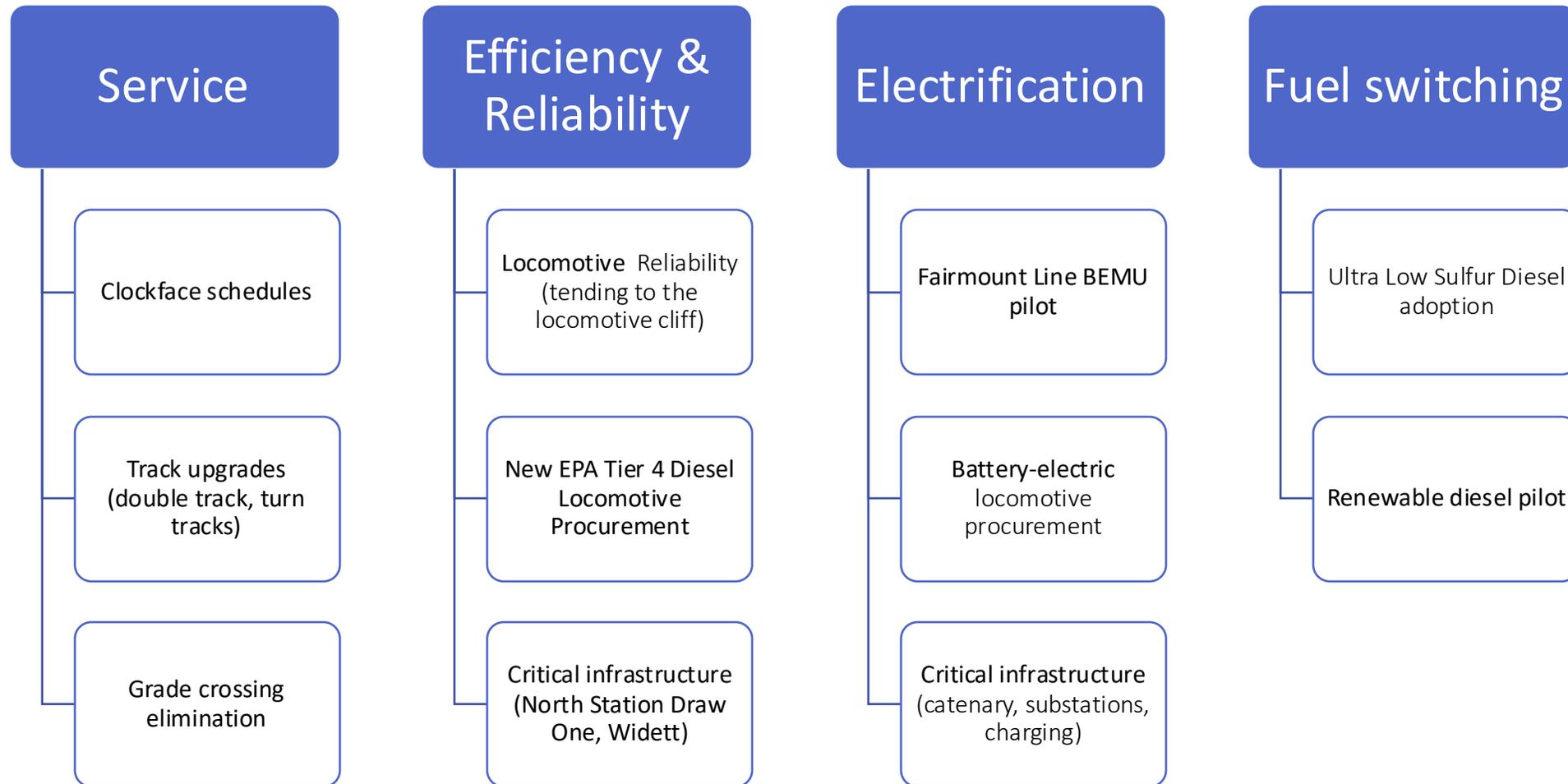
**We've made progress:**

- Reliability: North Station Draw One, Tier IV diesel locomotive procurement
- Frequency: interlockings, turnback tracks, double tracks
- Accessibility: mini-highs, accessibility initiatives
- Decarbonization: Fairmount pilot, fuel switching, procurement for battery-electric locomotives for deployment on the Providence line

We're developing a Rail Modernization Plan and will be doing public engagement to inform the plan and its implementation later in the spring.



# Rail modernization through a decarbonization lens (43% of emissions)



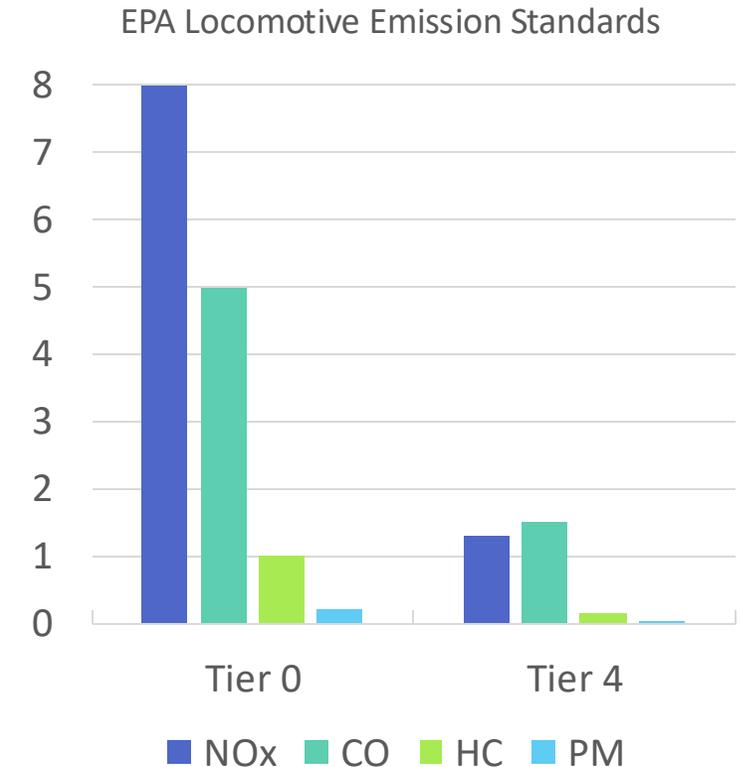
# Fleet reliability is a critical decarbonization lever.

1. Locomotive overhauls for will boost reliability, which supports increased service.
  - As the diesel fleet ages, it is getting increasingly unreliable
  - Increased service supports increased ridership and can reduce single occupancy vehicle usage and regional emissions
2. Procuring new locomotives will further improve reliability and reduce emissions.
  - We need new locomotives to maintain current levels of service and to expand service as part of shifting to the Regional rail model.
  - We can decarbonize with electrification and fuel switching, but we cannot make the switch to electric rolling stock without the necessary facilities and power infrastructure.



# We're adopting the next generation of rolling stock.

- Tier IV Diesel Locomotives
  - New diesel locomotives complying with the most EPA emissions standard, Tier IV, will replace MBTA Tier 0+ legacy fleets.
  - Platform based procurement structure - Increased reliability with service proven designs
  - Multi-Agency consortium procurement
  - Increased economies of scale
- New Battery-Electric Locomotive Procurement
  - Vehicle is 100% zero emissions
  - Significant noise reductions
  - MBTA specific route plan for catenary use where available and battery use for end of line (e.g., between Providence and Wickford Junction)
- BEMUs for Fairmount Line
  - 100% zero emissions and noise reductions
  - Battery improvements have eliminated the need to install new catenary



# We're laying the groundwork for decarbonization.

- We're making a downpayment on decarbonization.
- We are piloting BEMUs on the Fairmount Line in the near term.
- We are taking early action to decarbonize along the Northeast Corridor.
  - The Providence Line is partially electrified, so can we procure and deploy battery-electric locomotives through Wickford Junction without the need to build additional catenary.
  - Battery-electric locomotives can also be flexibly deployed onto the other lines (Stoughton, Needham, others).



*Conceptual design of potential decarbonized Commuter Rail train provided by Stadler in response to MBTA RFI*



# How do different rolling stock technologies compare?

Type	Diesel locomotive	Electric locos	Electric multiple unit (EMU)	Battery-electric multiple unit (BEMU)	Battery-electric locos
Description	Uses onboard diesel combustion to pull coaches	Draws power from overhead catenary (OCS) to pull coaches	Electric “trainsets” that draw power from OCS	Electric “trainsets” that self-propel using both OCS and onboard batteries	Draws power from either OCS or onboard batteries to pull coaches
Examples	MBTA Commuter Rail	SEPTA, Amtrak Northeast Corridor	Metra, SEPTA, NJT, Metro North, LIRR	SEPTA, Caltrain	Orders from Metro North, Metra
Pros	Mature tech, can purchase used locomotives	Mature tech, can purchase used locomotives	Fastest acceleration	Increasing adoption levels, limited OCS buildout	Limited OCS buildout, leverage existing coach fleet
Cons	Slowest acceleration speeds	Requires installing OCS across the entire line	Full OCS buildout, replacing both locos and coaches	High cost of replacing both locos and coaches	No prototype has yet been delivered or tested



# What influences the choice of rolling stock?

- Many factors such as:
  - Power infrastructure needs
  - Environmental context
  - Ridership volume
  - Line length and number of stops
- The decision on appropriate rolling stock will vary based on the characteristics of different lines and the existing fleet
  - E.g., BEMUs may be a better fit for shorter lines with relatively lower ridership

**There are differing levels of grid infrastructure readiness across our network.**

- The southside of the system can build on the Northeast Corridor, but the infrastructure has limited capacity.
- The northside does not have any enabling infrastructure.
- Transmission studies and permitting are handled through the regional grid operator, ISO-New England. Planning and delivery of new transmission can take 5-10 years.
- It will be highly challenging or imprudent to build power infrastructure in many parts of our network (e.g., in the coastal floodplain).



# Recent announcements

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- At the February board meeting, the MBTA announced that it will be procuring 10 Tier IV diesel locomotives and 10 battery-electric locomotives.
  - The diesel locomotives will help address critical state of good repair needs and bolster commuter rail reliability.
  - The battery-electric locomotive procurement will enable MBTA to electrify the Providence Line in ~5 years.
- We announced that we're developing a regional rail modernization plan and will be engaging members of the public later in the spring.
  - [www.mbta.com/projects/rail-modernization-plan](http://www.mbta.com/projects/rail-modernization-plan)



A photograph of a train yard at night. In the foreground, a white maintenance machine with a large triangular structure on top is visible. Behind it, several diesel locomotives are parked on tracks. The locomotives are white with blue and yellow stripes. One locomotive has the number '044' and a 'T' in a circle on its side. The scene is illuminated by overhead lights, and the ground is a mix of concrete and gravel. A large white text overlay reads "Remaining emissions sources".

# Remaining emissions sources

BC HIGH  
ES 7-12  
PEN HOUSE

SUFFOLK  
UNIVERSITY

T  
044

# Electricity (24% of gross greenhouse gas emissions)

## Power purchasing and sources

- The MBTA has purchased Renewable Energy Credits since 2021 to cover its power.
- Note: Upcoming energy re-procurement.

## Growing demand

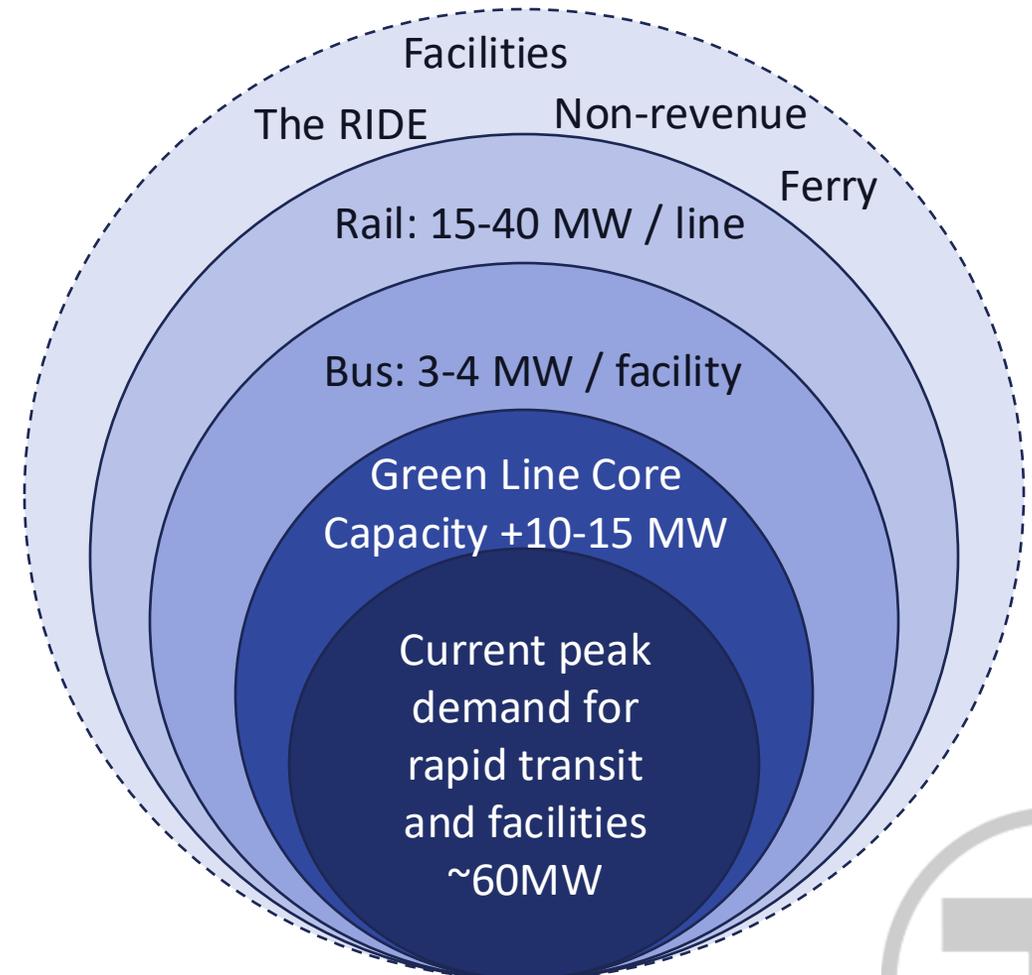
- Largest electricity consumer in MA
- Increasing capacity and electrifying will add load

## Infrastructure needs

- \$5 billion State of Good Repair backlog,  $\frac{3}{4}$  of assets beyond their useful life (2023 CNAI).
- Regional rail electrification requires transmission-level infrastructure with unique permitting processes.

## Resilience needs

- Importance of emergency back-up generation and life safety systems



*Note: Estimates subject to change, figure not to scale.*



# Snapshot of remaining emissions sources



## Ferry

*4% of emissions*

Scoping is underway for a study of alternative fuel technologies. Challenges include reliability for long duty cycles, high energy density needs and limited vessel options.



## Non-Revenue Vehicles

*4% of emissions*

Study found that most Class 1 and 2 vehicles could be electrified but require significant charging infrastructure due to long duty cycles. Many medium and heavy-duty vehicles did not have an available EV option.



## Facilities

*4% of emissions (steam and gas only)*

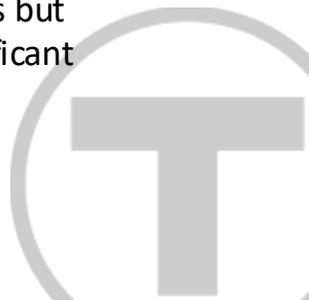
The MBTA is updating its Design Standards and Guidelines and will implement relevant recommendations from the state's 2026 Embodied Carbon Reduction Plan.



## The RIDE

*3% of emissions*

Study found that up to ½ of the fleet could be electrified with minimal operational changes but would require significant capital funding.



# Delivering decarbonization is a balancing act:

- Excellent service is the MBTA's highest decarbonization priority to support the Commonwealth's climate goals.
- We've made major strides. There are further opportunities to reduce our direct emissions, as well as costs.
- This a dynamic field of practice with emerging and rapidly evolving technology. We'll continue to monitor which investments can meet our service goals.

