



2018-2040 Green Bus Technology Plan

November 2017

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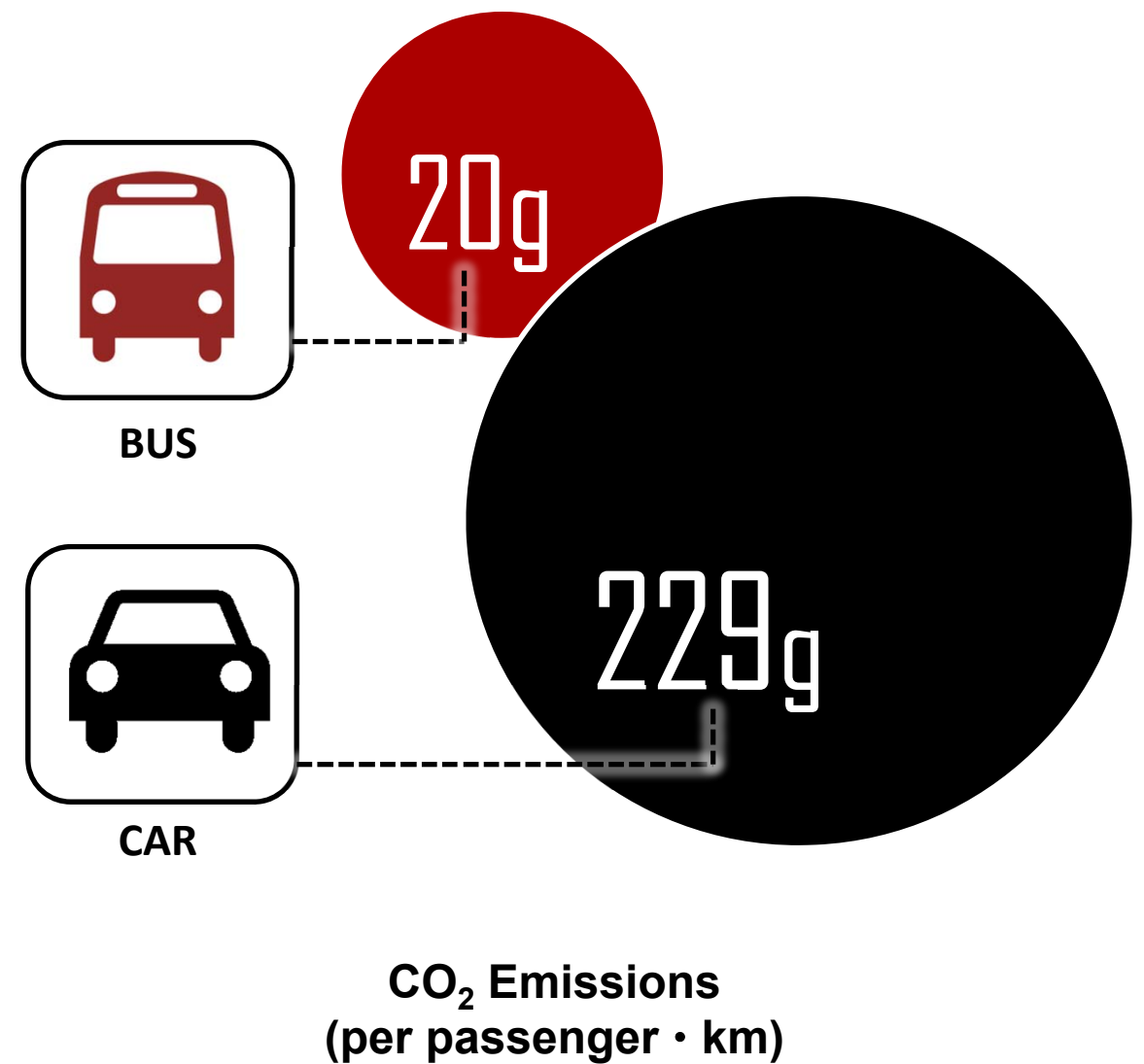
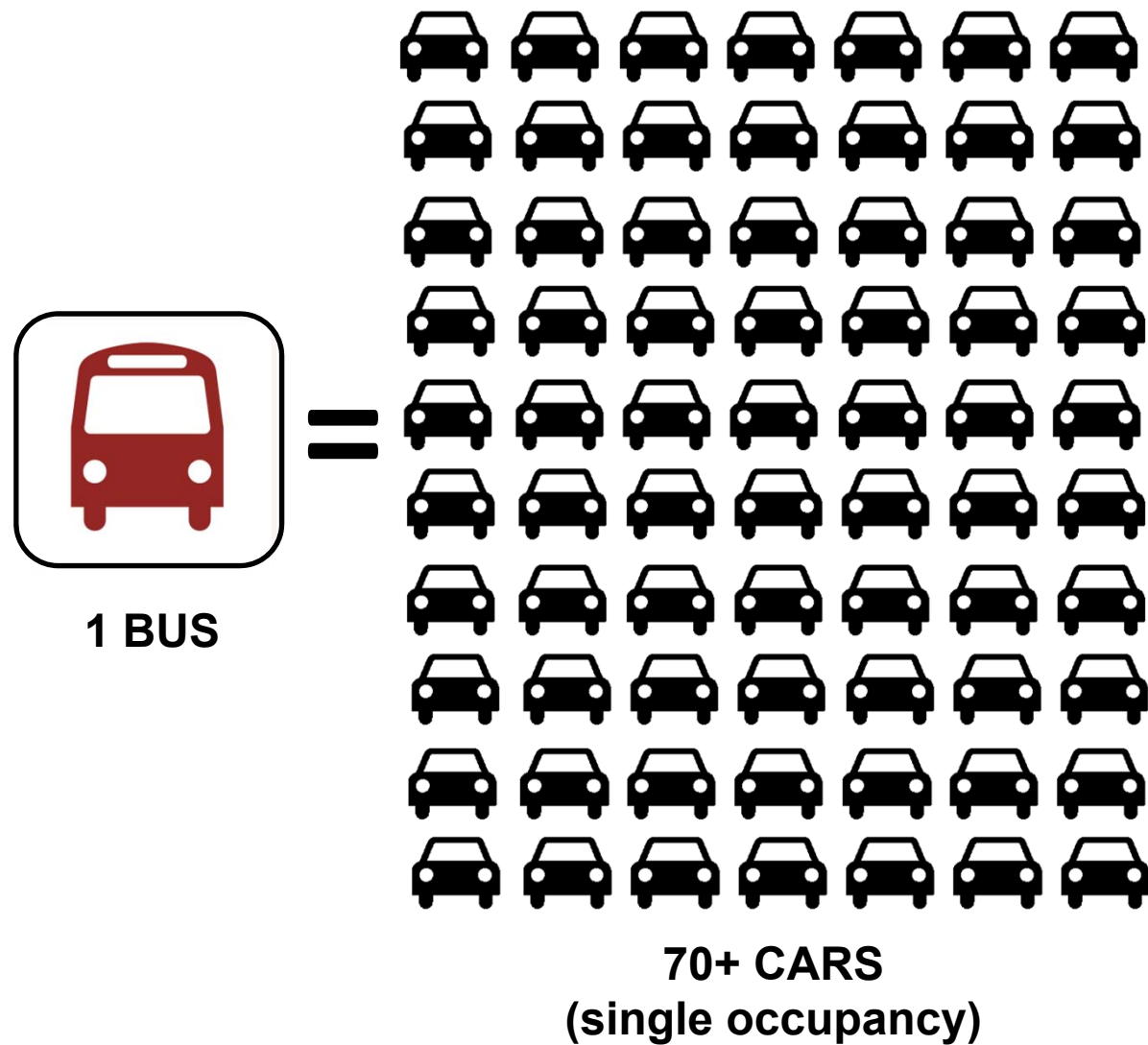


| Agenda

1. Evolution of Bus Technology
2. City / TTC Emissions Targets
3. Current Bus Technology Options
4. Recommendations
5. Proposed Procurements
6. Next Steps

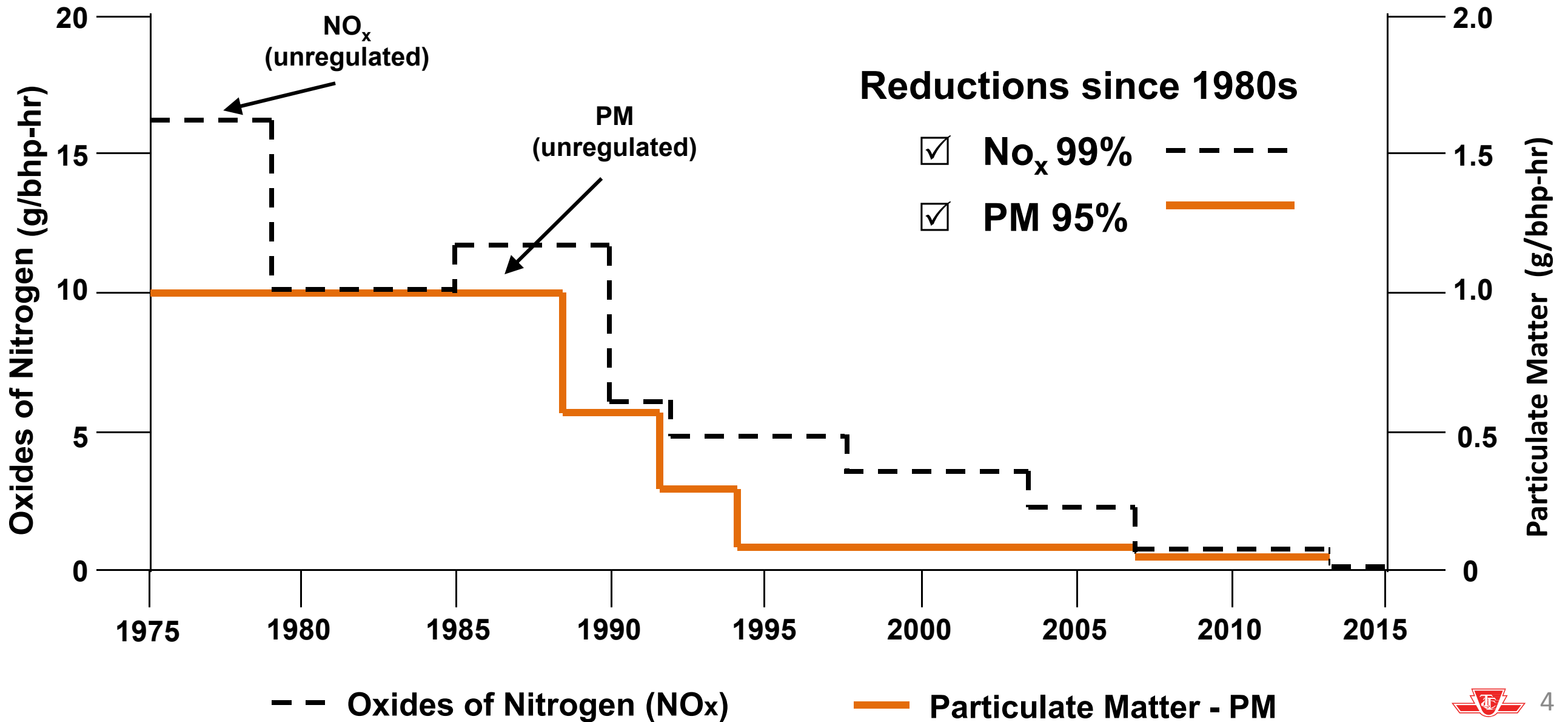
1 | Evolution of Bus Technology

Transit is Green

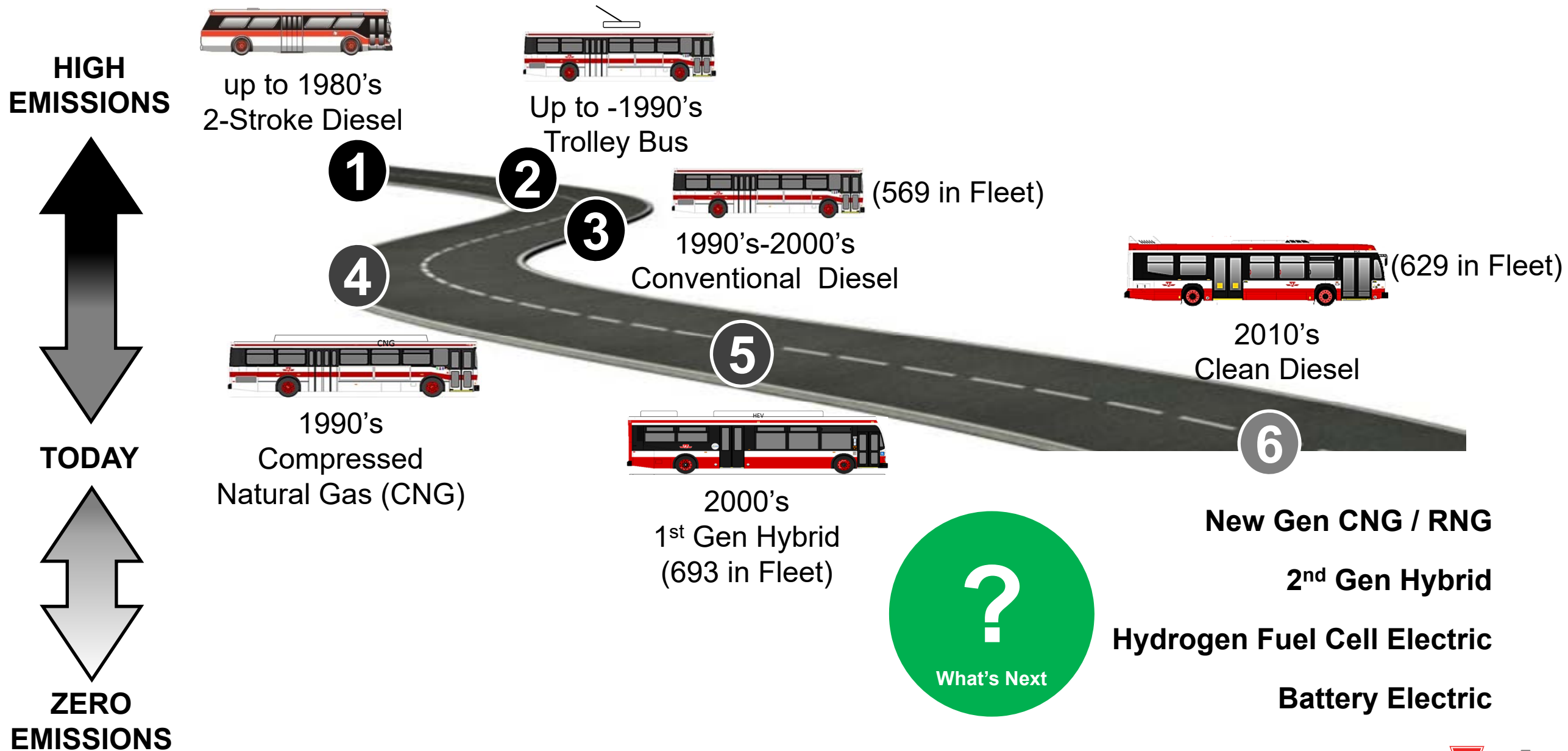


1 | Evolution of Bus Technology

Evolution of Diesel Engine Emissions Standards

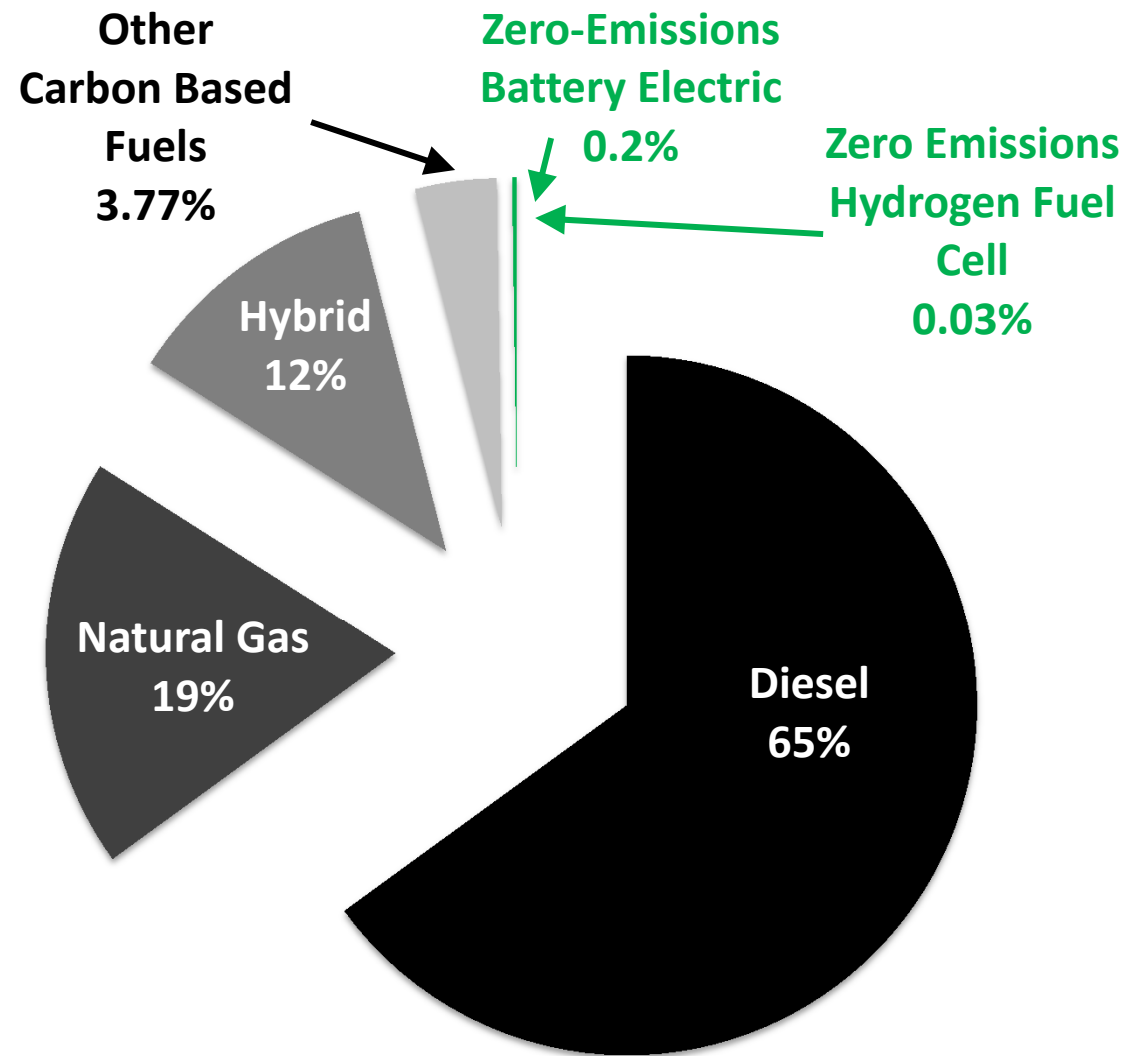


1 | Evolution of Bus Technology @ TTC



1 | Evolution of Bus Technology

Current Technologies Used in North America



2 | City / TTC Emissions Targets



TransformTO Target:

Reduce greenhouse gas (GHG) emissions 80% by 2050

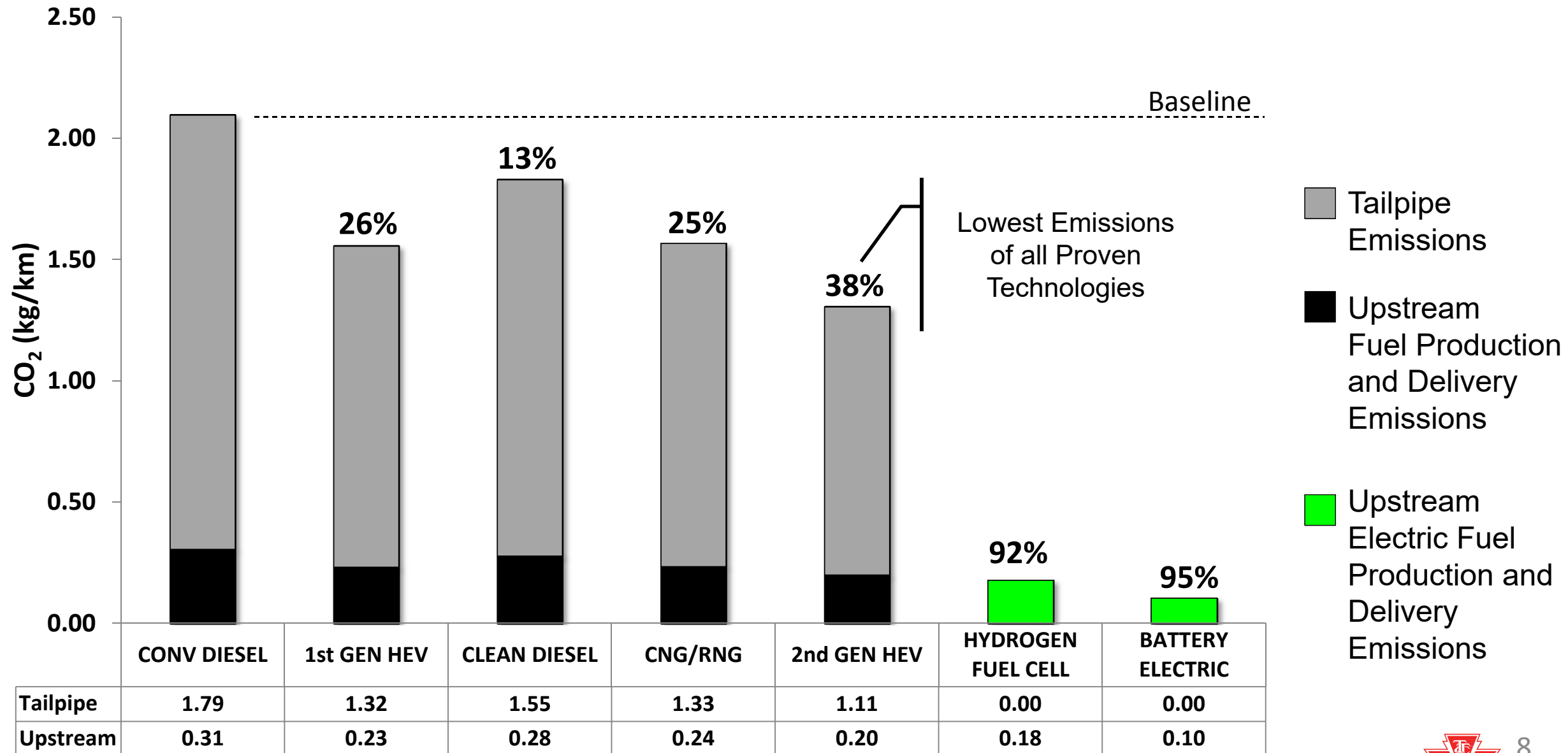


TTC Target:

Steady-state procurement of zero-emissions buses by 2025 in line with the C40 Fossil-Fuel-Free Streets Declaration, and an all zero-emissions bus fleet by 2040.

3 | Current Bus Technology Options

Green House Gas (GHG): CO₂ Emissions per kilometer



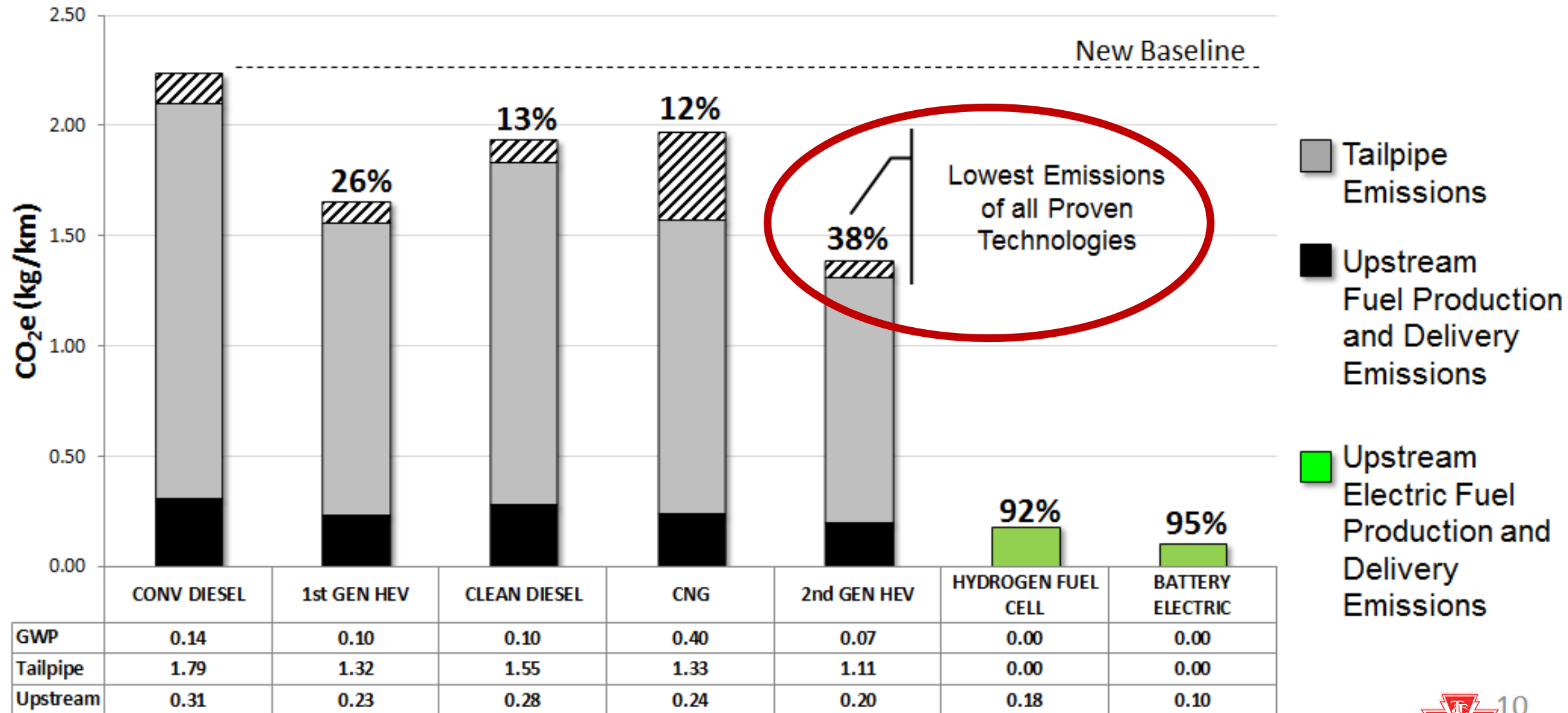
3 | Current Bus Technology Options

Global Warming Potential Factors

Pollutants/Compounds	GWP 100 years
CO ₂ - Carbon Dioxide	x1
CH ₄ - Methane	x34
N ₂ O - Nitrous Oxide	x298

3 | Current Bus Technology Options

Green House Gas (GHG): CO₂ Emissions per kilometer



3 | Current Bus Technology Options

Public Health Perspective / Impact on Local Air Quality

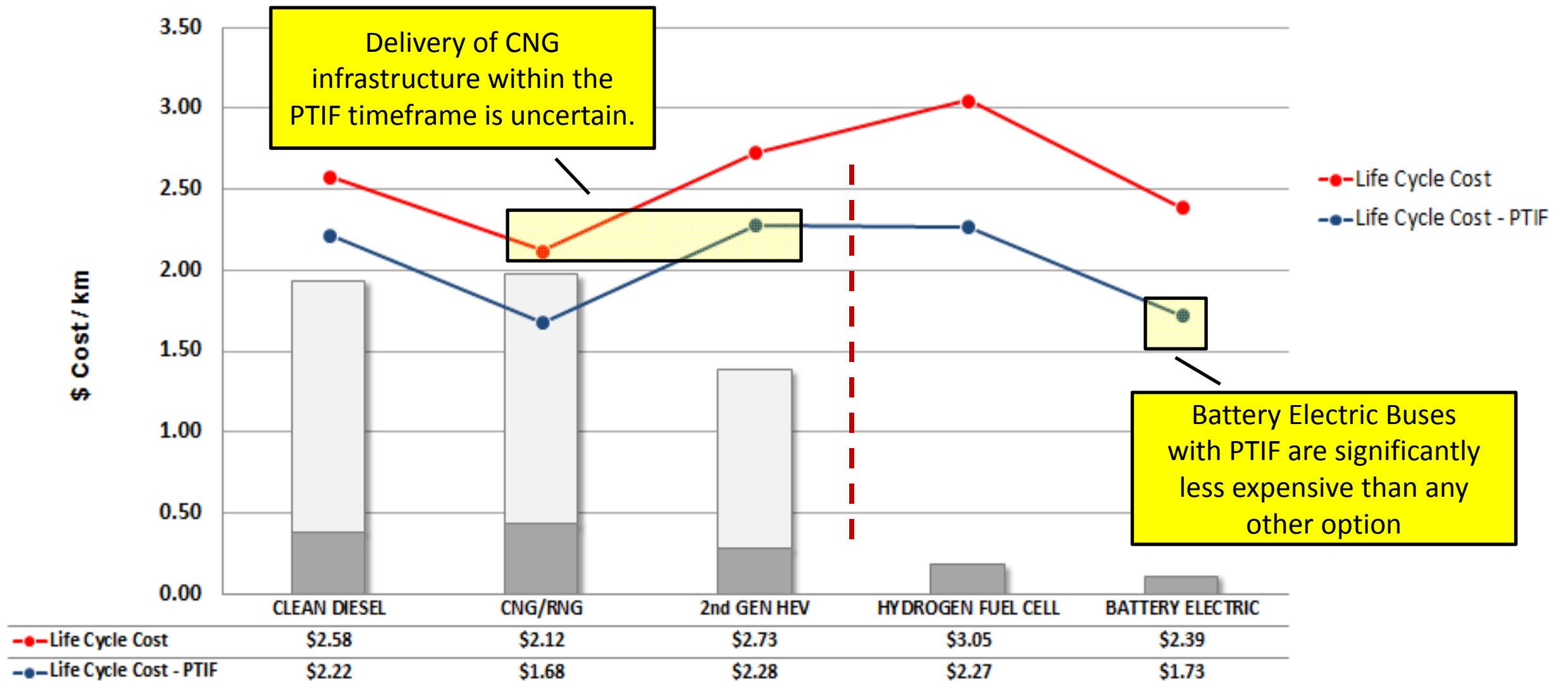
Toronto Public Health:

The relative comparison of tailpipe emissions from the four propulsion technologies resulted in the following ranking:

- i. Battery Electric (zero emissions)
- ii. Diesel-Electric Hybrid / Compressed Natural Gas
- iii. Diesel

3 | Current Bus Technology Options

Life Cycle Cost Estimates vs Emissions



Proven Technologies

Unproven Technologies

3 | Current Bus Technology Options

Other Considerations: Natural Gas

- 12% lower tailpipe emissions vs diesel
- Same driving range as diesel
- Low fuel cost + potential for Renewable Natural Gas
- 16% lower maintenance costs
- 20% of transit buses in North America

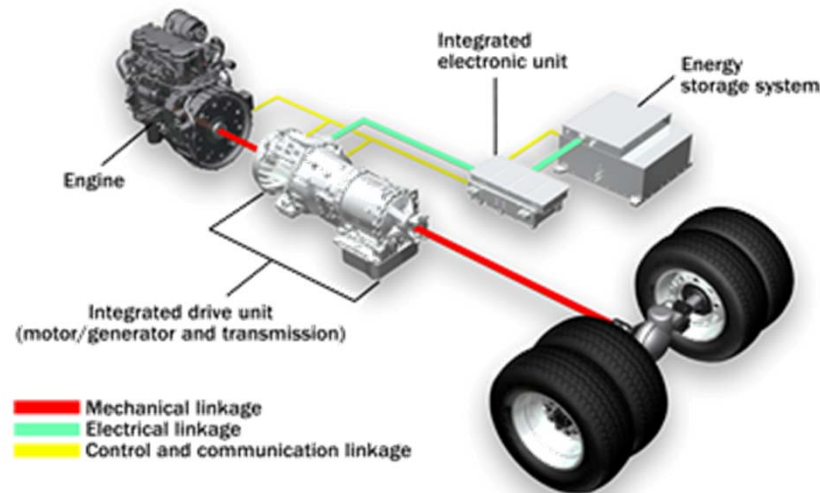


- Bus capital cost +\$70k vs. diesel
- Infrastructure required:
 - Fuelling & de-fuelling stations
 - Maintenance facility ventilation
- Bus operations tied to infrastructure

3 | Current Bus Technology Options

Other Considerations: 2nd Generation Hybrid Electric

- 38% Lower tailpipe emissions vs diesel
- Same driving range as diesel
- No infrastructure required
- TTC has maintenance & operating experience
- Start/Stop + EV mode
- Nova Bus and New Flyer are have production slots available;
- Bus capital cost +\$150k vs. diesel



3 | Current Bus Technology Options

Other Considerations: Battery Electric



- ZERO tailpipe emissions
- Limited driving range – 250 km (50% of TTC Service)
- Low operating and maintenance cost
- 30% fewer parts – higher reliability, theoretically
- TTC hybrid experience transferable

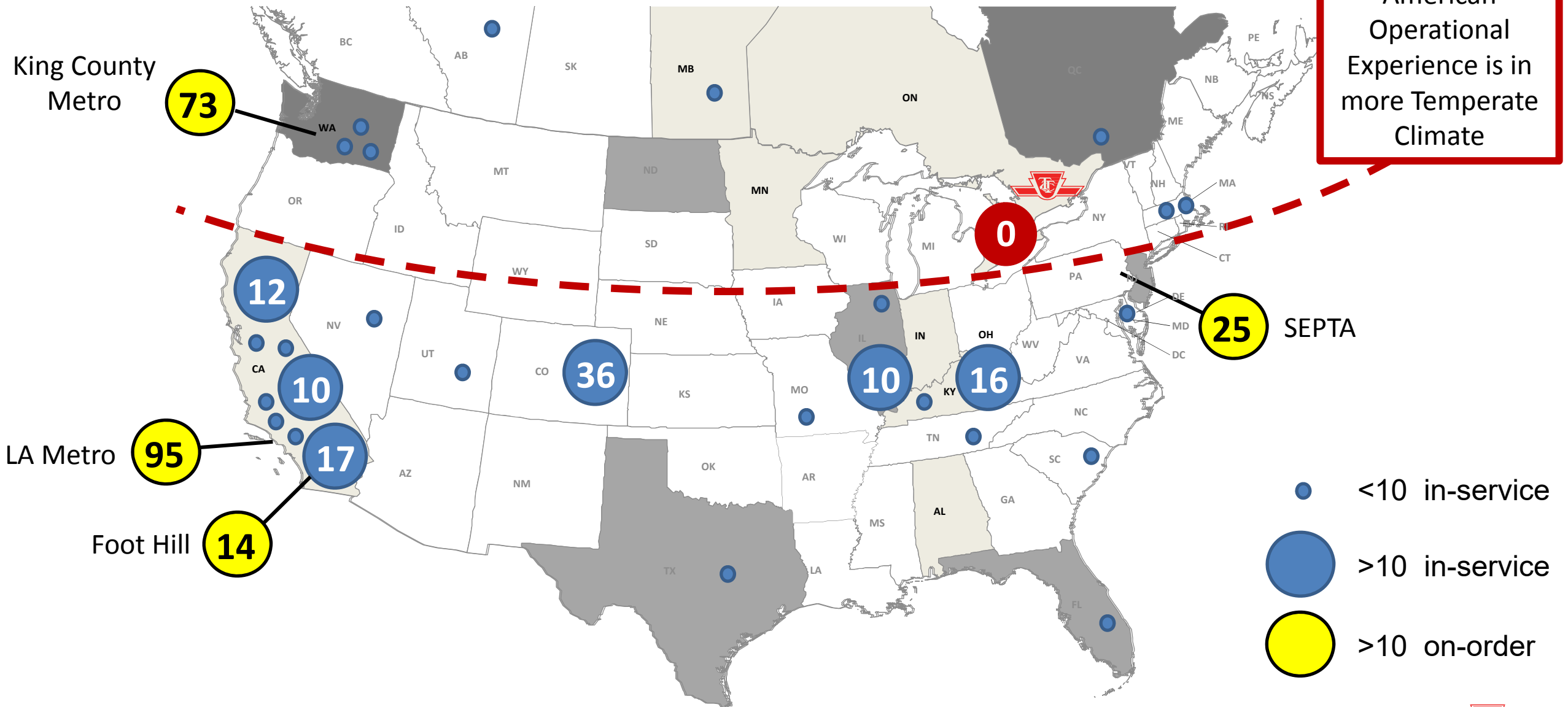


- Charging infrastructure required
- Bus tied to infrastructure
- Bus capital cost + \$350k vs. diesel
- Long term reliability unknown



3 | Current Bus Technology Options

Battery Electric Buses Operating in North America



3 | Current Bus Technology Options

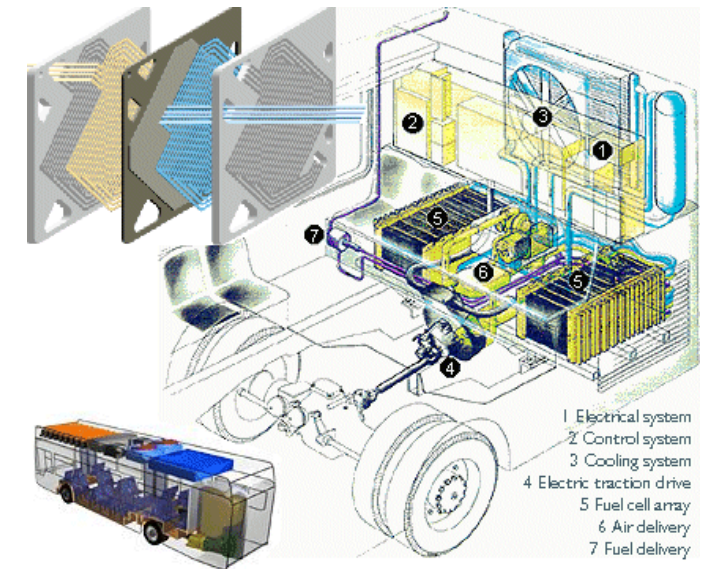
Other Considerations: Hydrogen Fuel Cell



- ZERO tailpipe emissions
- Good driving range – 450km (90% of TTC Service)
- TTC hybrid experience transferable

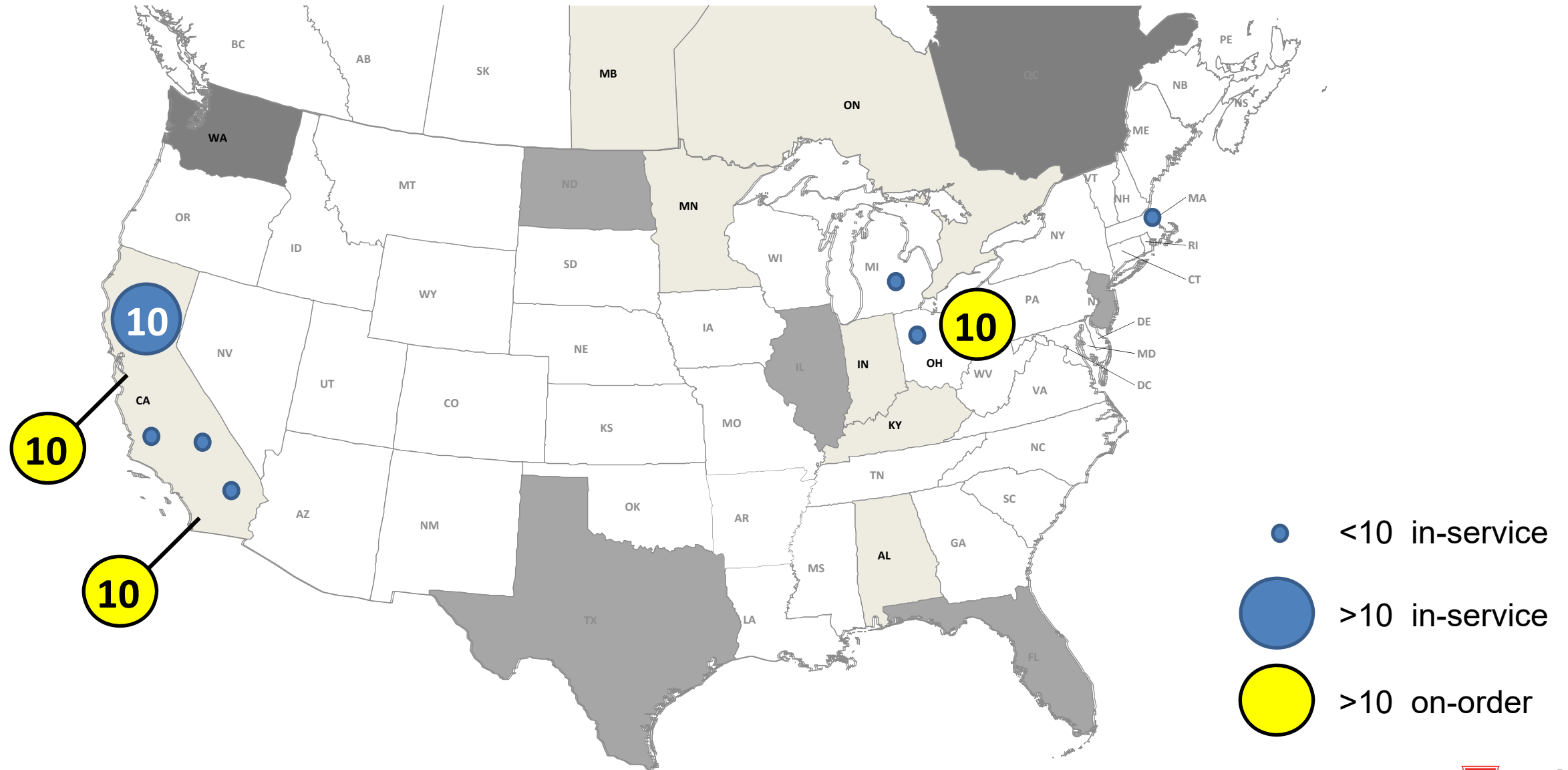


- Bus capital cost +\$500k vs. diesel
- Infrastructure required:
 - Fuelling station
 - Hydrogen generating plant
- Maintenance facility ventilation required
- Bus operations tied to infrastructure
- Long term reliability unknown



3 | Current Bus Technology Options

Hydrogen Fuel Cell Buses Operating in North America



4 | Recommendations

1. Purchase 30 All-Electric Buses

Delegate the authority to the TTC CEO to negotiate and enter into up to 3 contracts for the supply of a total of 30 all-electric buses and required infrastructure not to exceed the total project cost of \$50M based on the following:

- a) The award of contracts will be based on negotiating an acceptable agreement, satisfactory to TTC General Council with the only three qualified suppliers of long range (>200km/charge) all-electric buses, New Flyer, Proterra and BYD that are compliant with Transport Canada Motor Vehicle Safety Standards; and
- b) delivery of all 30 buses are to be delivered no later than March 31, 2019 in order to ensure that the buses eligible for the PTIF funding.

4 | Recommendations

2. Purchase 230 Hybrid-Electric Buses

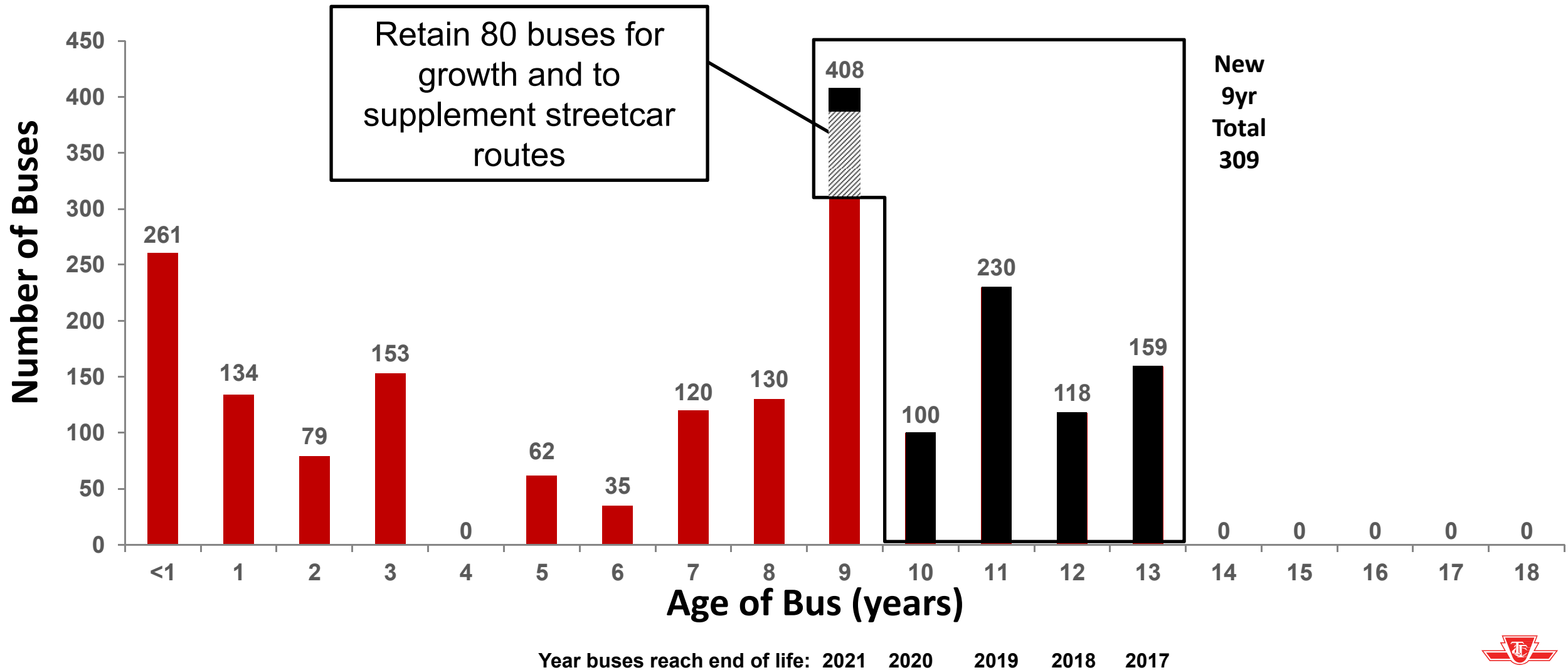
Delegate the authority to the TTC CEO to enter into a contract(s) with up to two suppliers for the supply of 230 new generation hybrid-electric buses not to exceed the total project cost of \$230M based on the following:

- a) The award of the contract(s) will be based on negotiating an acceptable agreement, satisfactory to TTC General Counsel with the only two bus suppliers, Nova Bus and New Flyer, capable of manufacturing hybrid-electric buses that are compliant with Transport Canada Motor Vehicle Safety Standards, and
- b) Hybrid-electric buses are to be delivered no later than March 31, 2019 in order to ensure that the buses are eligible for PTIF funding.

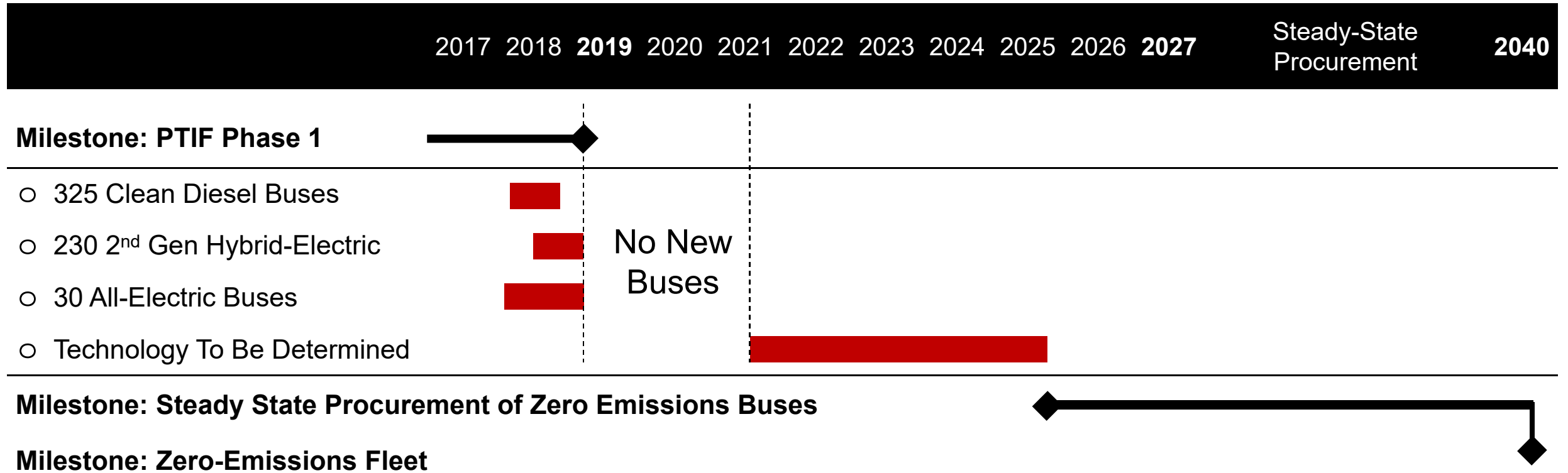
3. Report project status updates quarterly through the CEO Report.

5 | Existing and Proposed TTC Procurements

Impact on Bus Age Profile as of October 2017



6 | Next Steps



◆ Major Milestone

■ Est. Timeline



Questions

Thank you to our partners

