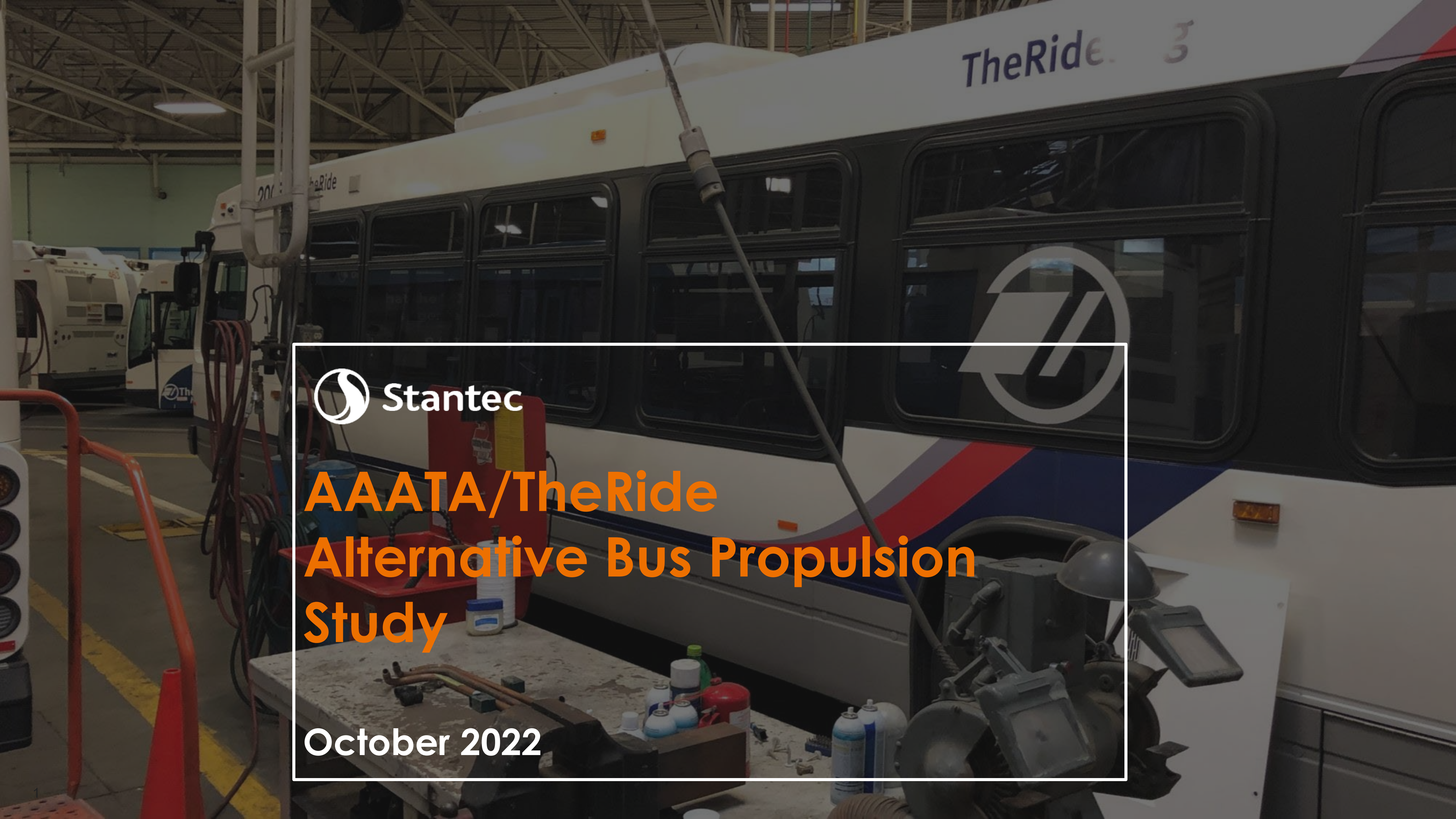

Stantec

AAATA/TheRide Alternative Bus Propulsion Study

October 2022

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Outline

1. Project overview
2. Context & Background
3. Benefits and Costs
4. Risks and Challenges
5. Technology Overview
6. Financial Evaluation
7. Conclusions
8. Next Steps

Project Overview

- Public transit agencies across the US have begun to adopt and transition to zero-emission buses (ZEBs) to reduce emissions from bus fleets
- TheRide's Board has directed the agency to explore alternative bus propulsion technologies as a way to reduce pollution from transit operations
- Michigan has no state mandate; no federal mandate (although a ZEB transition plan is needed to apply for federal funding)
- The federal government is prioritizing the funding of ZEBs as a way to combat climate change and improve air quality, particularly in historically disadvantaged communities
- We focused on ZEBs, but initially considered low-emission buses too

This is a preliminary exploration and NOT a final engineering or financial study. It is not an endorsement of one technology or another. Further detailed work is needed to move ahead.

Context / Background

- The City of Ann Arbor has established targets to reduce climate change through the (non-binding) A^2Zero Climate Action Plan
- The A^2Zero Plan estimated that TheRide's fleet emits ~10,700 tons of CO_2e annually—**0.5%** of GHGs throughout the region
- The A^2Zero Plan estimated that transitioning to ZEBs and the reduction in GHG would cost about **$5,800 per ton of GHG**
    - *A community solar program in the A2Zero Plan could eliminate about the same amount of GHG for about $18 per ton*
- Overall, the GHG emissions from AAATA's fleet is small and the cost to decarbonize is high

Benefits

- The modeling estimated **~7,000 tons of CO_2e** per year from the current fleet
- A ZEB fleet can reduce GHG emissions by **~27-50%** over the next 12 years
  - Not completely zero emissions because of carbon intensity of electrical grid as well as hydrogen supply chain, as well as continued diesel operations
- Once 100% ZEB, reducing 7,000 tons of CO_2e per year can amount to ~$371k of social benefit per year
- Potential cost savings around electricity vs. diesel fuel and potential savings around maintenance
- Quieter, smoother ride for customers and operators

Costs

- The chief cost drivers for the ZEB transition include the **premium on vehicles over diesel equivalents and the related fueling infrastructure**
- Capital cost estimates – up $75M above current diesel buses over 25 years
- Federal funding through competitive grants are available (up to 80% of capital), but long-term funding may be uncertain
- These transition costs and their funding needs must be balanced with other capital projects stemming from the long-range transit plan

What is a Zero-Emission Bus?

Battery Electric Bus (BEB)

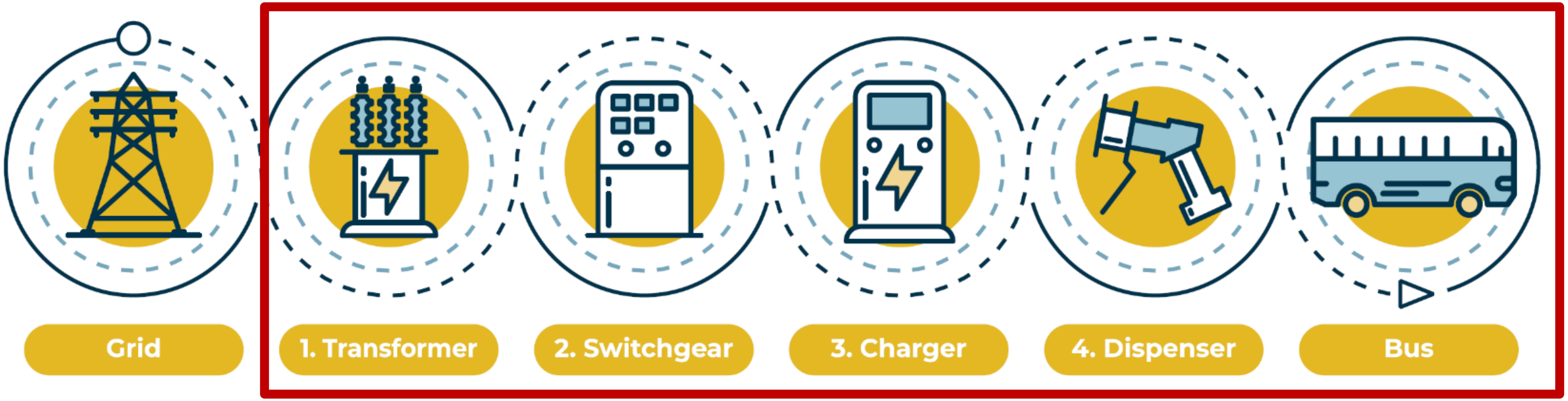
- Propulsion occurs from electricity directly stored in batteries
- Fueling occurs by recharging batteries

Hydrogen Fuel Cell-Electric Bus (FCEB)

- Propulsion occurs from hydrogen converted by fuel cells into electricity for propulsion
- Fueling occurs by refilling on-board hydrogen tank

Battery-Electric Buses

Items with 'significant' footprints



BEBs

Pros

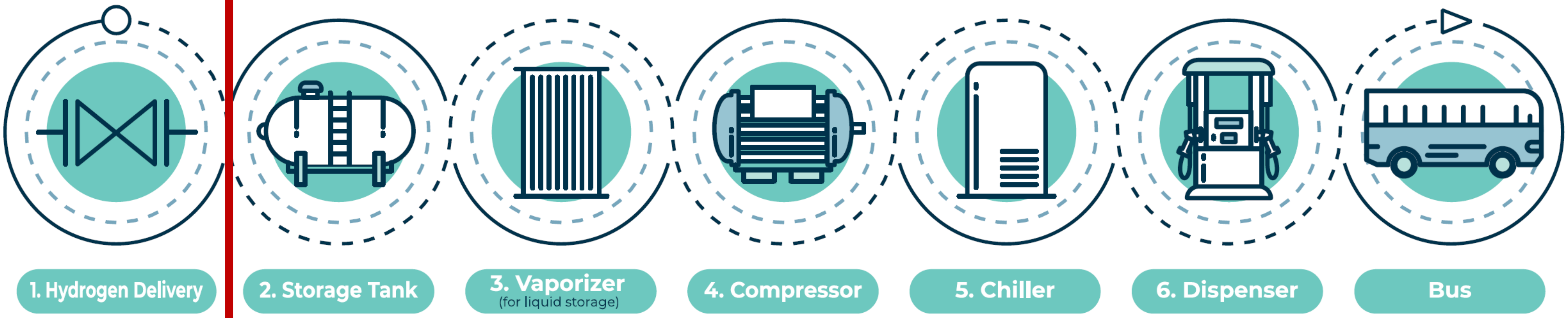
- Lower vehicle costs compared to hydrogen buses
- Lower maintenance costs
- Battery range expected to improve
- Lower fuel costs

Cons

- Range limited. Can deliver 62% of service in cold weather
- Space requirements for chargers and related infrastructure
- Electrical upgrades required
- Electricity rates more complex than diesel contracts
- Less cost effective at scale

Fuel Cell-Electric Buses

Items with 'significant' footprints



FCEBs

Pros

- Long operating range – can deliver over 90% of service in cold weather
- Minimal changes to servicing cycle (fueling, etc.)
- Lower maintenance costs
- More cost effective at scale

Cons

- Space requirements for on-site fueling infrastructure
- More expensive vehicles
- Significant building upgrades
- More expensive fuel compared to electricity – costs coming down

Financial Evaluation

Primary Inputs:

- Predictive modeling outcomes for BEBs and FCEBs
- Bus energy/fuel consumption
- Unit cost assumptions

Primary Outputs:

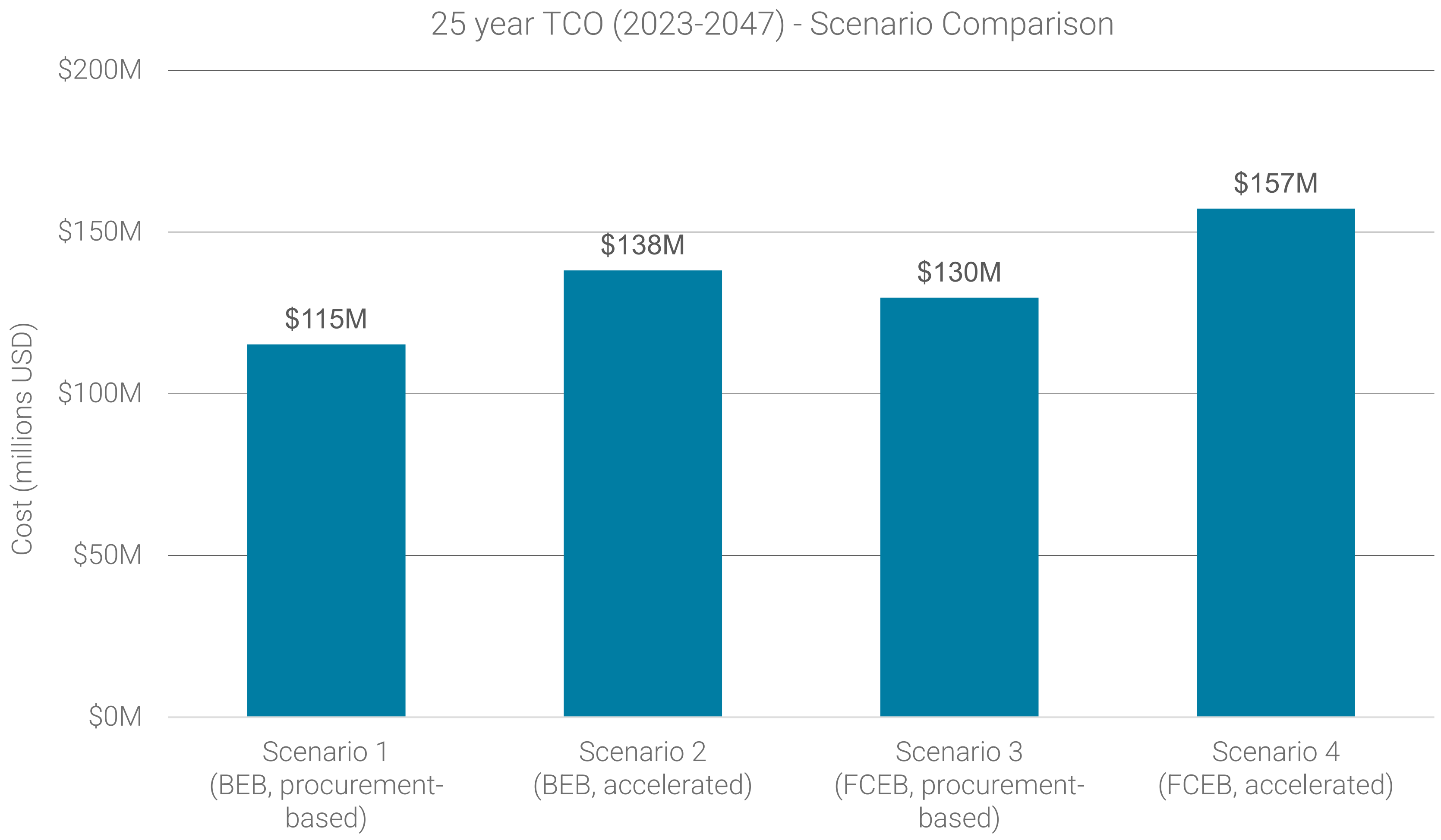
- Operating and capital cost comparisons to business-as-usual
  - Total cost of ownership across the 25-year horizon
  - Year-over-year cash flow implications

Scenarios Evaluated

Scenario 1: Transition to BEBs, procurement-based approach* • Annual replacement of 8 buses in line with current procurement practices • Long-range BEBs considered w/ 675 kWh battery • **Full fleet transition by 2036**	**Scenario 2: Transition to BEBs, accelerated approach*** • Long-range BEBs considered w/ 675 kWh battery • **Full fleet transition by 2030**
Scenario 3: Transition to FCEBs, procurement-based approach • Annual replacement of 8 buses in line with current procurement practices • 37.5 kg hydrogen tank and 100 kWh battery • **Full fleet transition by 2036**	**Scenario 4: Transition to FCEBs, accelerated approach** • 37.5 kg hydrogen tank and 100 kWh battery • **Full fleet transition by 2030**

**Assumes 1:1 replacement based on assumed battery improvements. To start transition on easier to electrify blocks, reblocking may be needed.

Scenario Total Cost of Ownership Comparison

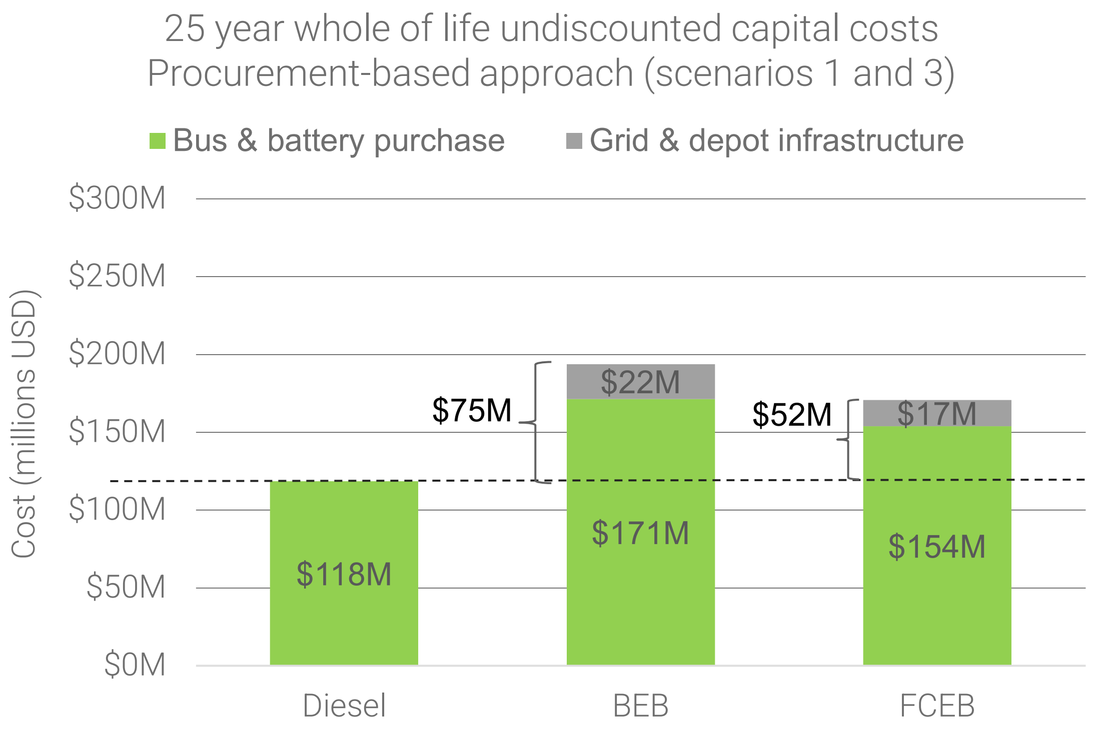


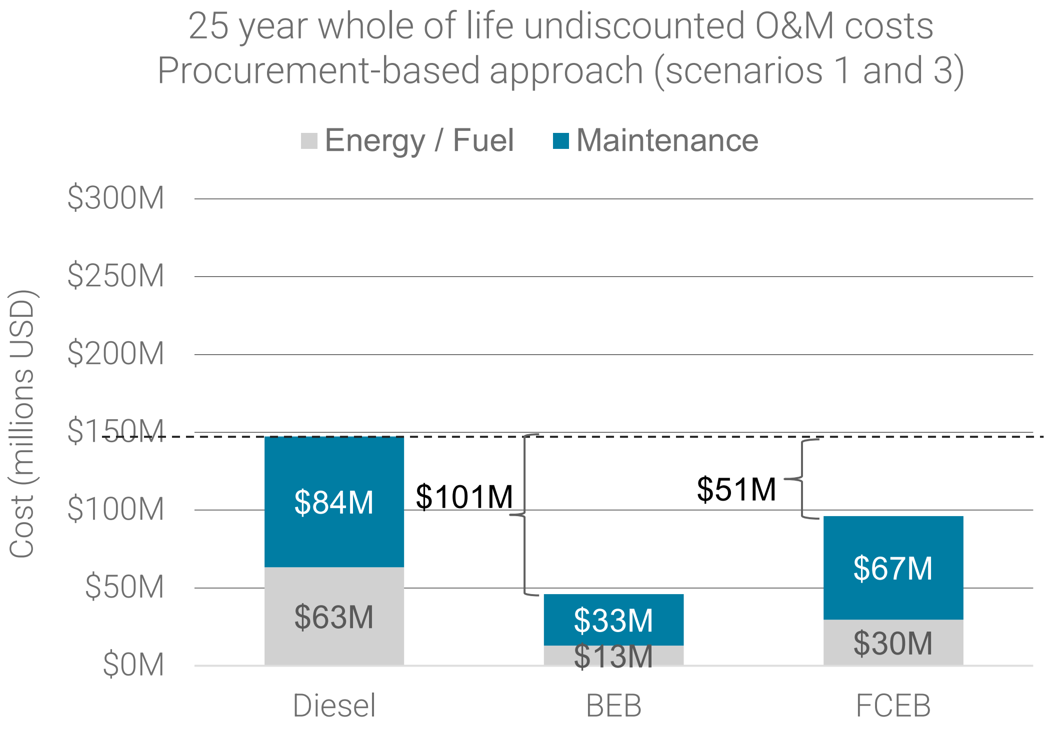
After balancing total capital requirements, the timing of investments, and O&M savings potential, and then comparing the *relative* financial impacts of the scenarios, we can make two observations:

1. The procurement-based approach is more pragmatic than the accelerated approach.

2. Implementing BEBs is expected to have fewer net costs over the 25-year horizon than implementing FCEBs.

How much will the procurement-based approach cost?





Takeaways:

- Scenario 1 requires incremental net capital requirements of $75M across the 25-year horizon, which includes a $7.7M investment in year 1 (2023).
- Scenario 1's O&M savings potential across the 25-year horizon is $101M
- However, future cash flows are sensitive to future vehicle and infrastructure capital costs, which can be difficult to predict. Additionally, the modeling does not account for a possible increase in fleet size which may be required.

Conclusions

- A full transition to ZEBs will impact GHGs in the Ann Arbor area by less than 1%
- ZEBs could potentially result in O&M savings, but an upfront short-term investment up to $75M over and above business-as-usual will be required

BIGGEST CHALLENGES

Facility constraints

Infrastructure upgrades

Cost uncertainties and technology maturation

Staff and resource capacity

Funding and local matches

BIGGEST OPPORTUNITIES

Pollution reduction and societal benefits

Potential cost savings for fuel and maintenance

Quieter buses

Next Steps

- TheRide will engage with the community and staff regarding the technologies described in this study
- Feedback is being sought. Please visit www.TheRide.org
- TheRide will use the results of discussions to chart a path forward on implementation