

City of Mankato

Zero Emission Bus Fleet Transition Study

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Introduction

- Goal:
Feasibility of transitioning City of Mankato's fixed-route fleet to 100% zero-emission technology by 2040

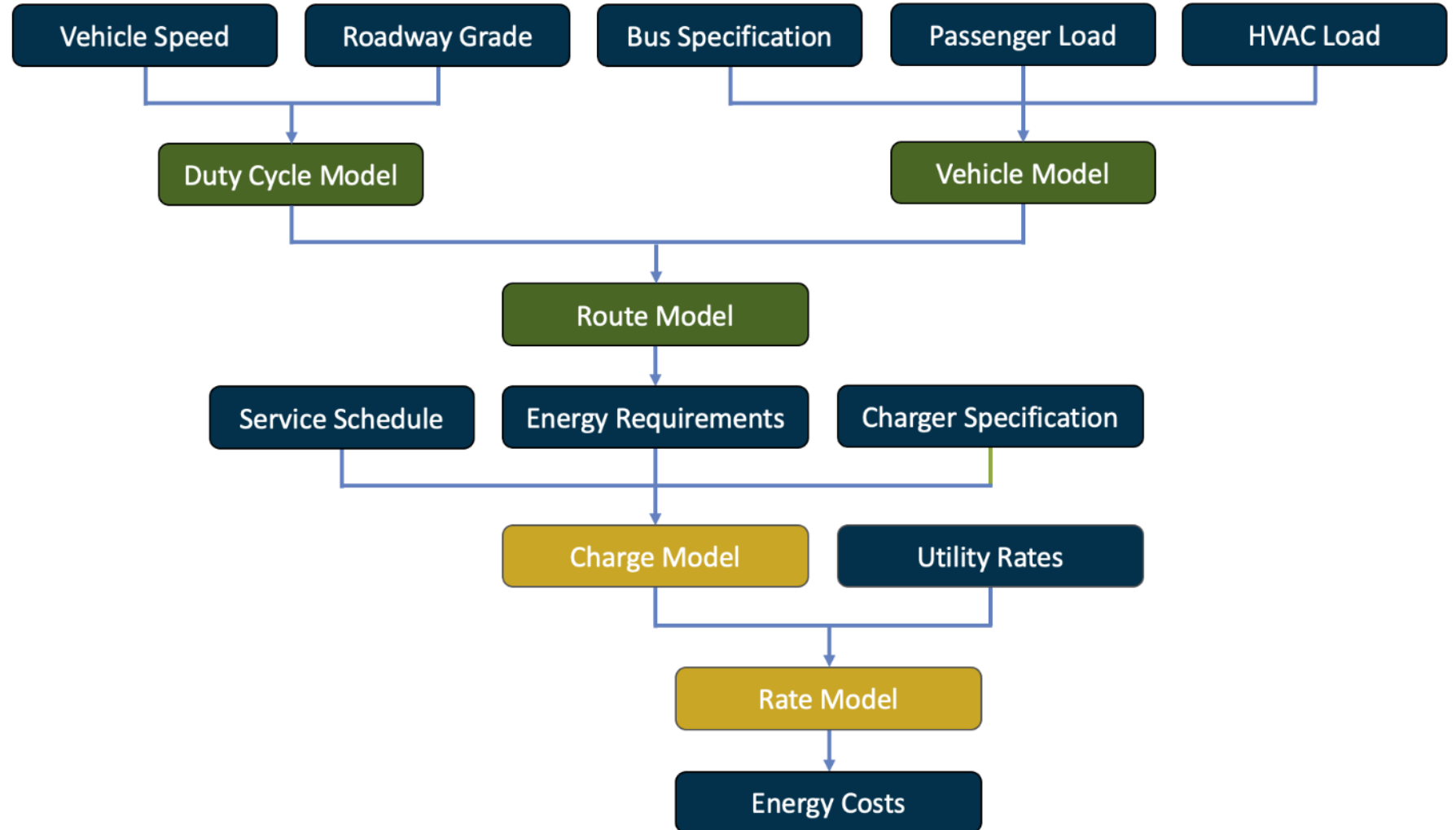


Service Assessment

Modeling & Analysis Methodology

Service Assessment:

- Determines the percentage of the agency's blocks that will be achievable each year





Assumptions: Vehicle Performance

Assumption Category	Assumption Details
Usable Energy	80% of nameplate battery capacity
Battery Degradation Estimate	69% of nameplate battery capacity
Vehicle Efficiency	All-electric heater
Battery Capacity	Increases 5% every 2 years based on anticipated technology improvements
Strenuous Conditions	HVAC loads at 17°F and auxiliary loads between 12-18 kW
Nominal Conditions	HVAC loads at 65°F and auxiliary loads between 3-5 kW

BEB Block Feasibility Percentage by Year

Bus Size [ft]	Block Quantity	Max. Block Distance (mi)	% Feasible in 2024	% Feasible in 2026	% Feasible in 2028	% Feasible in 2030	% Feasible in 2032	% Feasible in 2034	% Feasible in 2036	% Feasible in 2038	% Feasible in 2040
Cutaway	3	219	0%	0%	0%	0%	0%	0%	0%	0%	0%
35'	8	213	13%	13%	13%	13%	13%	13%	13%	25%	25%
40'	4	200	75%	75%	75%	75%	75%	75%	75%	75%	75%

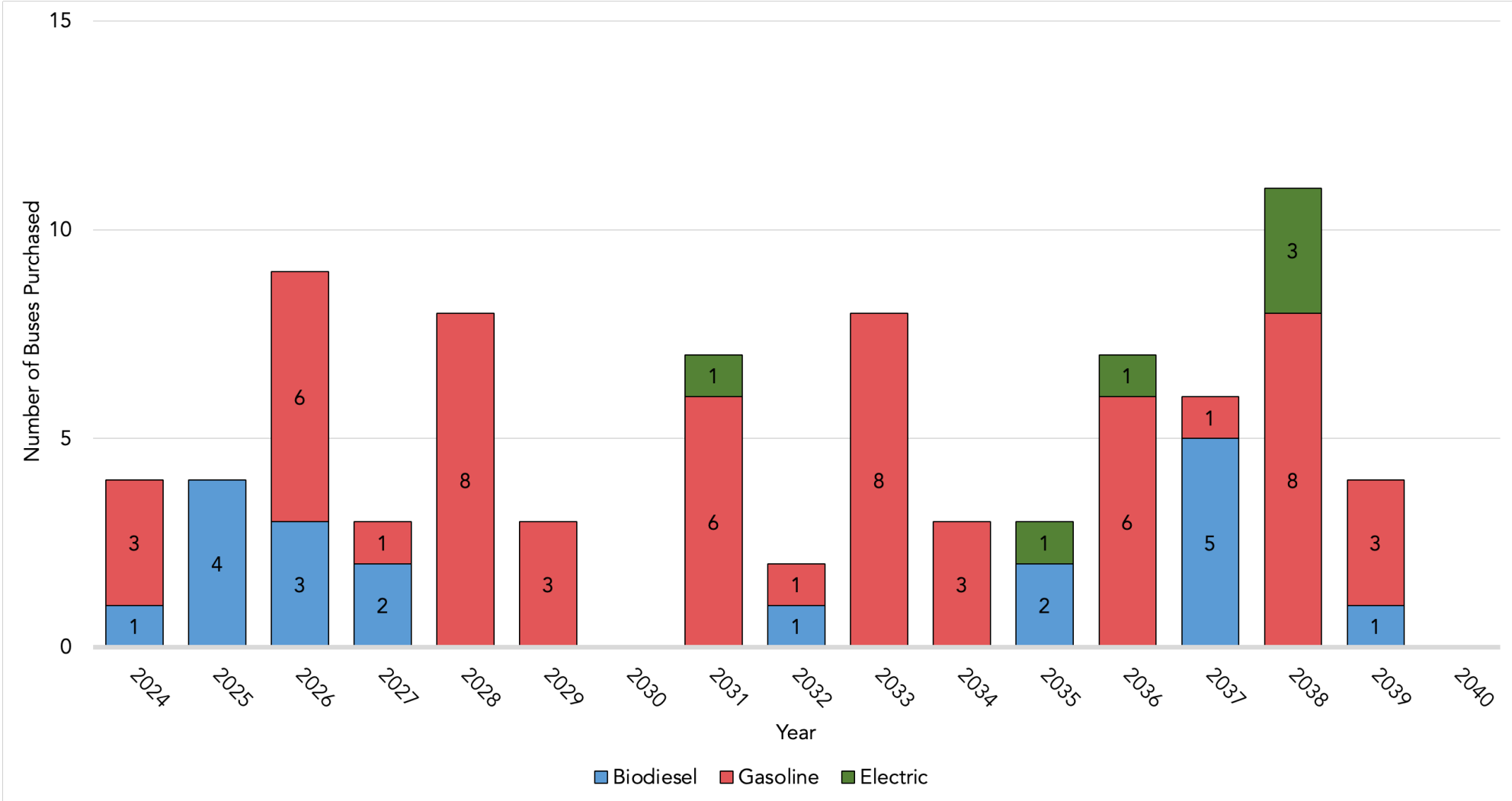
- Results are shown for every 2 years of transition (2024-2040)

Service Assessment - Summary

- Cutaway vehicles achieve 0% of all blocks by 2040
- 35' BEBs achieve 13% by 2035 and 25% by 2040
- 40' BEBs achieve 75% by 2035 and 75% by 2040
- Overnight charged BEBs cannot complete all current Mankato blocks by 2040
- CTE and Mankato decided on the following scenarios:
 - **BEB Depot Only**
 - **BEB Depot and On Route Charged**
 - **FCEB Only**
- All blocks are assumed feasible with FCEBs

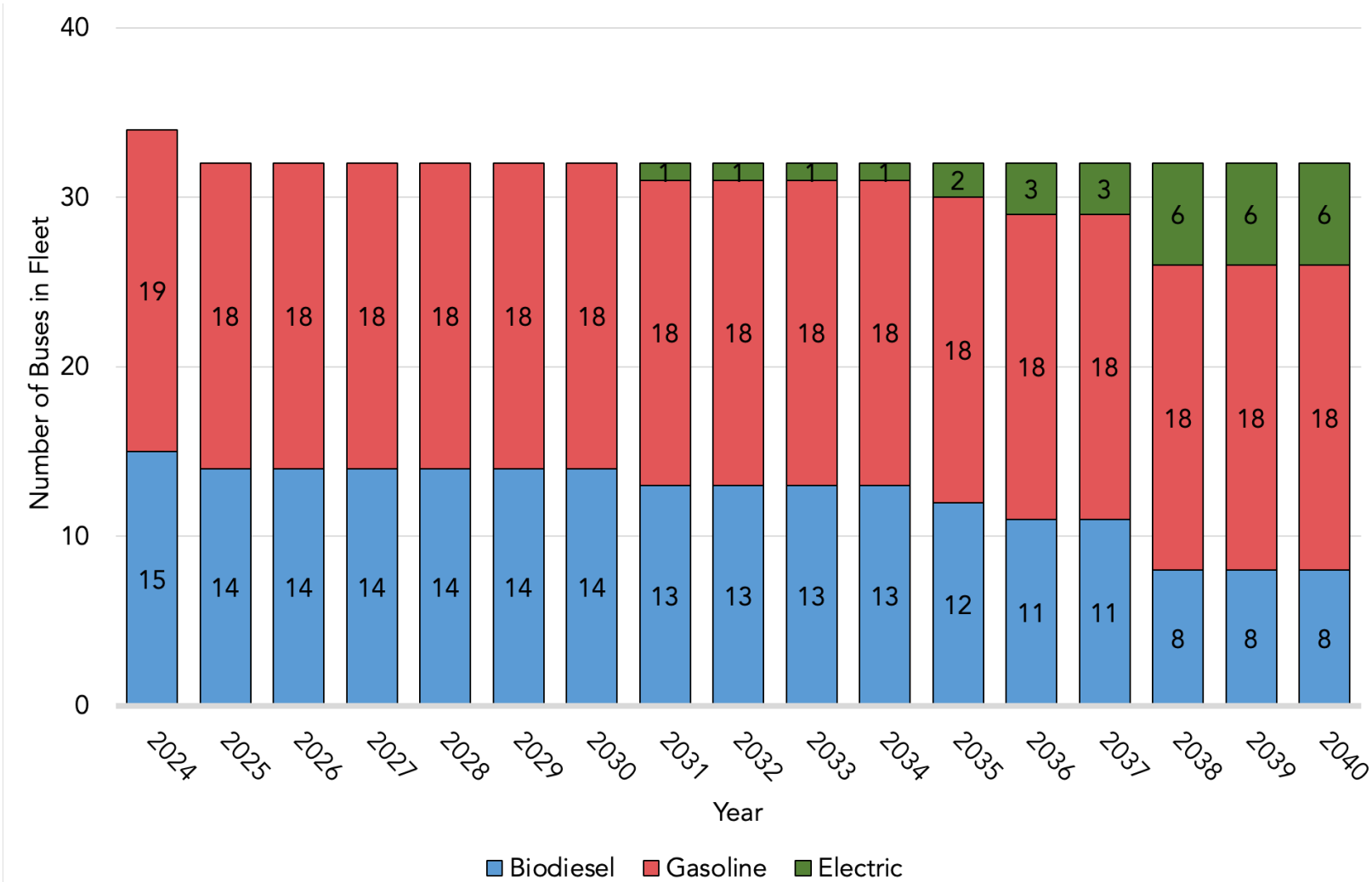
Procurement Phase-In Projection

BEB Depot Only



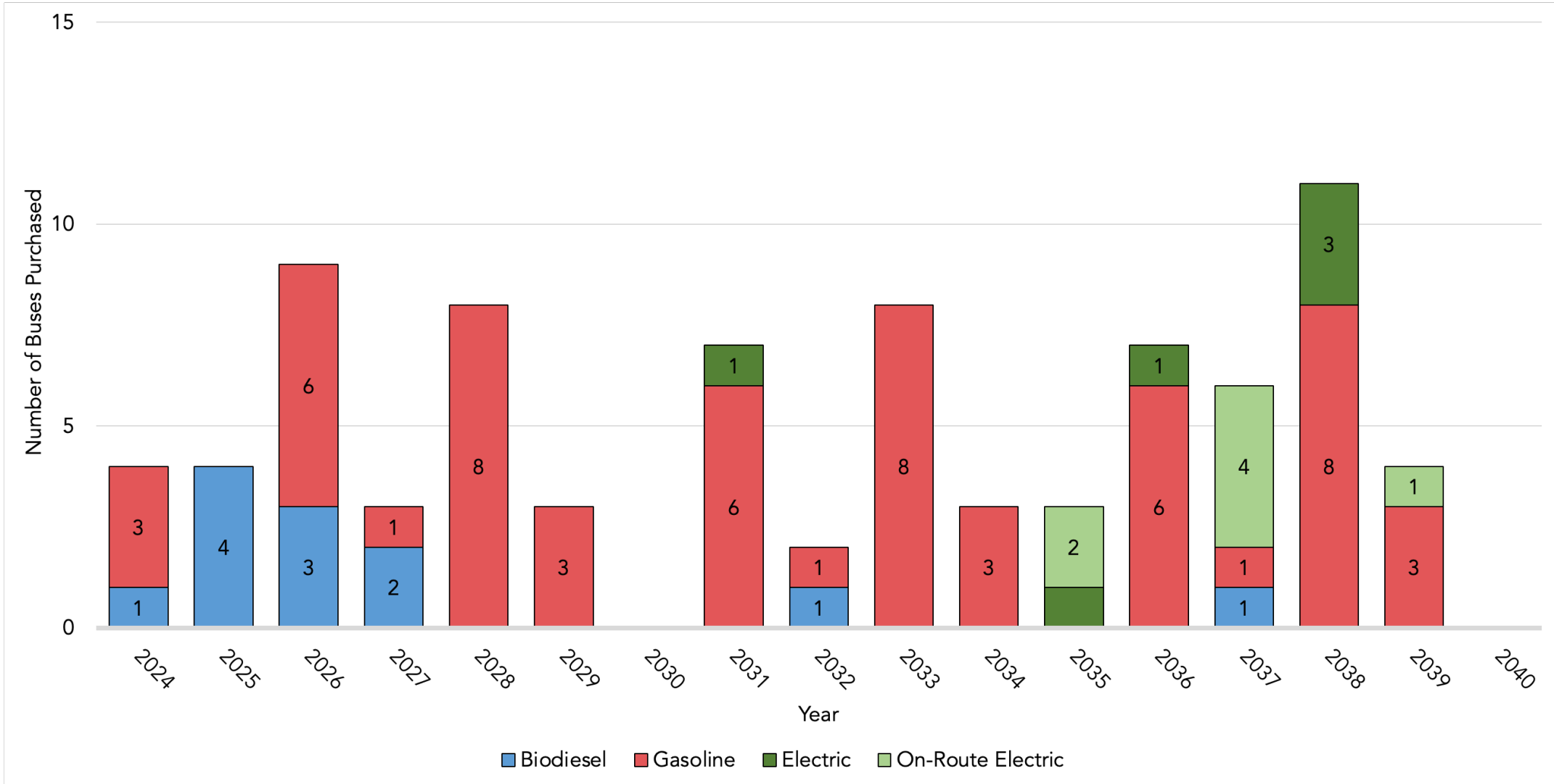
Fleet Composition

BEB Depot Only



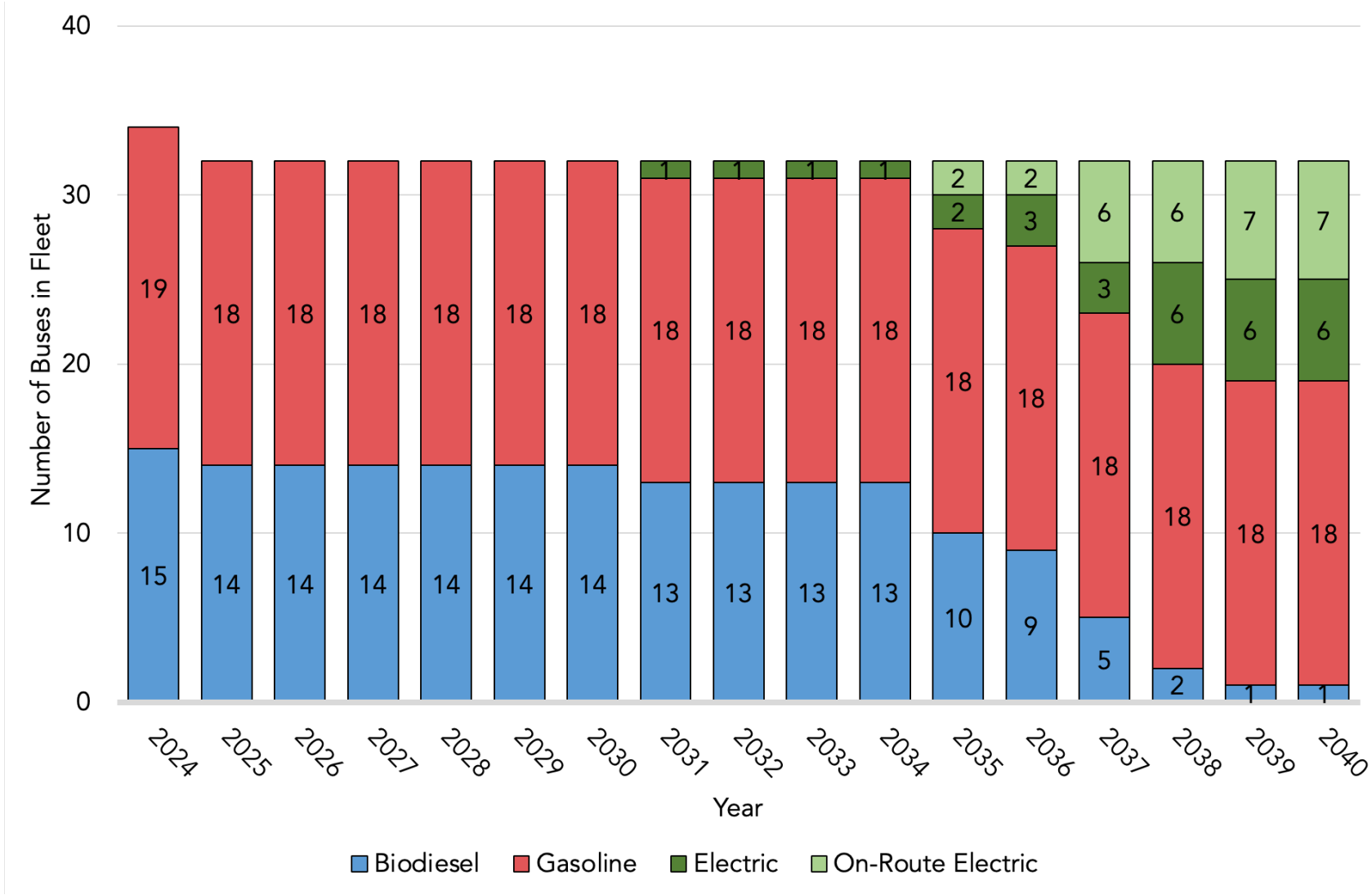
Procurement Phase-In Projection

BEB Depot and On Route



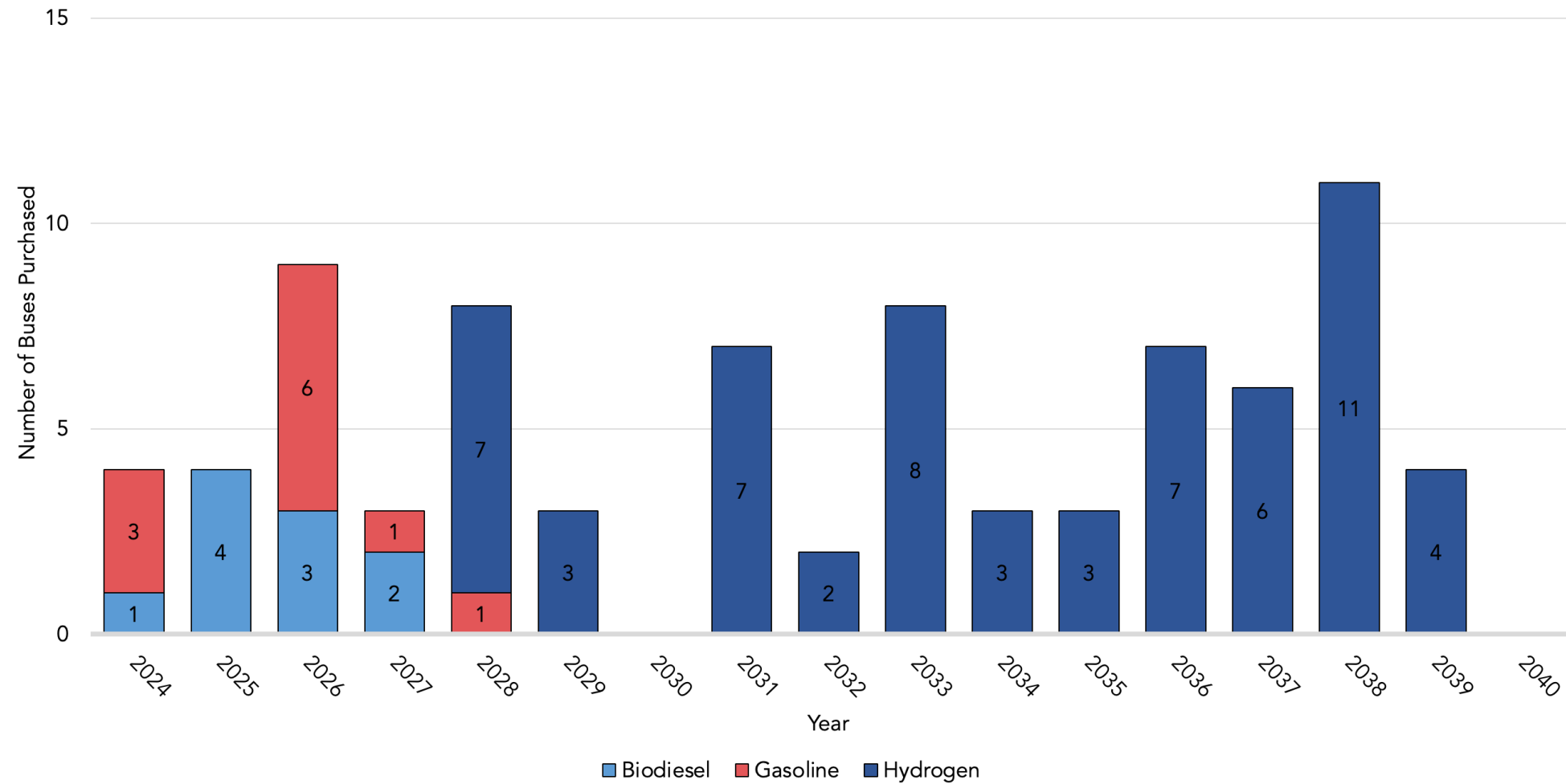
Fleet Composition

BEB Depot and On Route



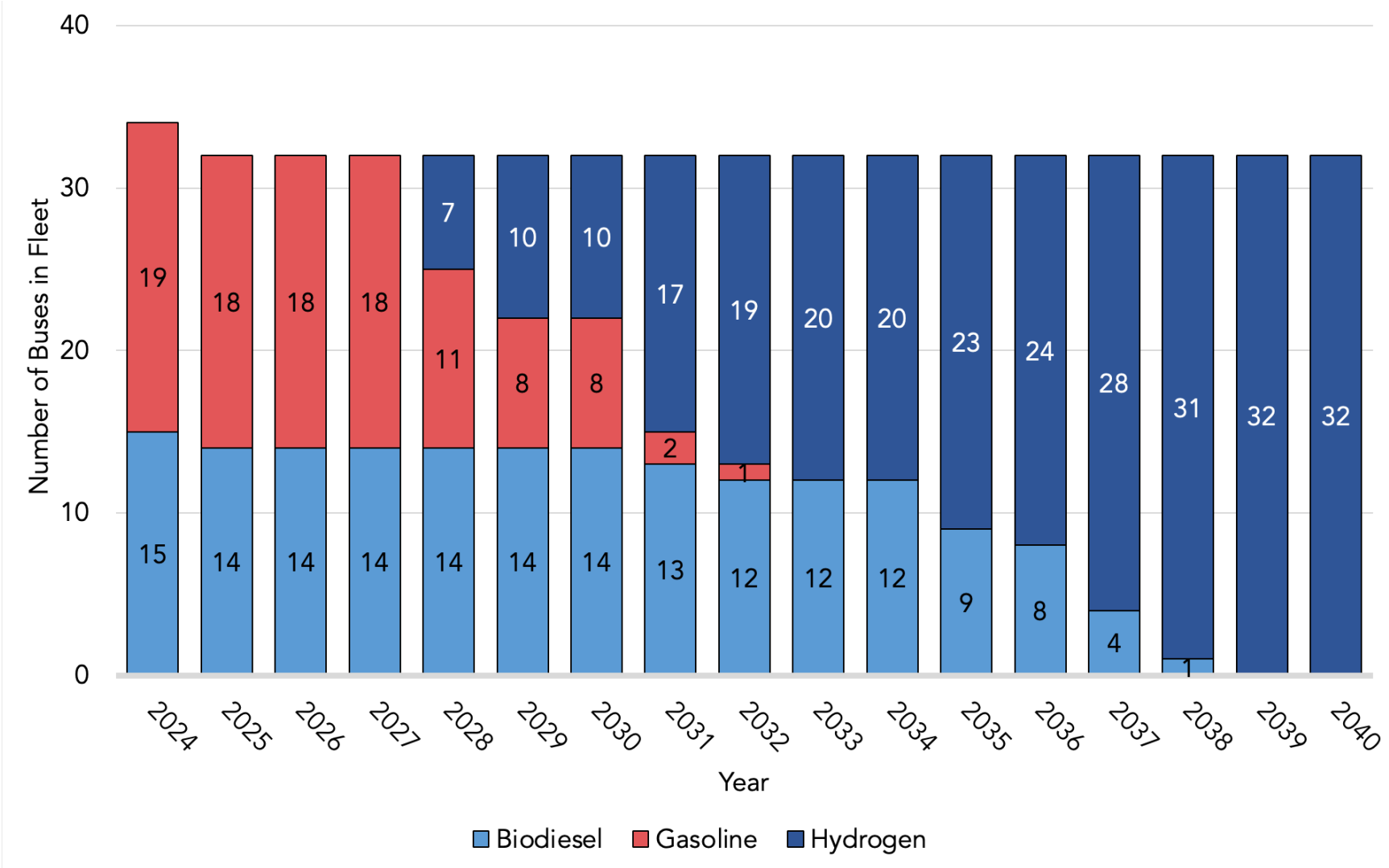
Procurement Phase-In Projection

FCEB Only



Fleet Composition

FCEB Only

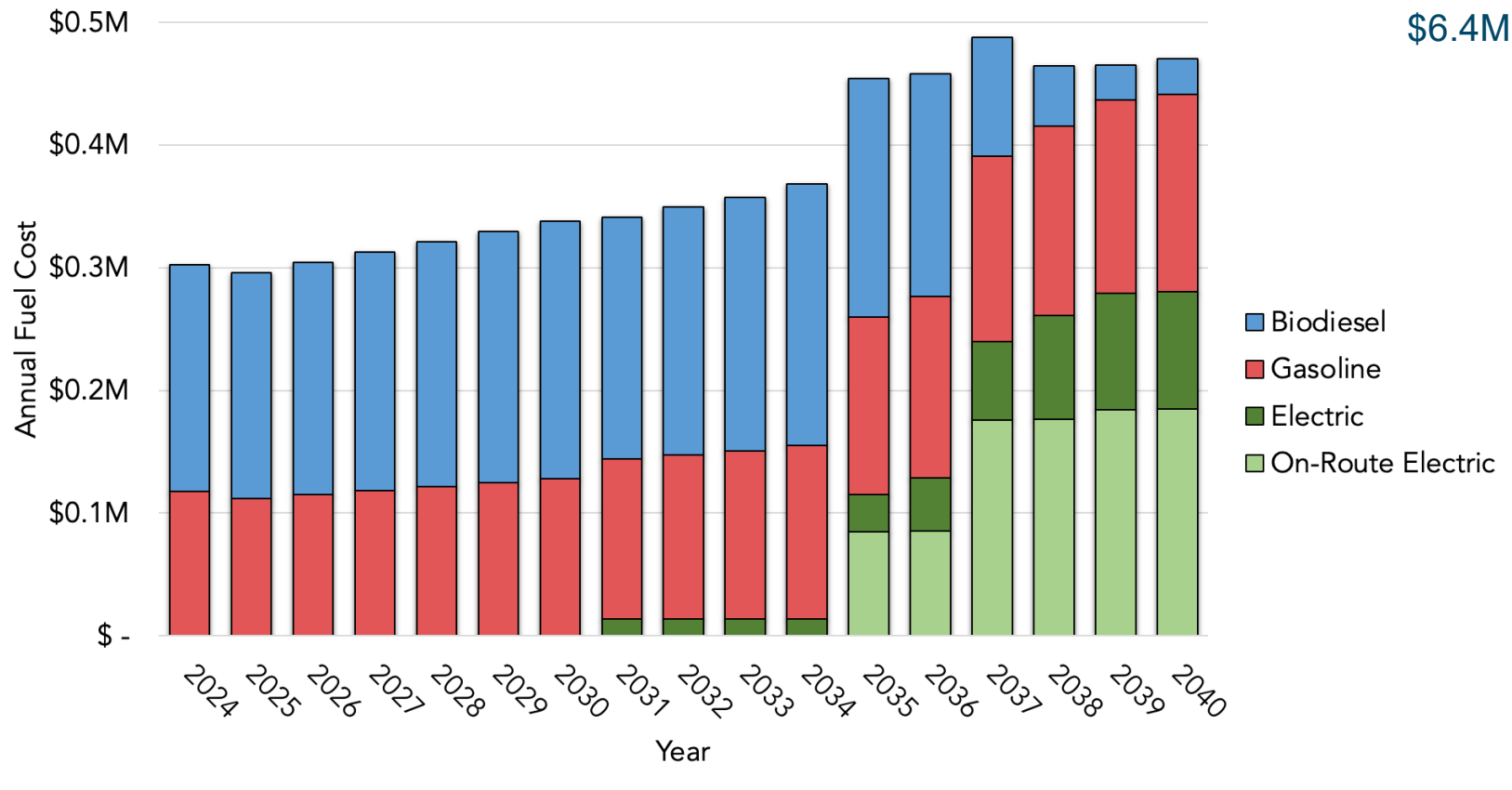


Fuel Assessment



Annual Fuel Costs by Fuel Type

BEB Depot and On Route



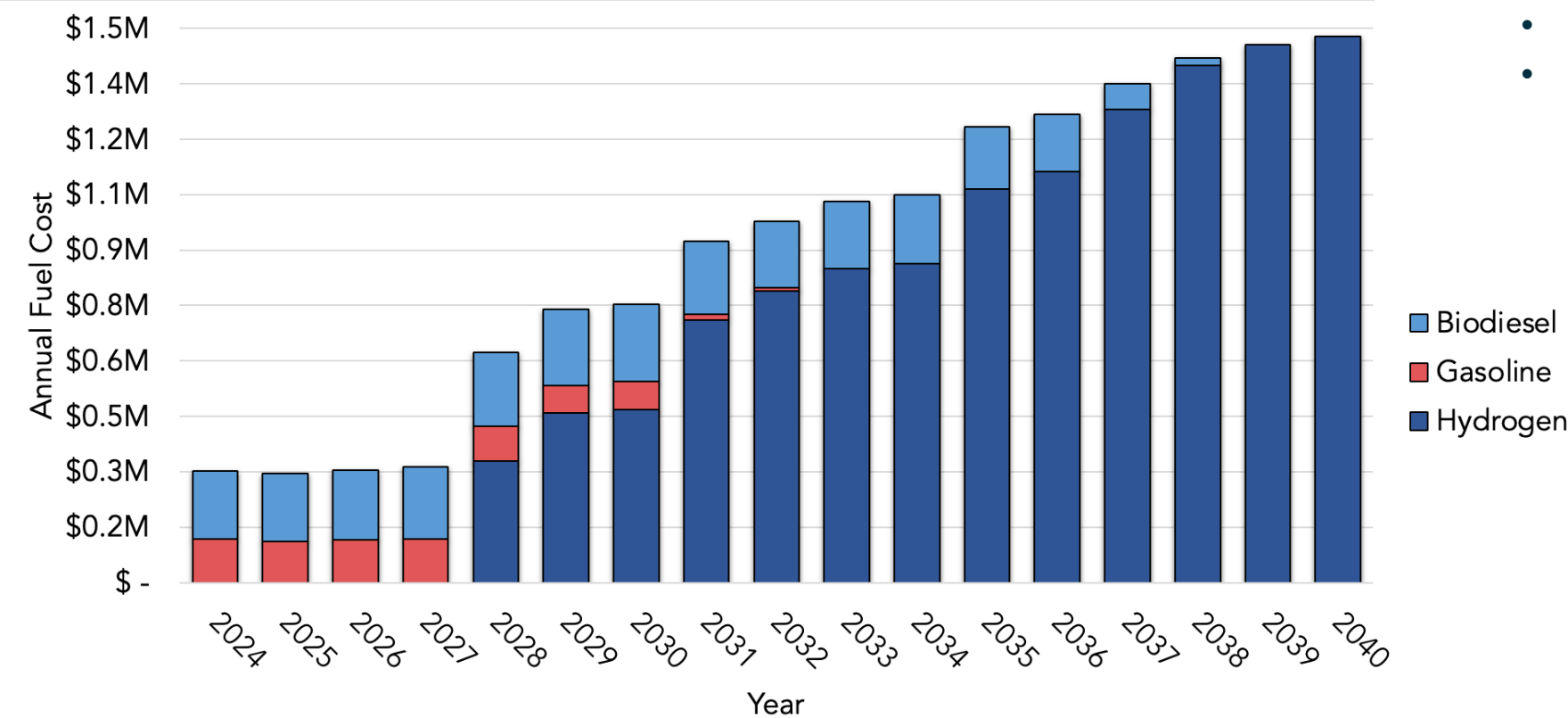
\$6.4M total expenditures from 2024-2040

- \$2.8M – Biodiesel
- \$2.3M – Gasoline
- \$469K – Electric
- \$891K – Electric (On Route)

Annual Fuel Costs by Fuel Type

FCEB Only

- \$15.5M total expenditures from 2024-2040
 - \$2.5M – Biodiesel
 - \$734K – Gasoline
 - \$12.3M – Hydrogen



Maintenance Assessment

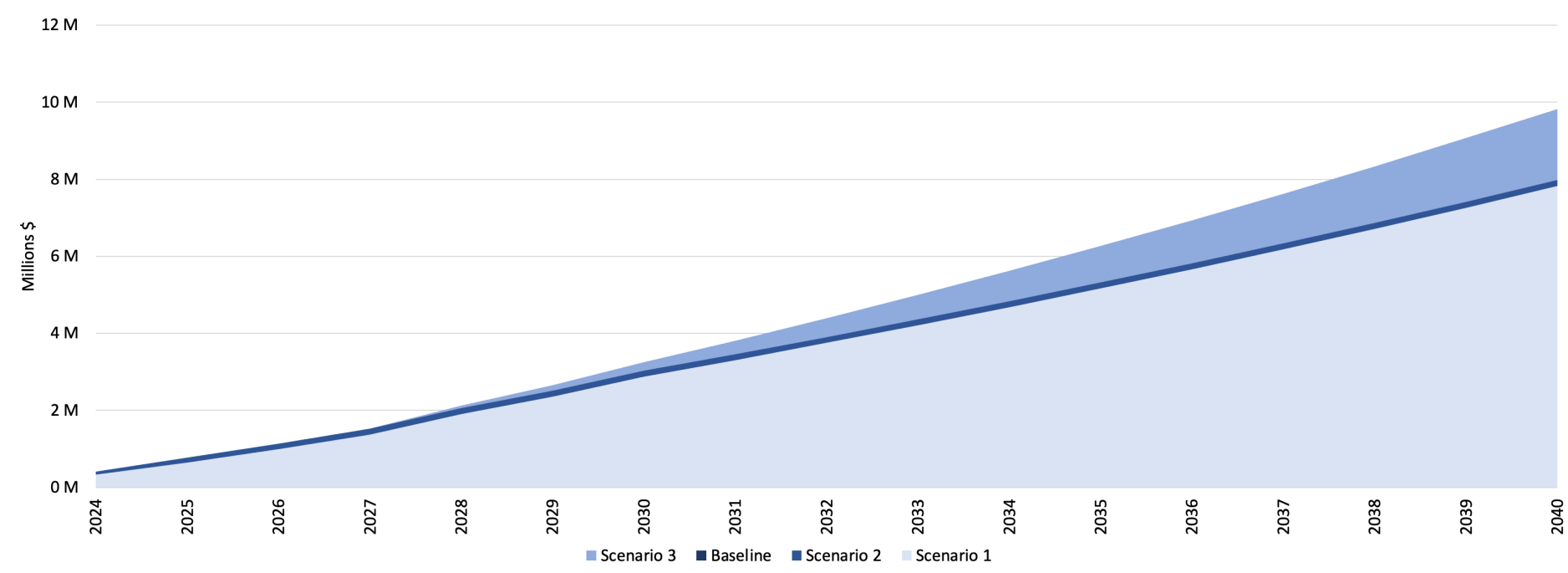
Maintenance Assessment Assumptions: Cost

Fuel Type	\$/mi	Source
Bio-Diesel	\$0.72	Mankato Maintenance Cost
Gasoline	\$0.33	Mankato Maintenance Cost
Electric	\$0.72	Equal to Bio-Diesel
Fuel Cell	\$0.56	Industry Average



Cumulative Comparison

All Scenarios

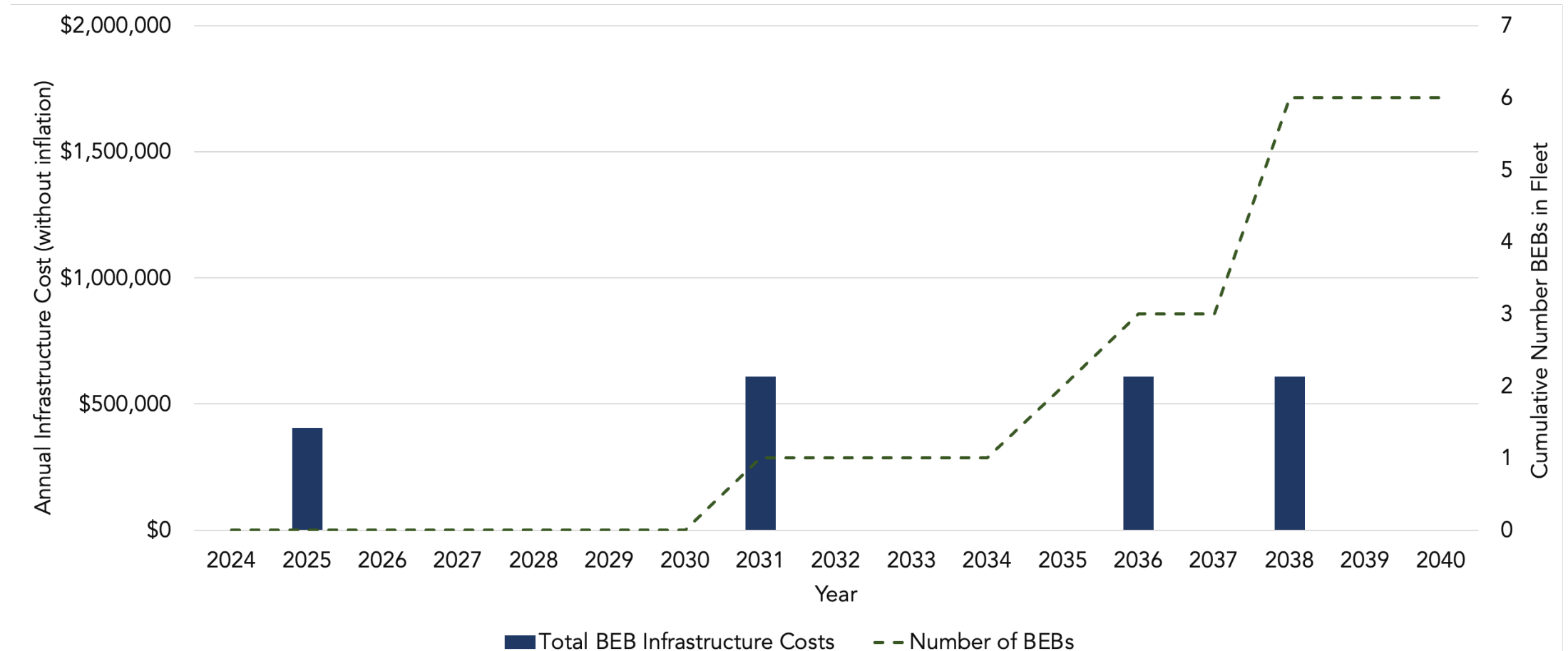


Costs	Baseline	ZEB Scenario 1 (BEB Depot)	ZEB Scenario 2 (BEB Depot & ORC)	ZEB Scenario 3 (FCEB)
Cumulative (\$)	\$8M	\$7.8M	\$8M	\$9.8M
Incremental over Baseline (\$)	-	-\$154K	-	+\$1.8M
% ZEB Fleet by 2040	0%	19%	41%	100%

Facilities Assessment

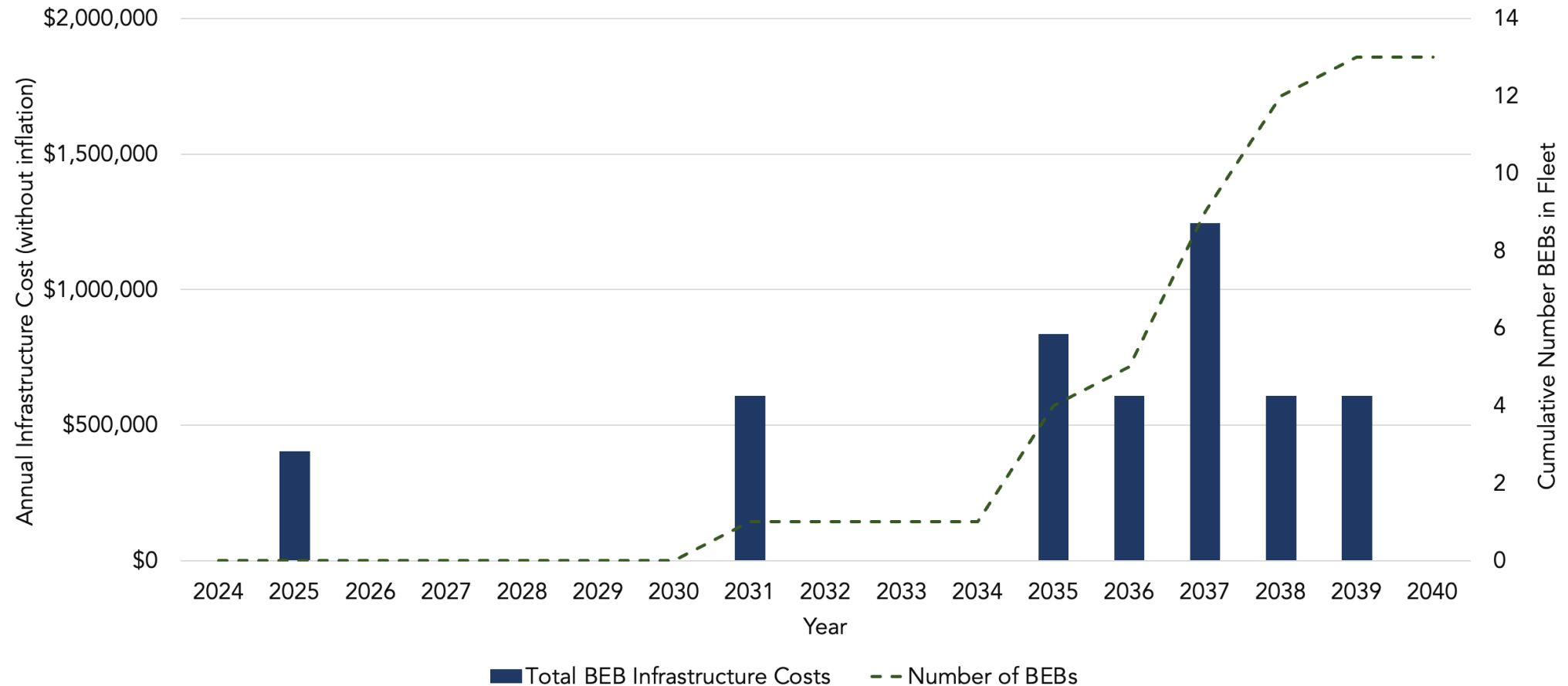
Facilities Assessment – Annual Costs

BEB Depot Only Scenario



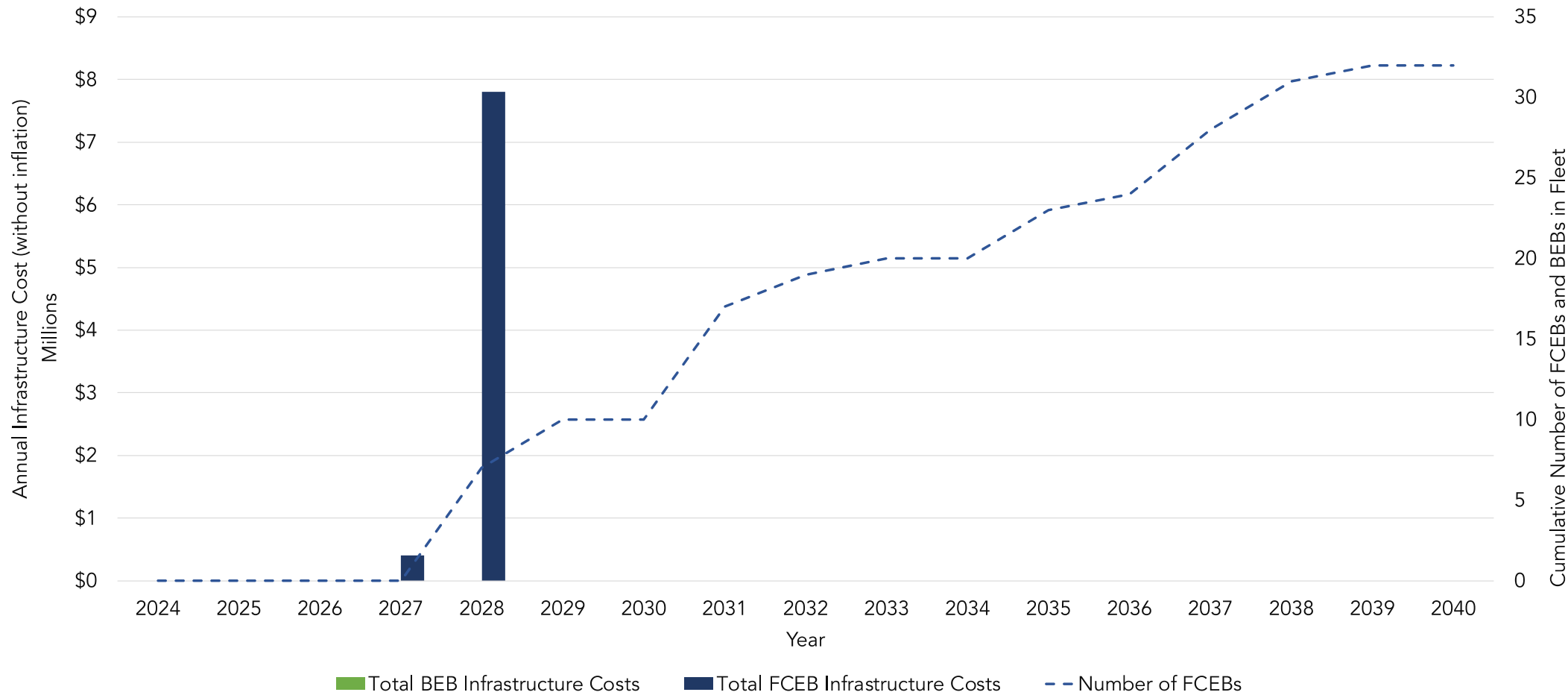
Facilities Assessment – Annual Costs

BEB Depot and On Route



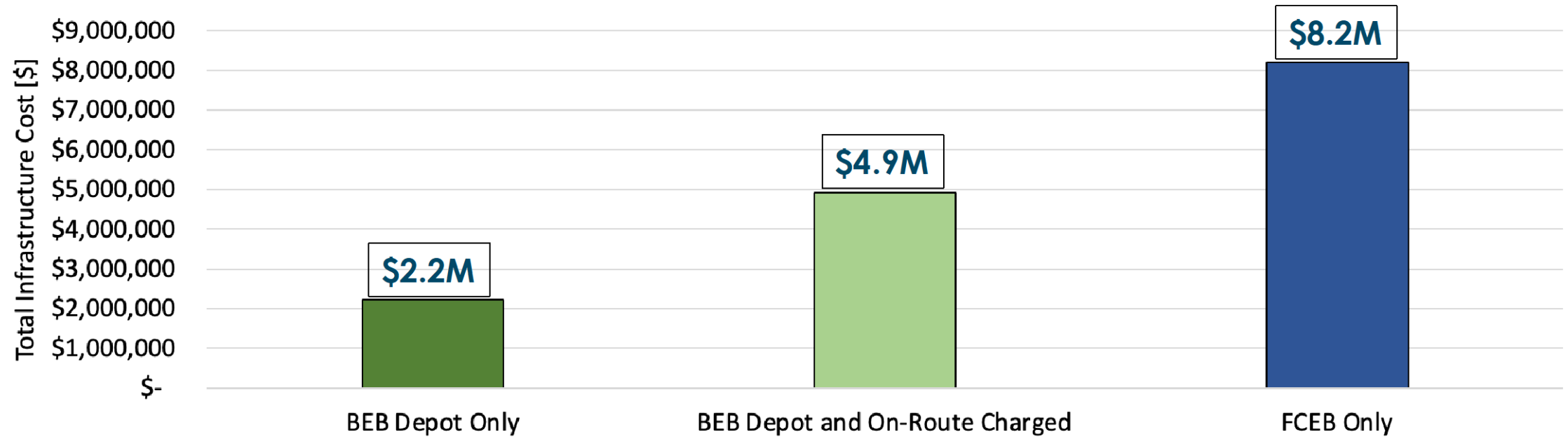
Facilities Assessment – Annual Costs

FCEB Depot Only Scenario



Cumulative Comparison

All Scenarios



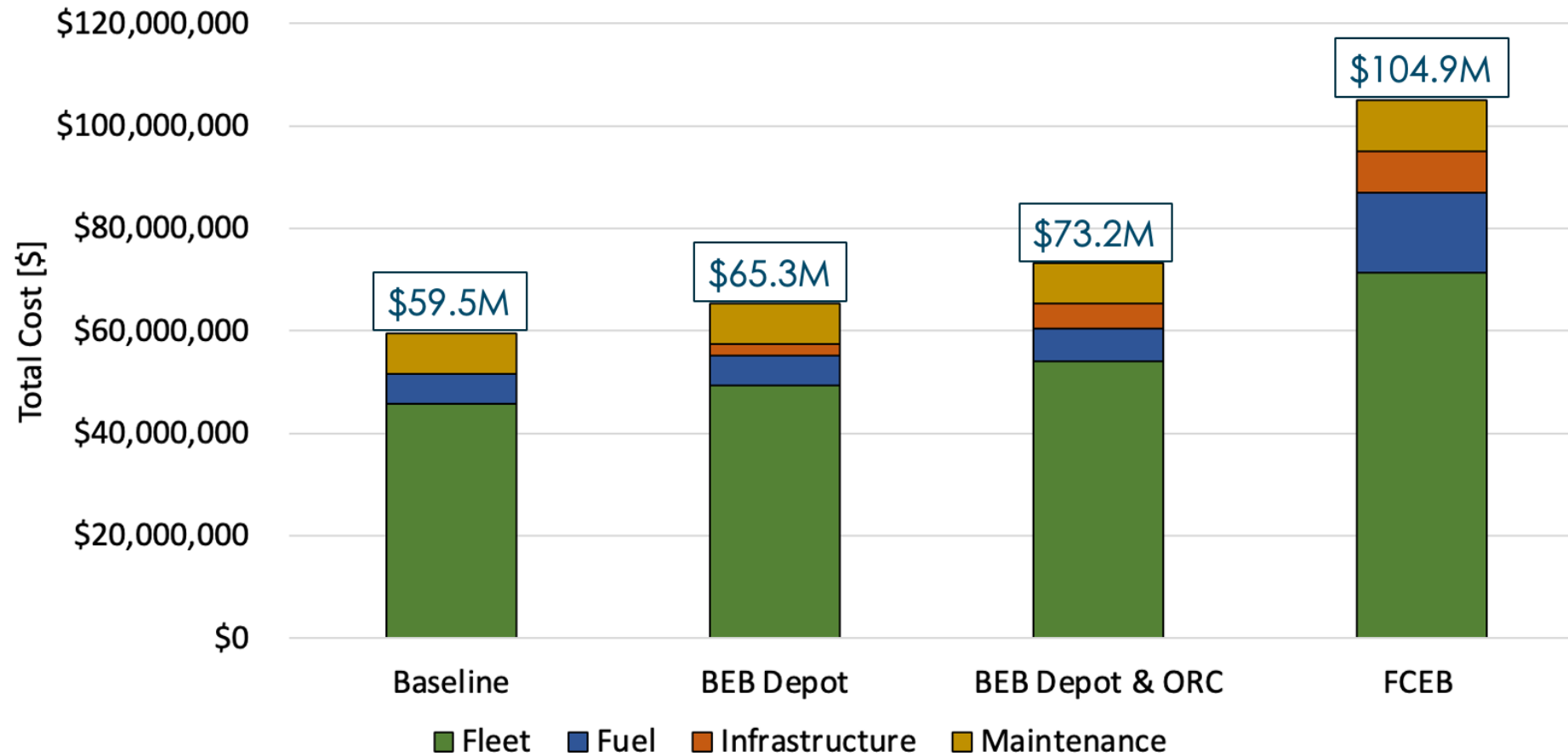
Total Cost of Ownership Assessment



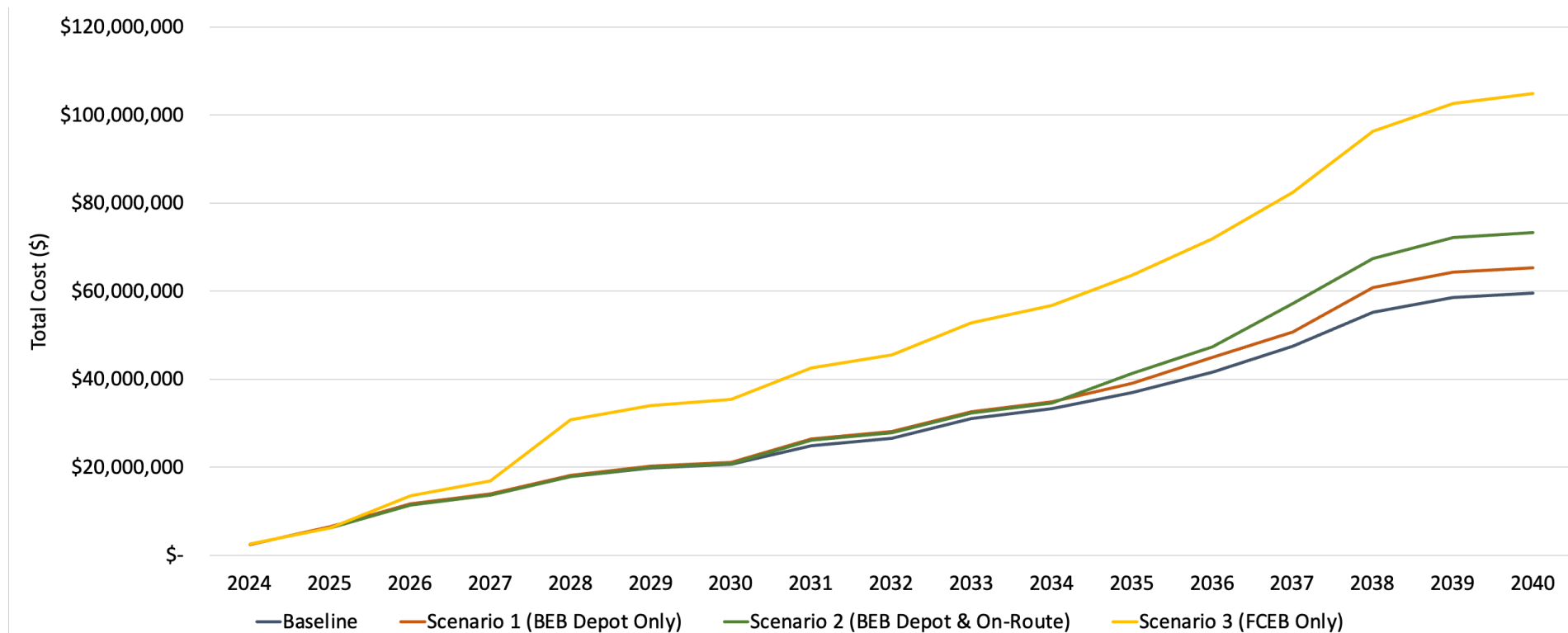
Total Cost of Ownership Assessment Methodology

- Compiles total cost results from Fleet, Fuel, Facilities, and Maintenance Assessments to show cumulative and annual costs through 2040
- Includes selected capital and operating costs of each fleet scenario
- Assumes no cost escalation or any cost reduction due to economies of scale for ZEB technology
- Future changes to Mankato's service level, depot locations, route alignments, and block scheduling were kept consistent

Total Cost of Ownership by Assessment Type



Total Cost of Ownership by Scenario



Total cost from 2024-2040:

- \$59.5M – Baseline
- \$65.3M – BEB Depot Only
- \$73.2M – BEB and ORC
- \$104.9M – FCEB Only



Total Cost of Ownership by Scenario and Assessment

Assessment	Baseline	ZEB Scenario 1 (BEB Depot)	ZEB Scenario 2 (BEB Depot & ORC)	ZEB Scenario 3 (FCEB Only)
Fleet	\$45,665,000	\$49,270,000	\$53,934,000	\$71,401,000
Fuel	\$5,904,000	\$5,930,000	\$6,422,000	\$15,521,000
Infrastructure	-	\$2,228,000	\$4,916,000	\$8,200,000
Maintenance	\$7,977,000	\$7,823,000	\$7,977,000	\$9,824,000
Total	\$59,546,000	\$65,251,000	\$73,250,000	\$104,946,000
Compared to Baseline	-	+\$5,705,000	+\$13,703,000	+\$45,400,000
% ZEB	0%	19%	41%	100%

Conclusion

BEB Depot Only scenario

- Total cost: \$65,251,000
- \$5,705,000 more than Baseline
- 19% ZEB fleet by 2040

BEB Depot and On Route Charged scenario

- Total cost: \$73,250,000
- \$13,703,000 more than Baseline
- 41% ZEB fleet by 2040

FCEB Only scenario

- Total cost: \$104,946,000
- \$45,400,000 more than Baseline
- 100% ZEB fleet by 2040

Recommendations

CTE recommends:

- Select a preferred scenario to refine and remain proactive with ZEB deployment grants
- Monitor local and regional developments
- Evaluate requirements for workforce and stakeholders
- Match the individual bus technology to the individual route and blocks

Thank you.

Questions?

