Intercity Zero-Emissions Analysis

Analysis Overview

Project Goals

Intercity Zero Emissions Analysis

Project Goals

- Perform an analysis of current and emerging zero emission vehicle technology to assist Intercity in preparing for the development of a long-term zero emissions fleet transition plan.
- Understand the barriers, constraints, risks associated with transitioning to zero emission.

ZEB 101

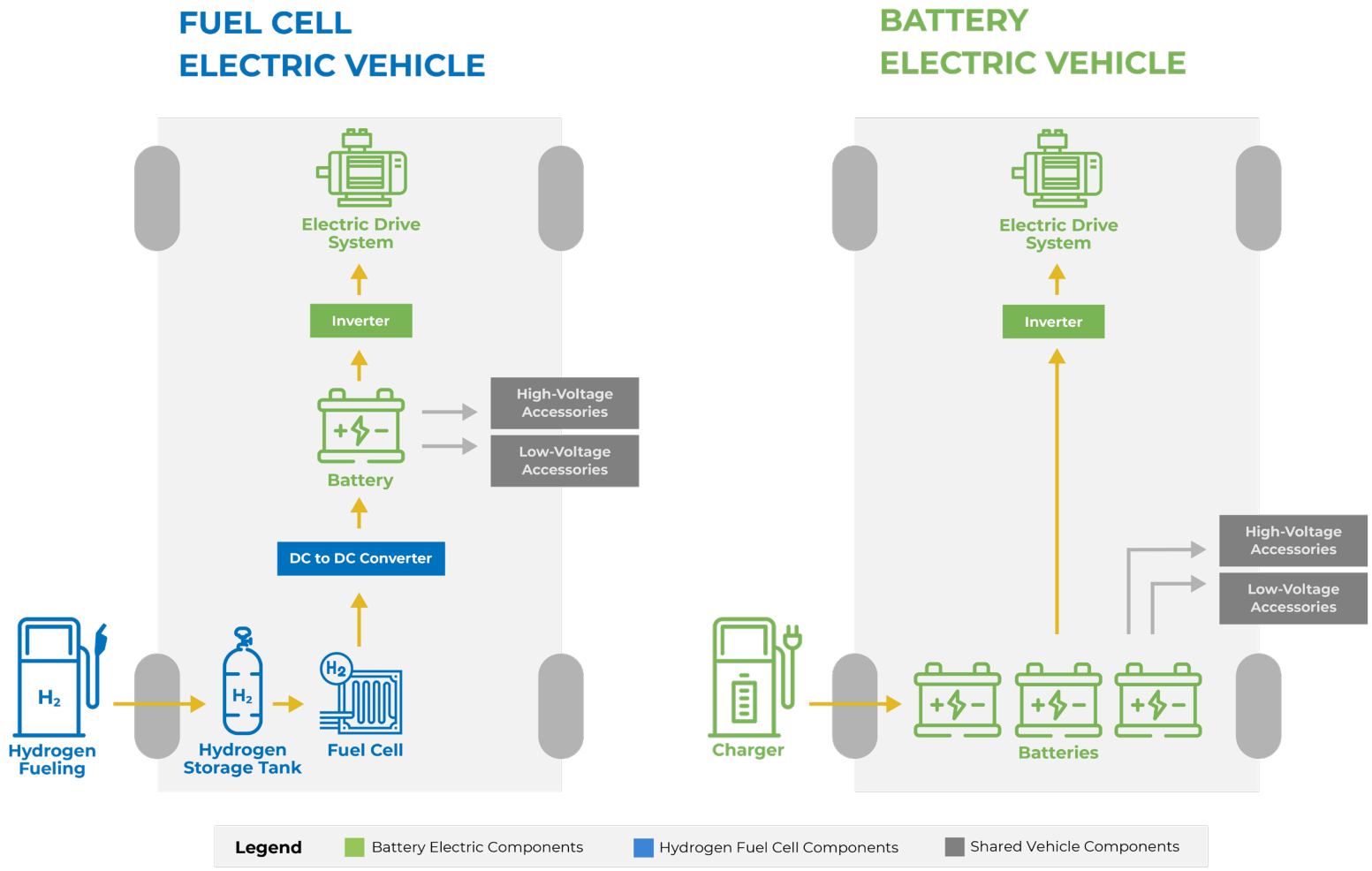
Zero Emission Buses —What's Different?

Propulsion System
- *Traction Motor instead of engine*

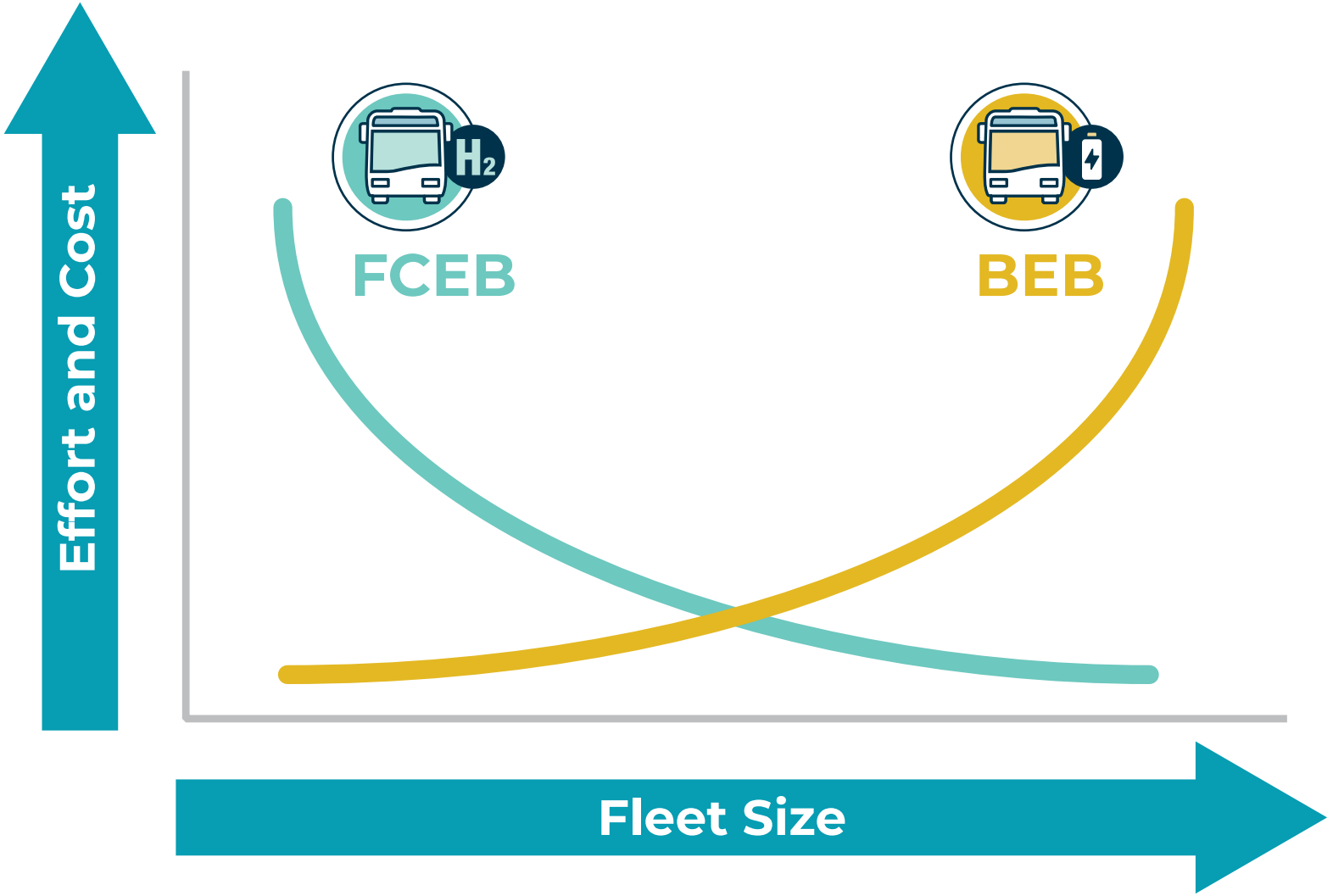
Energy Storage System
- *Battery instead of fuel tank*

HVAC
- *No "free" heat*
- *Electric heater*

Time to "Re-fuel"
- *FCEB: 10 minutes*
- *BEB: ~3 hours*



Scalability



Zero Emission Transit Bus OEMs

Battery Electric Options

- ARBOC Specialty Vehicles
- GreenPower Bus — The Future of Public Transportation
- ENC — REV Group
- New Flyer
- Gillig
- BYD
- MCI
- Hometown Coach
- NovaBus — bring life to your city
- Proterra

Fuel Cell Options

- ENC — REV Group
- New Flyer

Zero Emission Cutaway OEMs

Battery Electric Options

ENDERA

GreenPower Bus
The Future of Public Transportation

ZEUS ELECTRIC CHASSIS

MOTIV
it's inEVitable

OPTIMAL·EV

PHOENIX MOTORCARS

LIGHTNING eMOTORS

Fuel Cell Options*

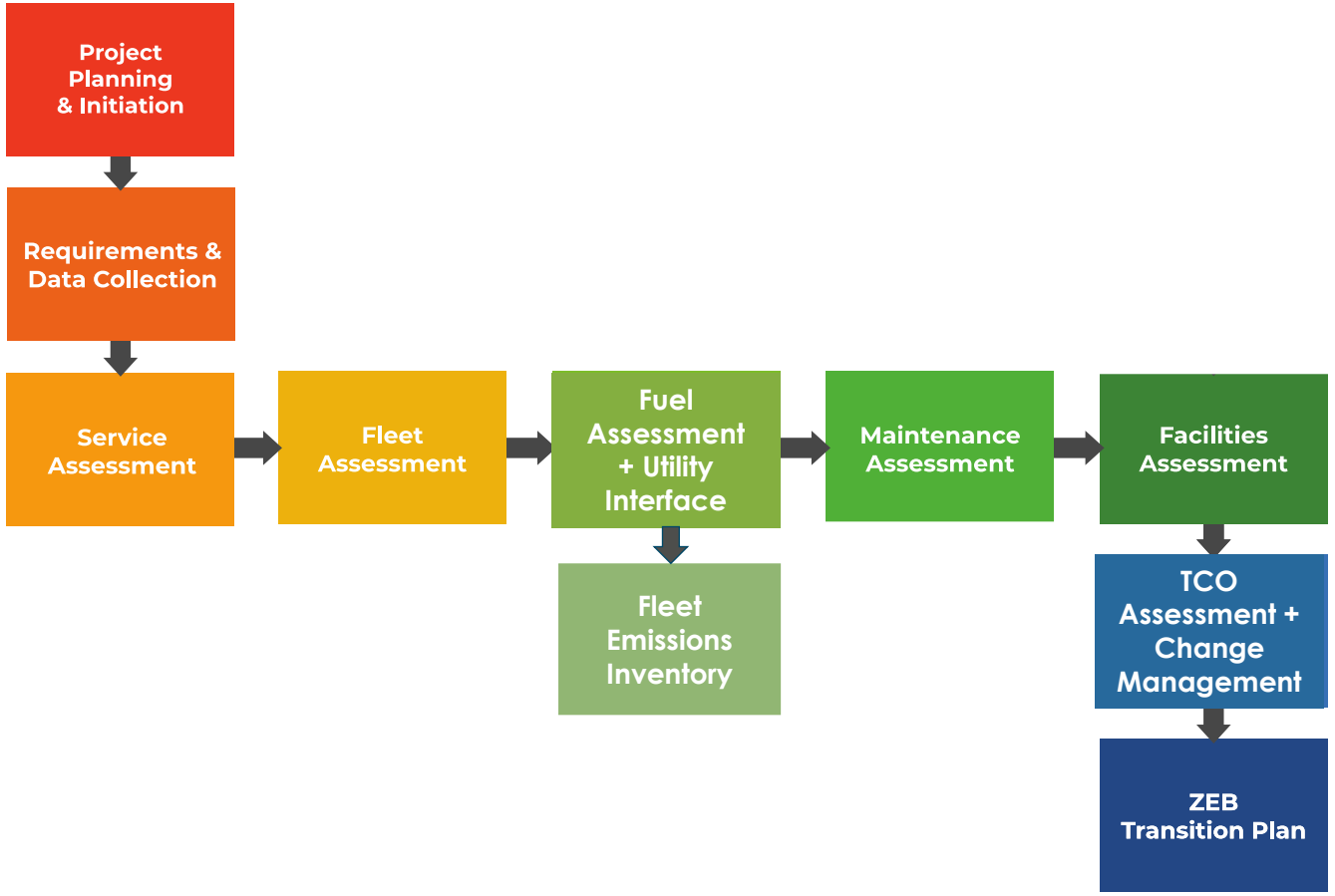
US HYBRID
by Ideanomics

plug

*US Hybrid and Plug Power offer fuel cell conversion systems.

Project Approach

ZEB Transition Approach and Methodology



Analysis ZEB Scenarios

Future ZEB Technology Scenarios

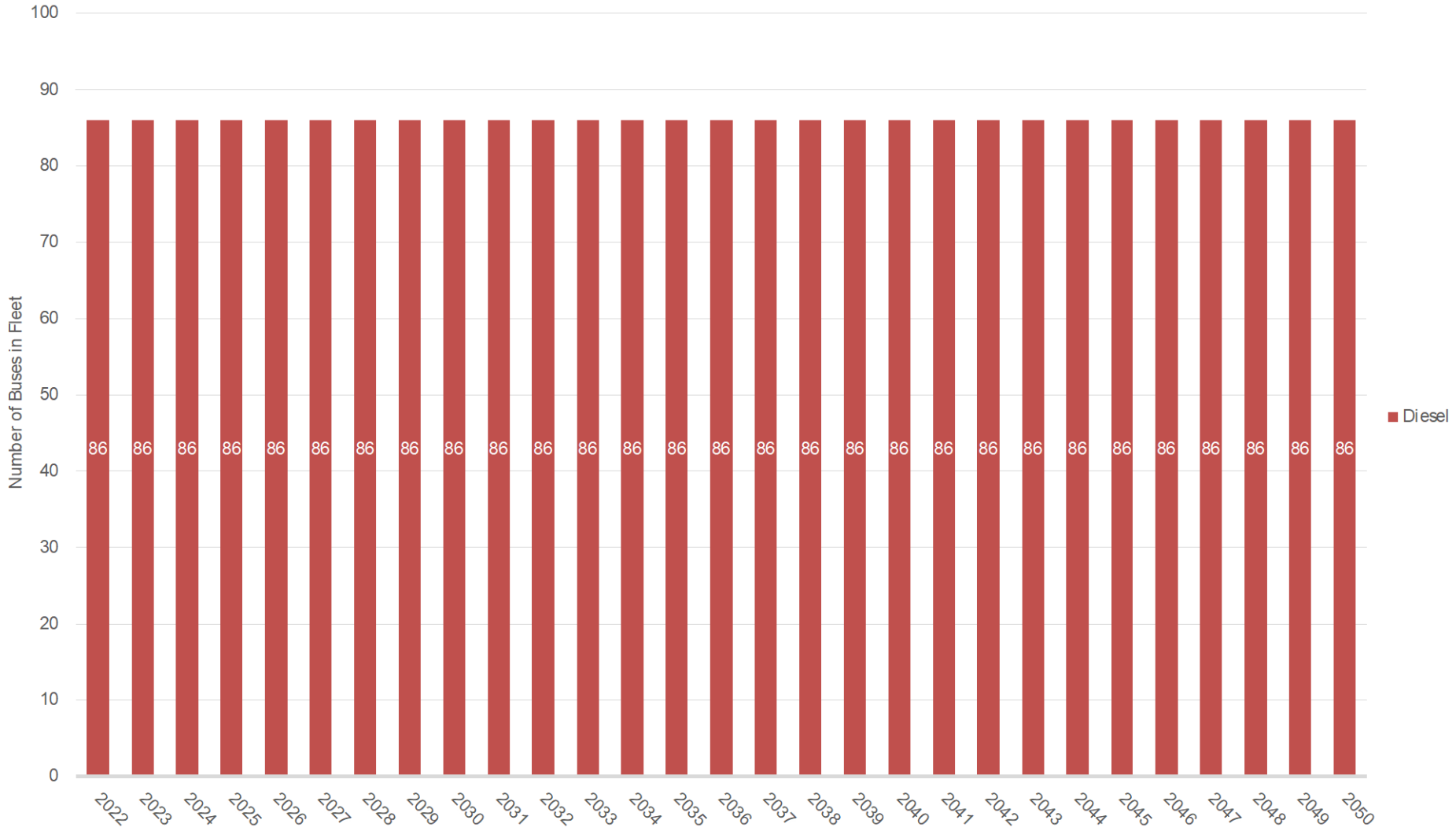
- 100% ZEB Procurement Fleet Transition
  - Replaces 35’ and 40’ diesel buses with ZEBs, starting in **2026** based on block feasibility.
  - If Intercity Transit were to procure 100% ZEBs moving forward, **100%** of the procurements in 2026 would be ZEBs, outside of planned procurements.
    - Bus purchases made before 2026 are not assumed to be ZEB because it’s assumed ZEB infrastructure would need until 2026 to be implemented.

- ZEB Technology Scenarios
  - BEB Depot-Only Charging
  - BEB Depot and On-Route Charging
  - Mixed Fleet (BEB and FCEB)
  - FCEB-Only

Fixed Route Fleet Analysis Results

Baseline Fleet Composition

Fixed-Route Service

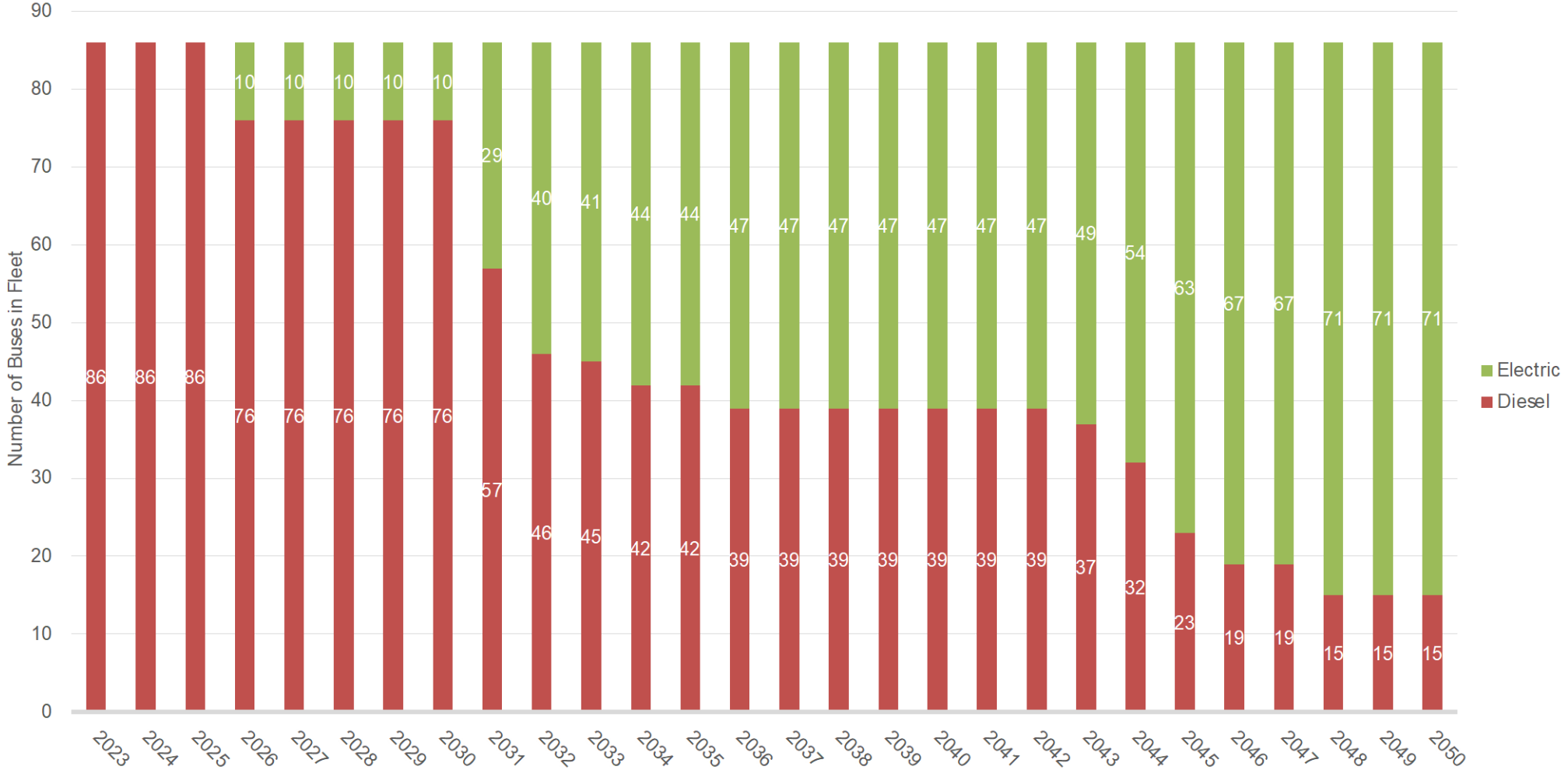


Note: 'Diesel' includes both diesel and diesel-hybrid vehicles

BEB Depot-Only Charging Fleet Composition

Fixed-Route Service

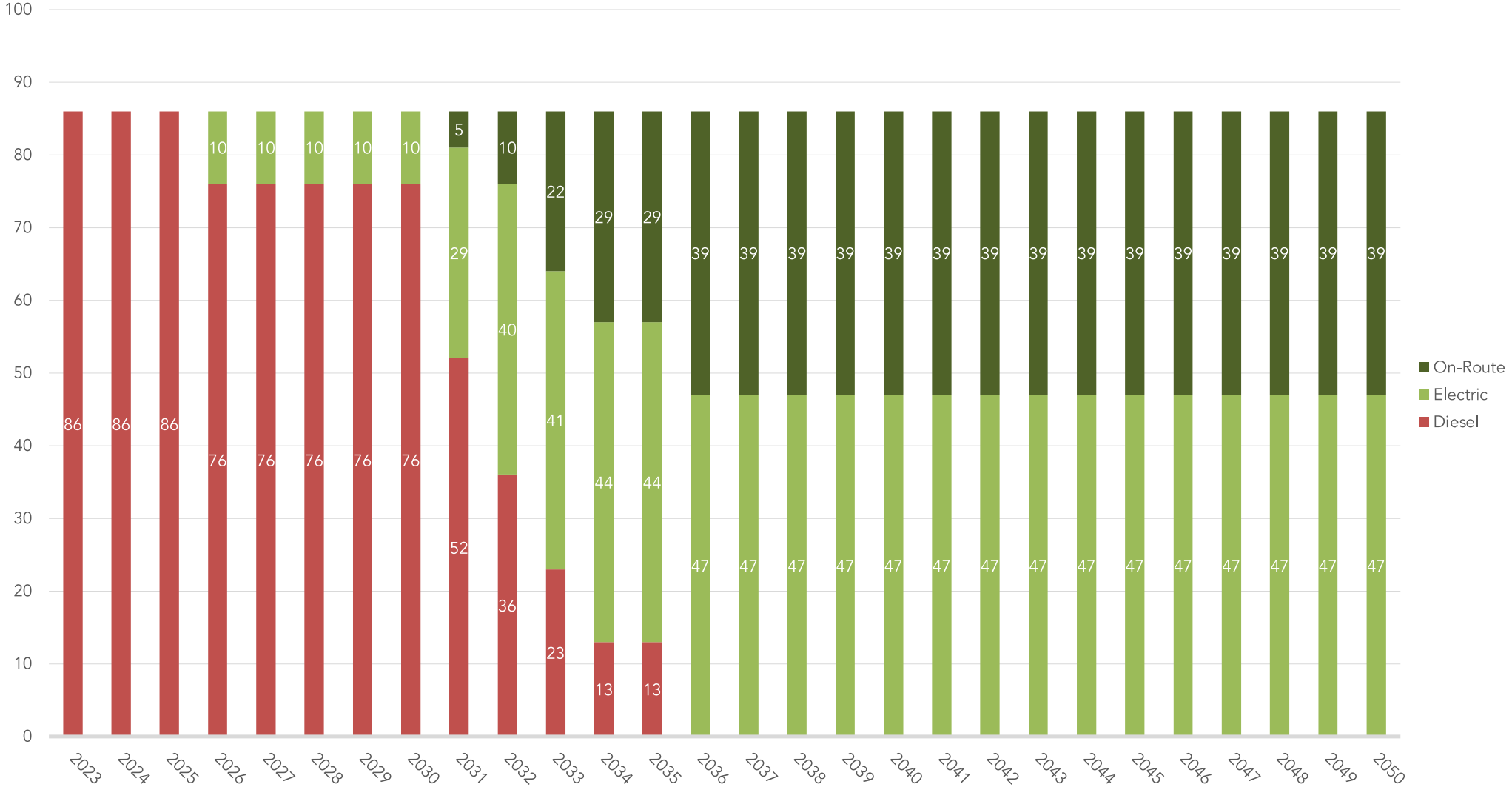
Replaces all 35’ and 40’ diesel buses with FCEBs based on block feasibility. All 35’ vehicles can be replaced by depot-only BEB alternatives. Since the feasibility of routes serviced by 40’ vehicles is dependent on BEB nameplate capacity improvements of 5% every other year, Intercity Transit’s depot-only BEB fleet will be 84% zero-emission by 2050. Other technology solutions will need to be considered to meet 100% zero-emission within this timeline.



BEB Depot and On-Route Charging Fleet Composition

Fixed-Route Service

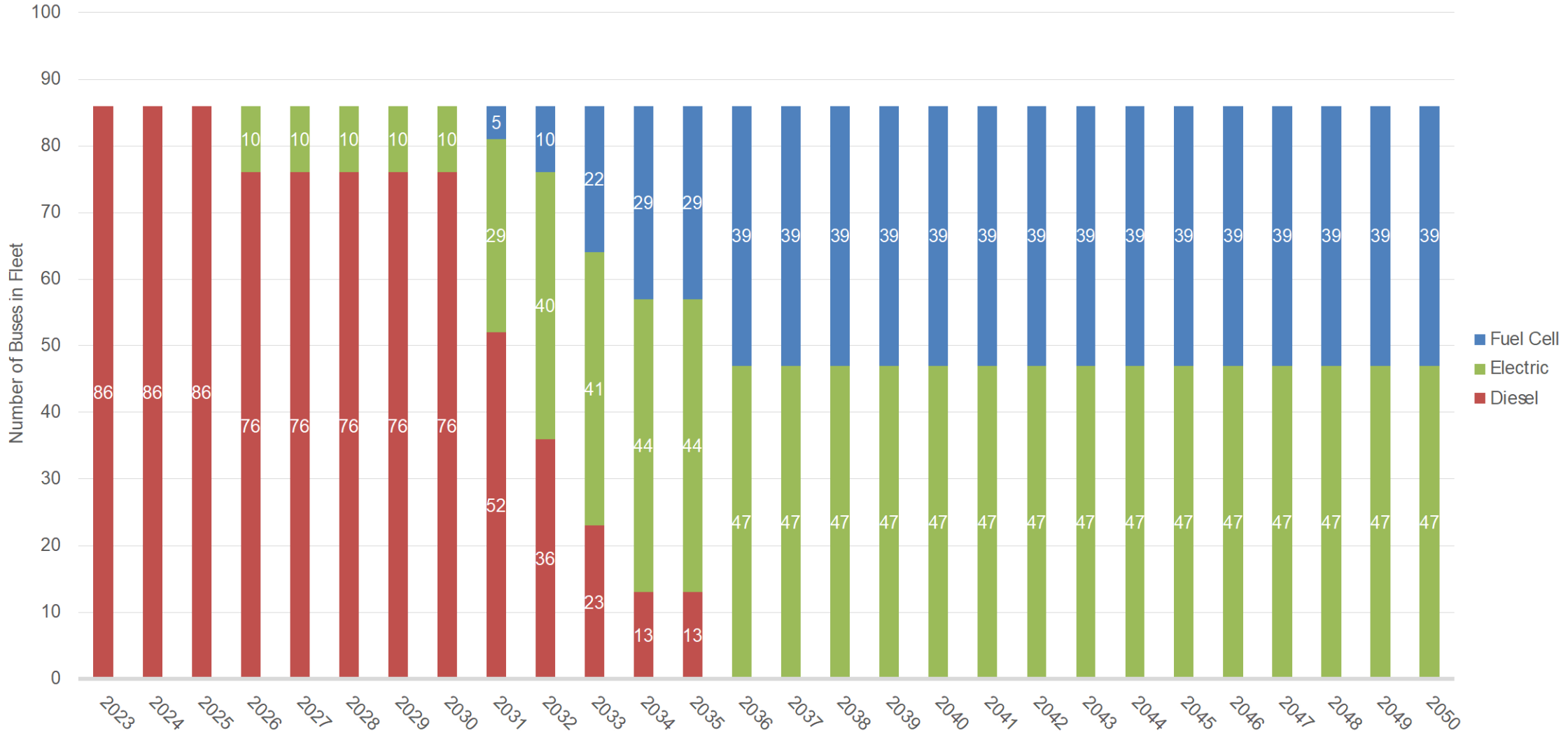
An overnight depot-charged BEB is deployed in place of a diesel bus, if the vehicle's block is feasible. An on-route charged BEB is deployed in place of a diesel bus, if the vehicle's block with overnight depot-charged BEB is infeasible. Once a bus is replaced with an on-route charged BEB, it stays on-route charged for perpetuity



Mixed (BEB and FCEB) Fleet Composition

Fixed-Route Service

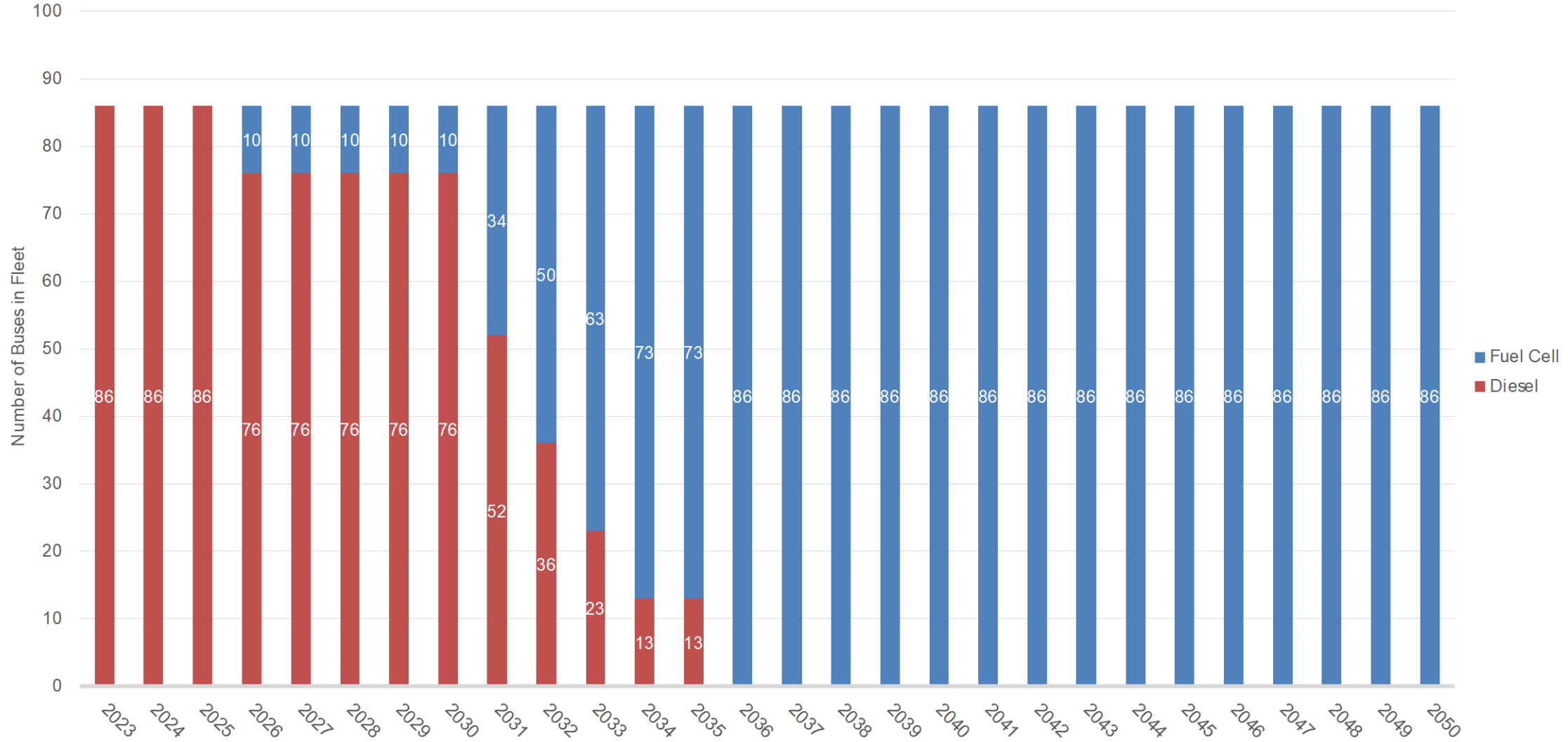
A depot-charged BEB is deployed in place of a diesel bus, if the vehicle's block is feasible. An FCEB is deployed in place of a diesel bus, if the vehicle's block is infeasible with depot charged BEB. Once a bus is replaced with an FCEB, it stays FCEB for perpetuity



FCEB Only Fleet Composition

Fixed-Route Service

Replaces all 35' and 40' diesel buses with FCEBs based on block feasibility. 98% of Intercity Transit's blocks are feasible based on current-day technology (350-mile range). With FCEB improvements, however, all blocks are expected to be feasible by 2050



Fuel Assessment Assumptions

Fuel Costs

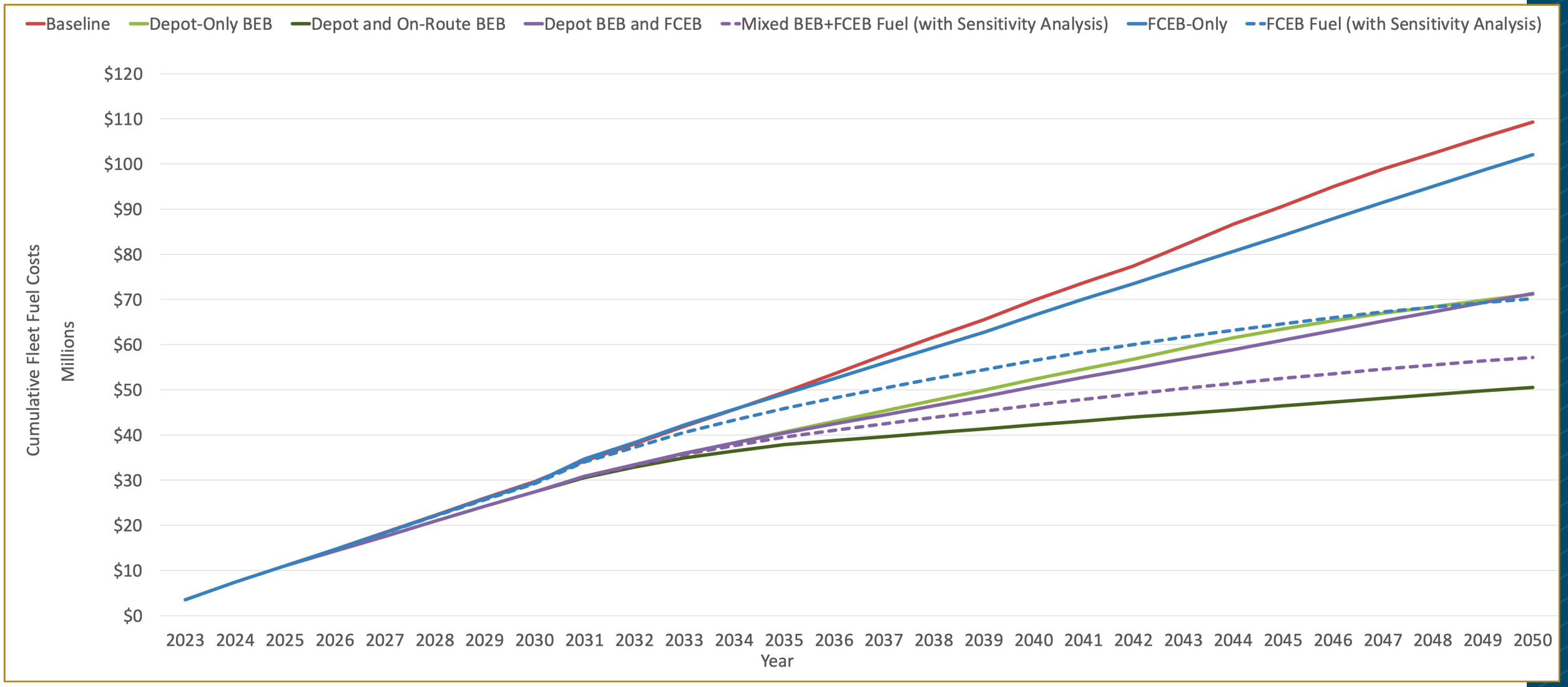
- Diesel:
  - Fluctuating inflation rate applied through 2050, based on the EIA's projection for diesel (transportation) fuel
  - 2022 price for diesel: $4.80/DGE, as reported by Intercity Transit
- Electricity:
  - Fluctuating inflation rate applied through 2050, based on the EIA's projection for electricity as a transportation fuel
  - Electricity costs assumed to be driven by Puget Sound Energy's (PSE) Schedule 26 for Large Demand General Service (>350 kW) (see Appendix for detailed charges).
  - Charger maintenance costs of $3,000 applied per depot and on-route charger
- Hydrogen:
  - Fluctuating inflation rate applied through 2050, based on the EIA's projection for compressed natural gas (transportation) fuel
  - Additional sensitivity analysis provided for the *Mixed* and *FCEB-Only* ZEB scenarios, to project a reduction in hydrogen costs by 3% YOY beginning in 2026 – assuming infrastructure has been built out for regional hydrogen production
  - 2023 price for hydrogen: $8.61/kg, based on the average Year 1 and Year 2 costs outlined in the GETBus + PlugPower temporary hydrogen fueling contract, dated March '23

**Total demand charges applied to the fuel costs are an average of summer and winter electricity rates, provided the fuel consumption remains consistent throughout the year.*

Cumulative Fuel Costs

All ZEB Scenarios, 2023-2050

Fixed-Route Service

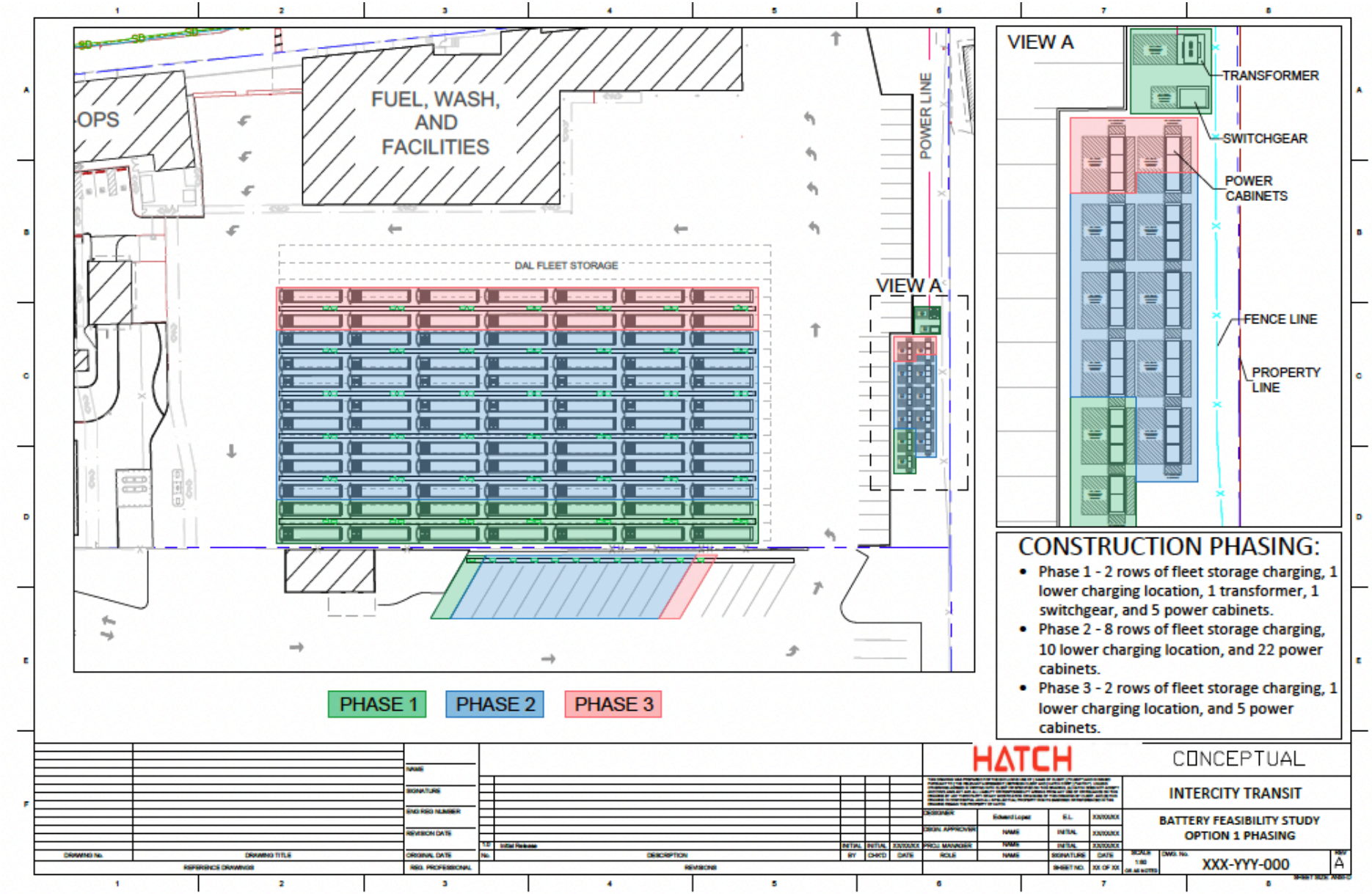


Infrastructure Assessment Assumptions

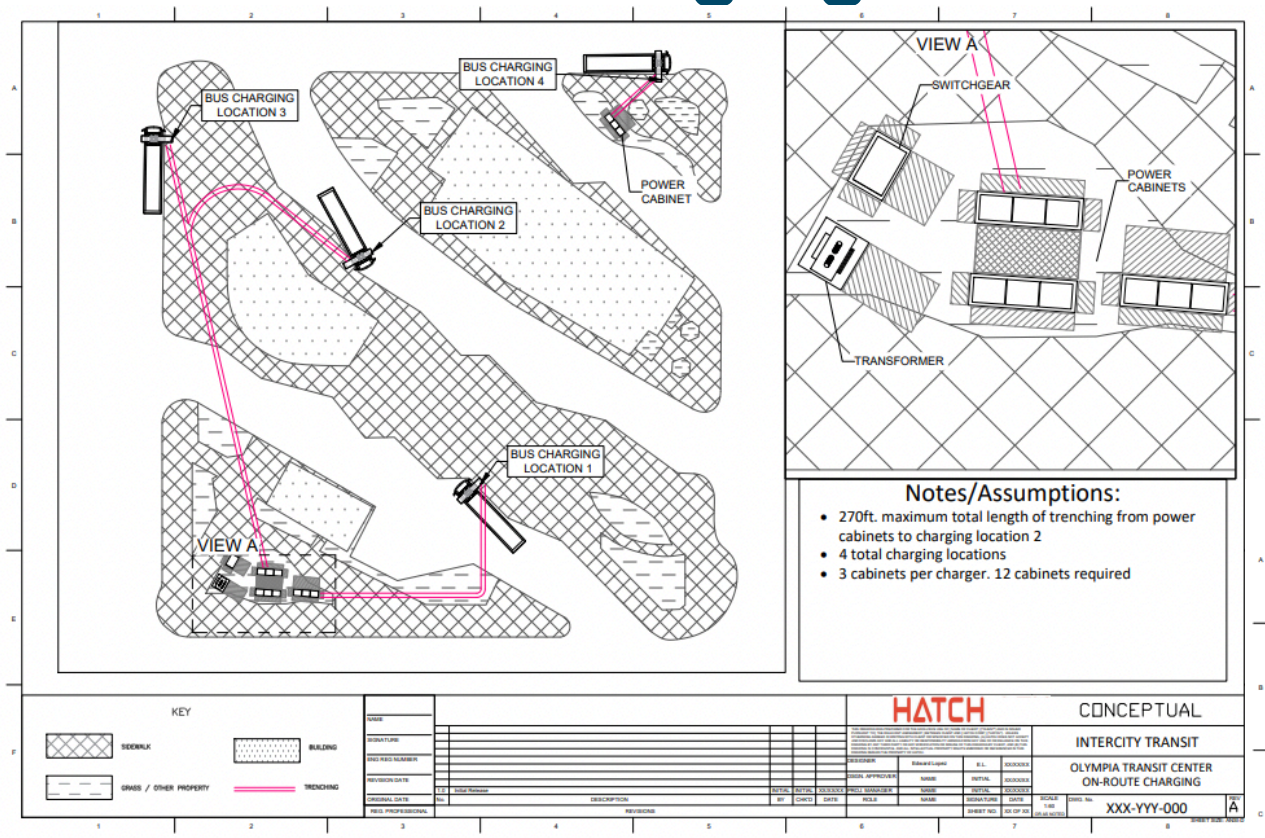
Fixed-Route Service

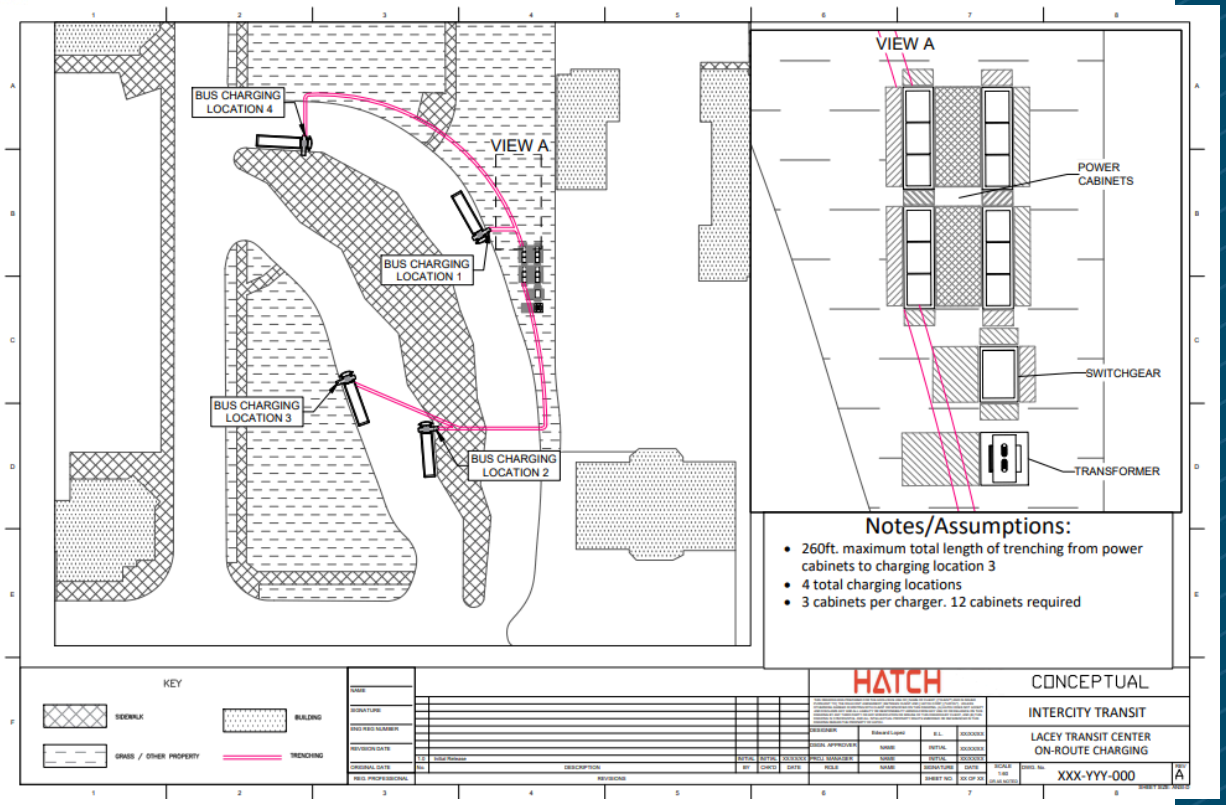
- CTE and Hatch assumed Intercity Transit's *Baseline* fleet is a continuation of today's operations, and therefore infrastructure costs are not considered for this business-as-usual scenario
- No land acquisition costs are included in the project costs.
- An inflationary rate of 3% YOY was applied to the infrastructure costs through 2050, based on the historical CPI for labor

Depot Charging Infrastructure Layout

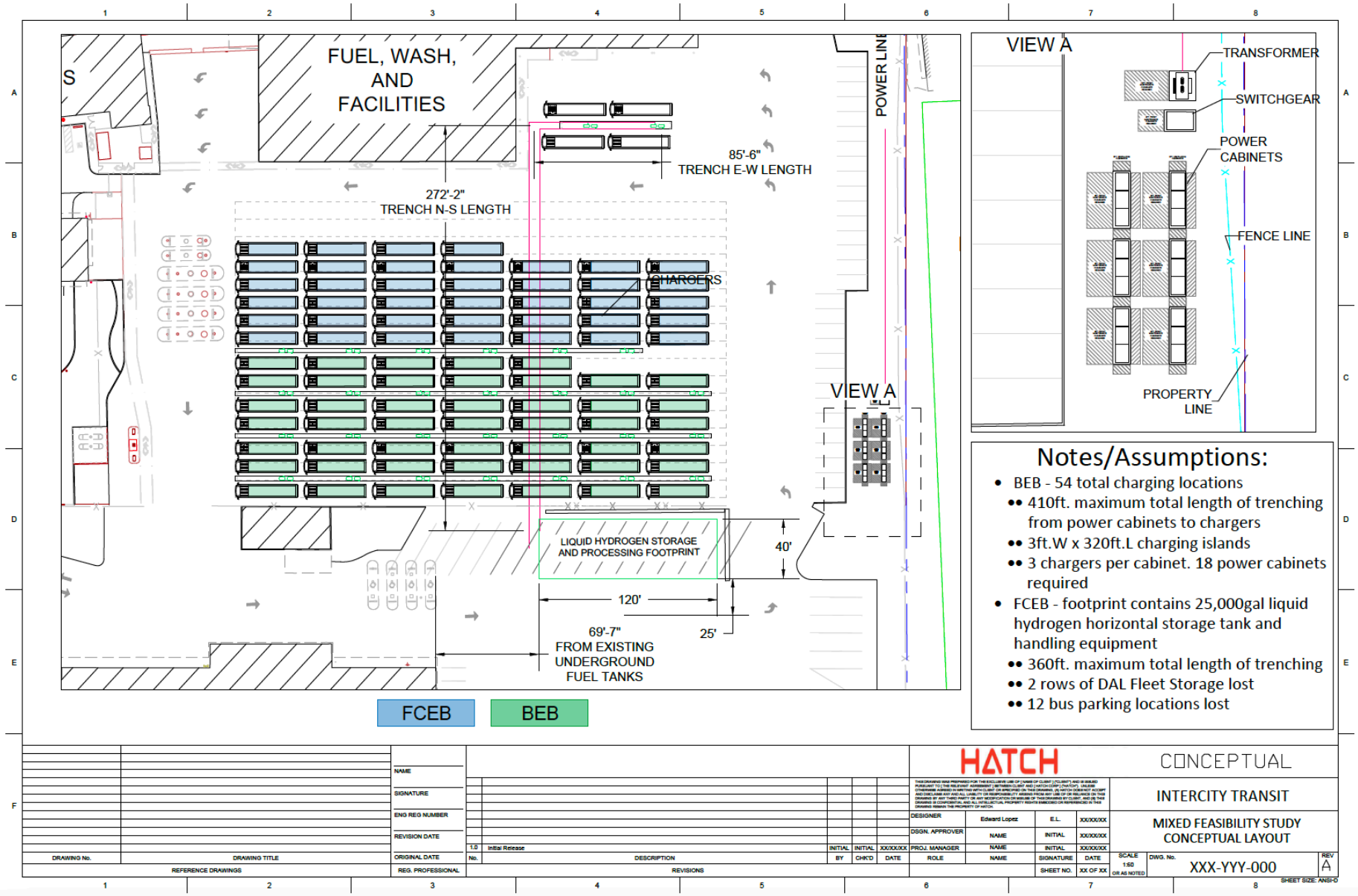


On-Route Charging Infrastructure Layouts - OTC and LTC

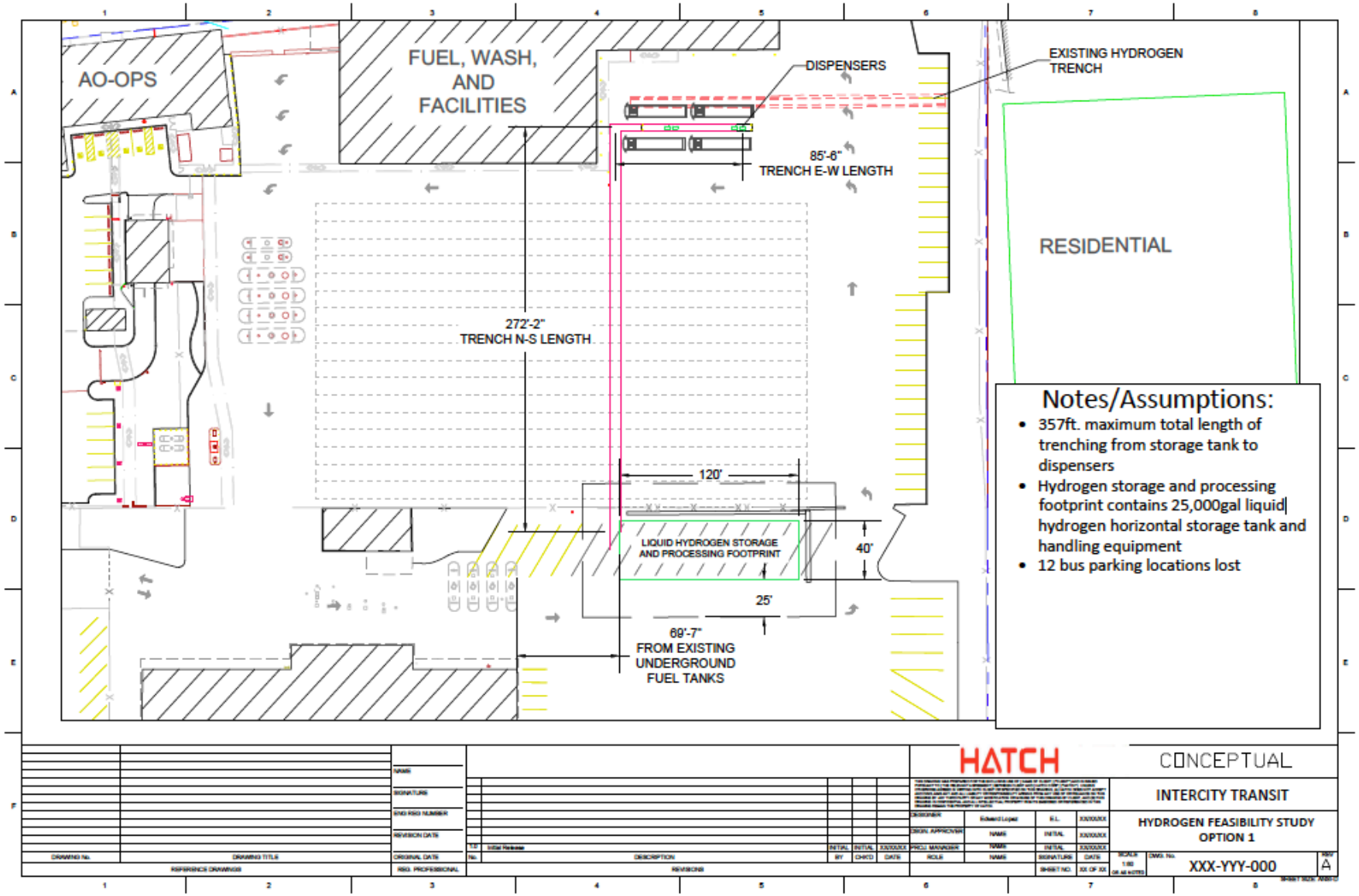




Depot BEB and FCEB Infrastructure Layout



Hydrogen Fueling Infrastructure Layout



Summary Cost Evaluation

Fixed-Route Service

All ZEB Scenarios, 2023-2050

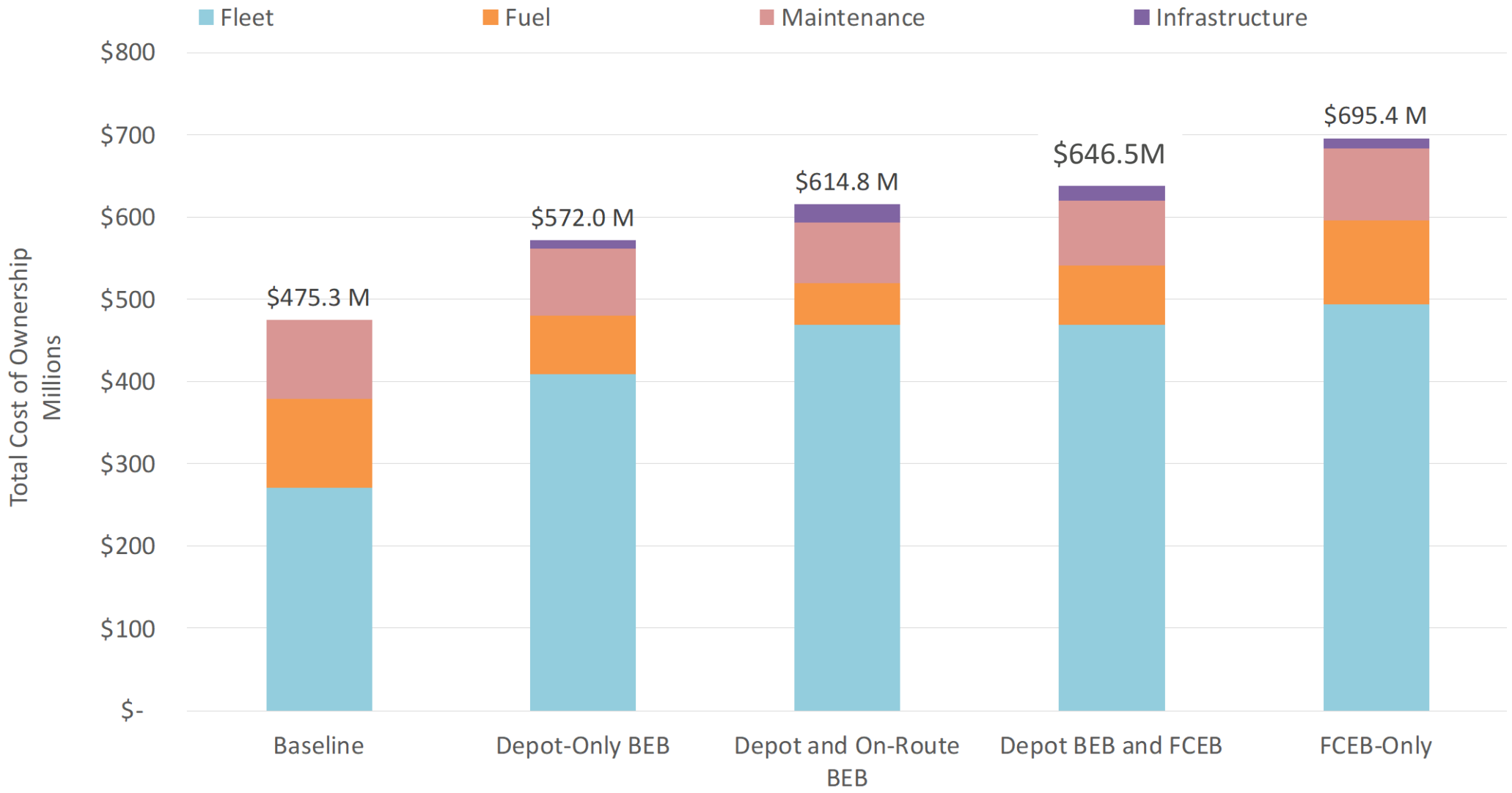
Total Cost of Ownership	Baseline	BEB Depot Charging Only	BEB Depot and On-Route Charging	Mixed Fleet (BEB/FCEB)	FCEB Only
Fleet	$270.3M	$408.8M	$468.6M	$477.5M	$493.5M
Fuel	$109.3M	$71.2M	$50.5M	$71.3M	$102M
Maintenance	$95.7M	$81.5M	$74M	$78M	$88.2M
Infrastructure	$-	$10.6M	$21.6M	$17.7M	$11.6M
Total	**$475.3M**	**$572M**	**$614.8M**	**$646.5M**	**$695.4M**
Compared to Baseline	$-	+$96.7M	+$139.5M	+$171.2M	+$220.1M
% of ZEB Blocks Achievable with ZEBs by 2050	**0%**	**83%**	**100%**	**100%**	**100%**

*Sensitivity analysis reduces overall costs for Mixed Fleet scenario by $14.1M and the FCEB-only Fleet Scenario by $31.9M

Total Cost of Ownership

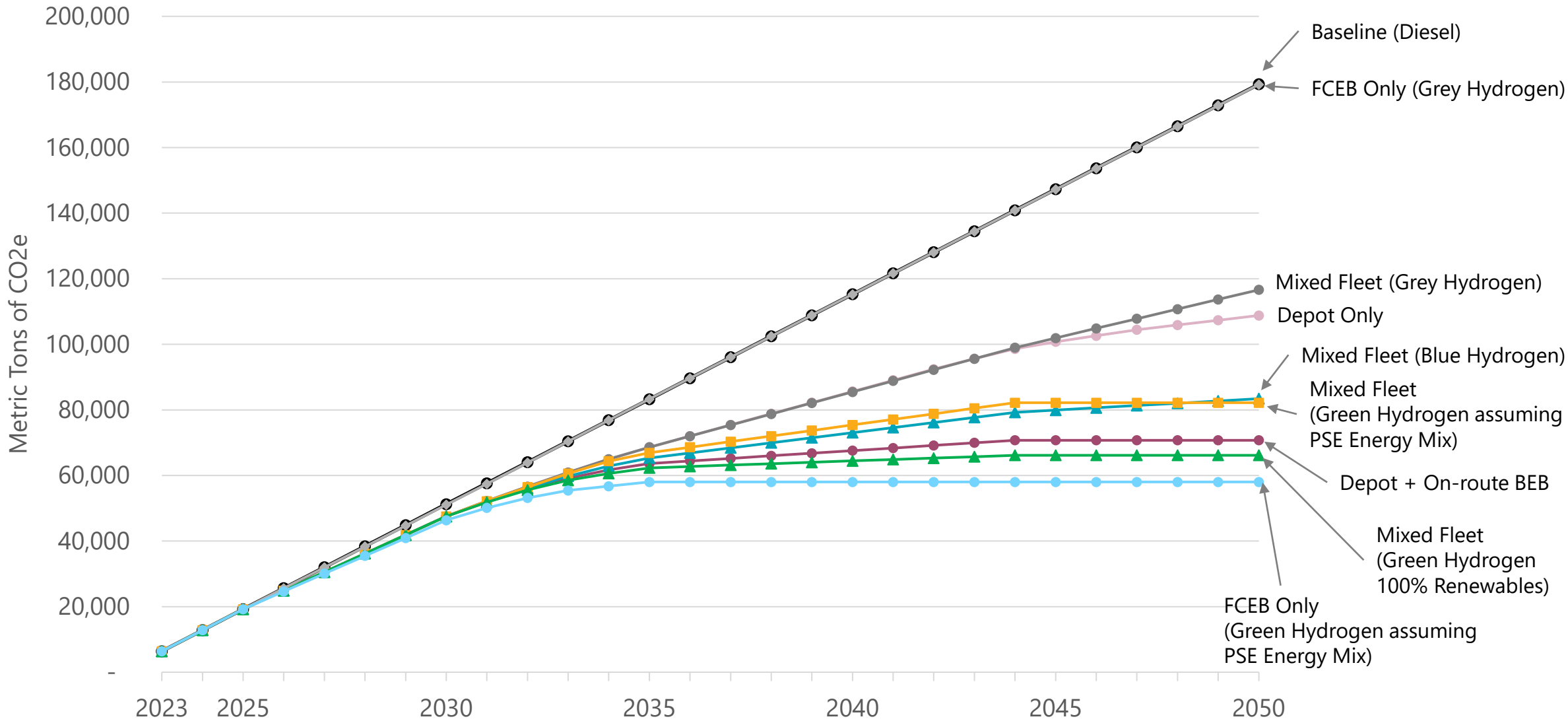
Fixed-Route Service

All ZEB Scenarios, 2023-2050



*Sensitivity analysis reduces overall costs for Mixed Fleet scenario by $14.1M and the FCEB-only Fleet Scenario by $31.9M

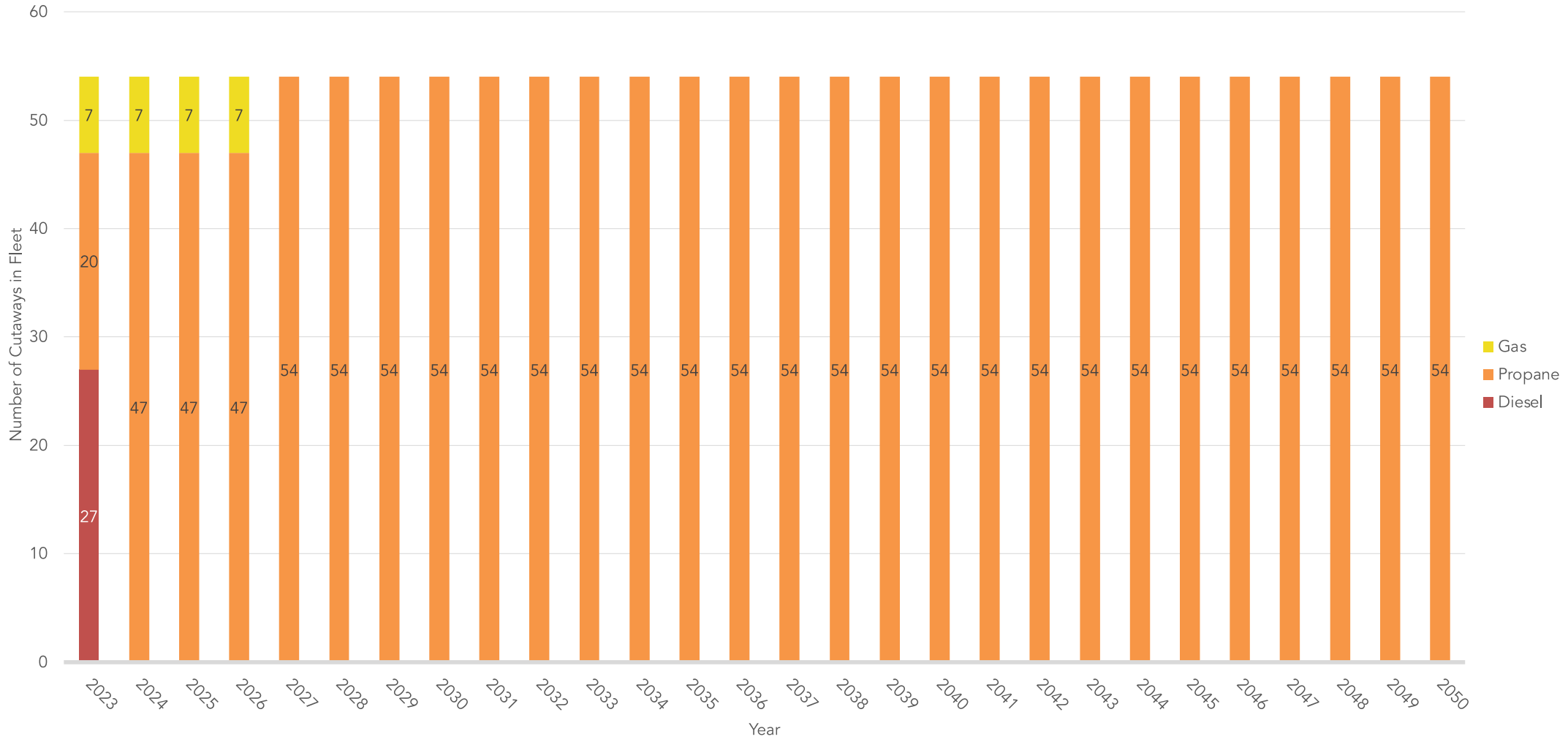
Cumulative Emissions – All scenarios



Dial-a-Lift Analysis Results

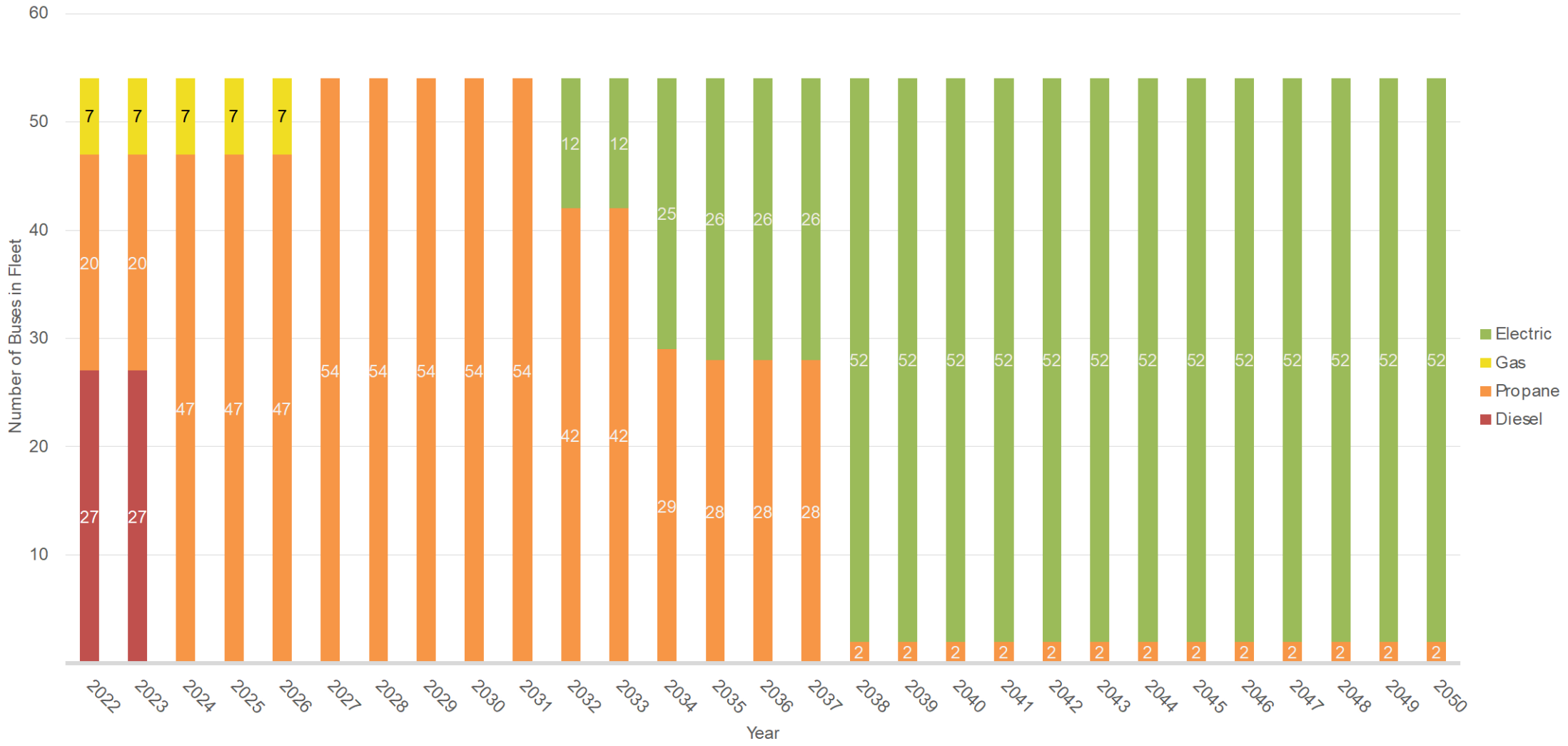
Baseline Fleet Composition

Dial-a-Lift



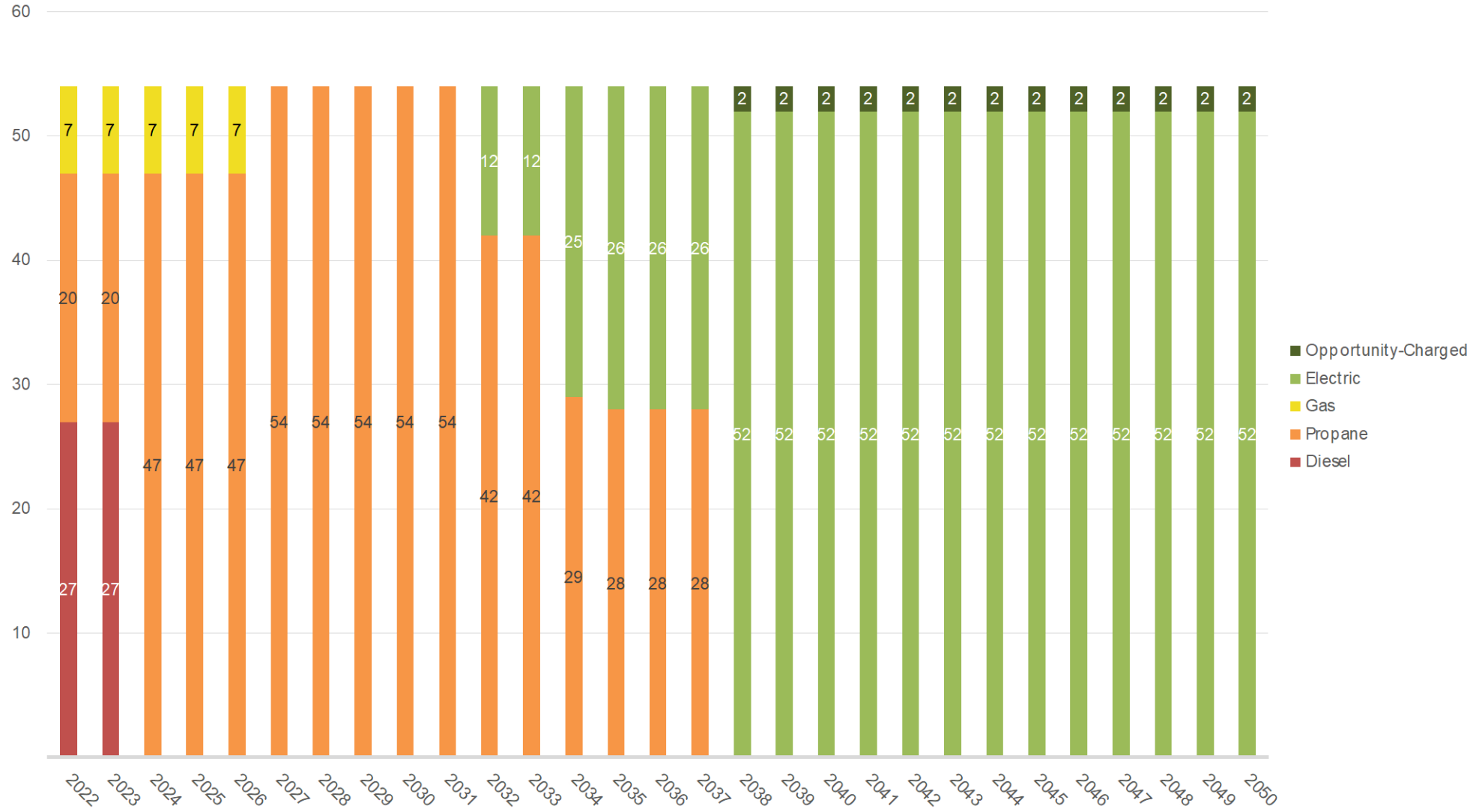
BEB Overnight Depot Only Fleet Composition

Dial-a-Lift



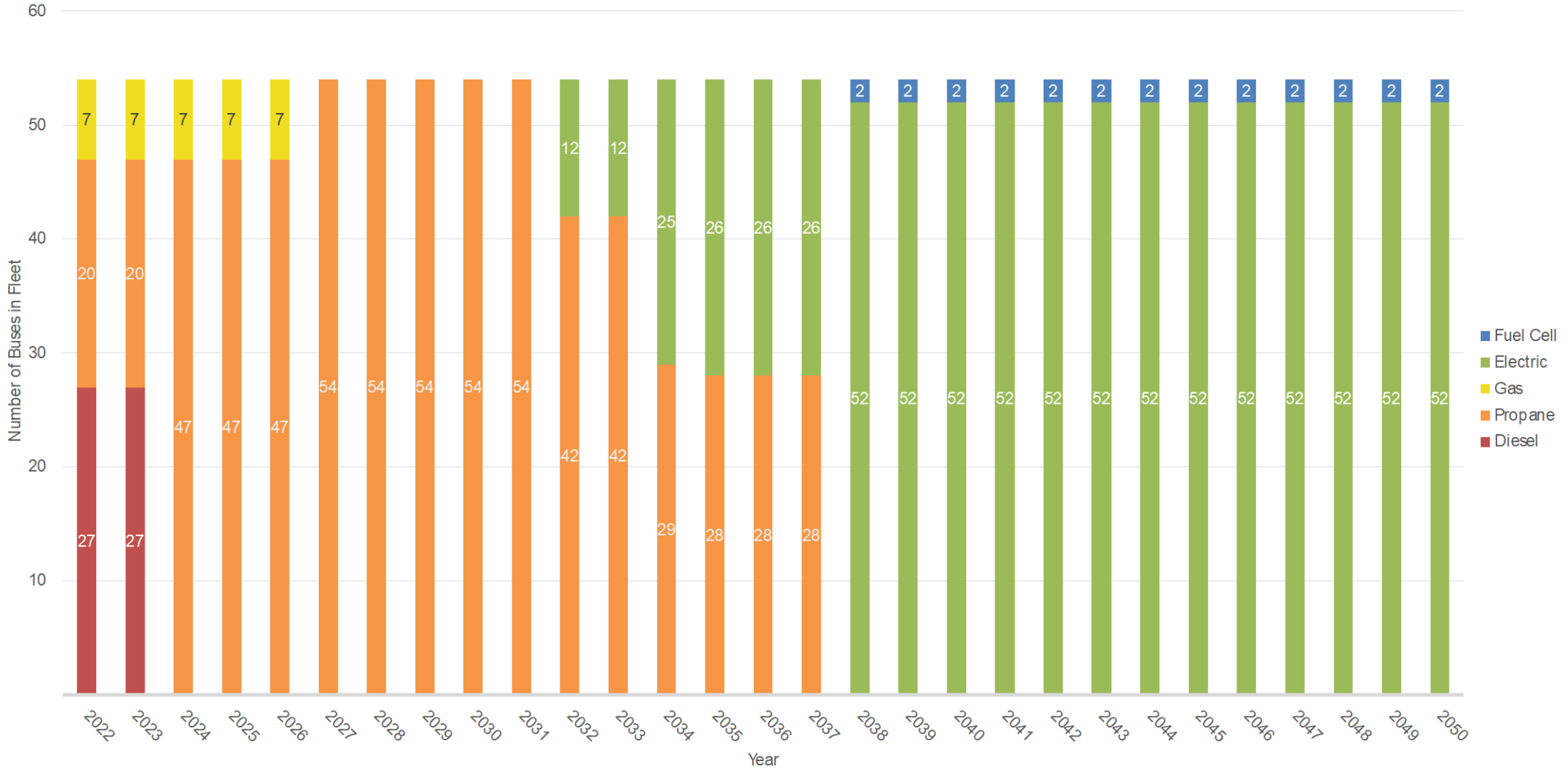
BEB Overnight Depot and Midday Charging Fleet Composition

Dial-a-Lift



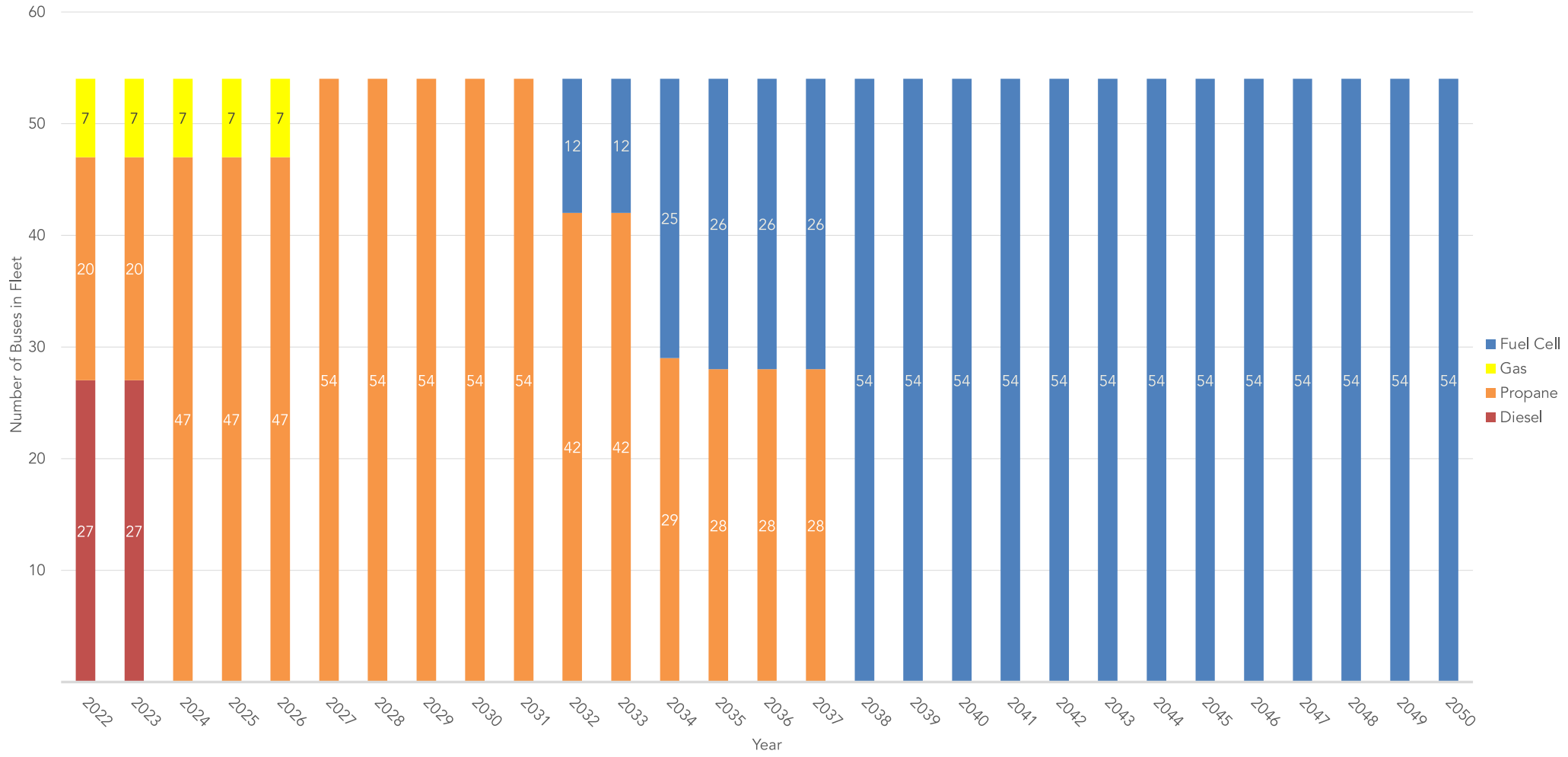
Mixed (BEB and FCEB) Fleet Composition

Dial-a-Lift



FCEB Only Fleet Composition

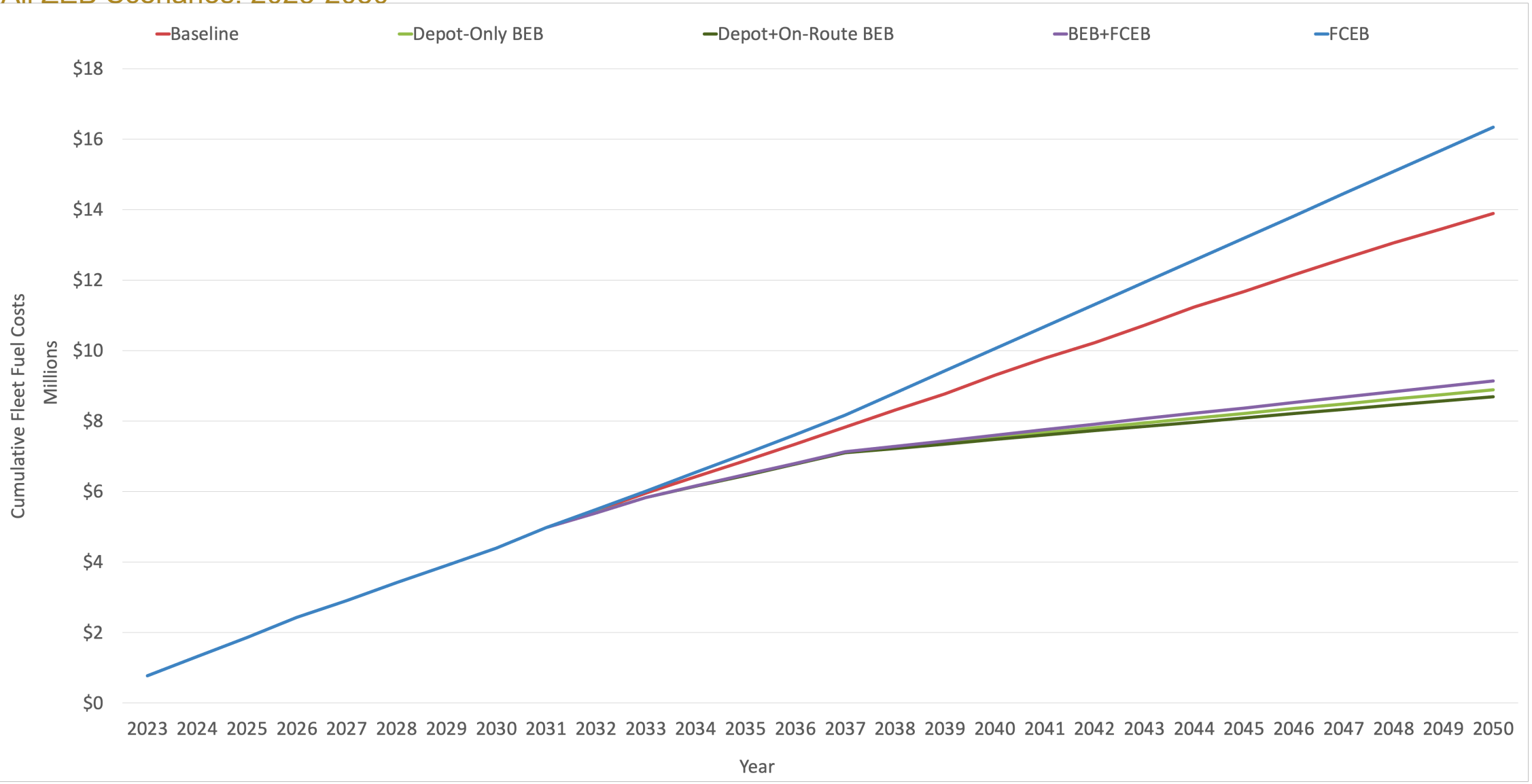
Dial-a-Lift



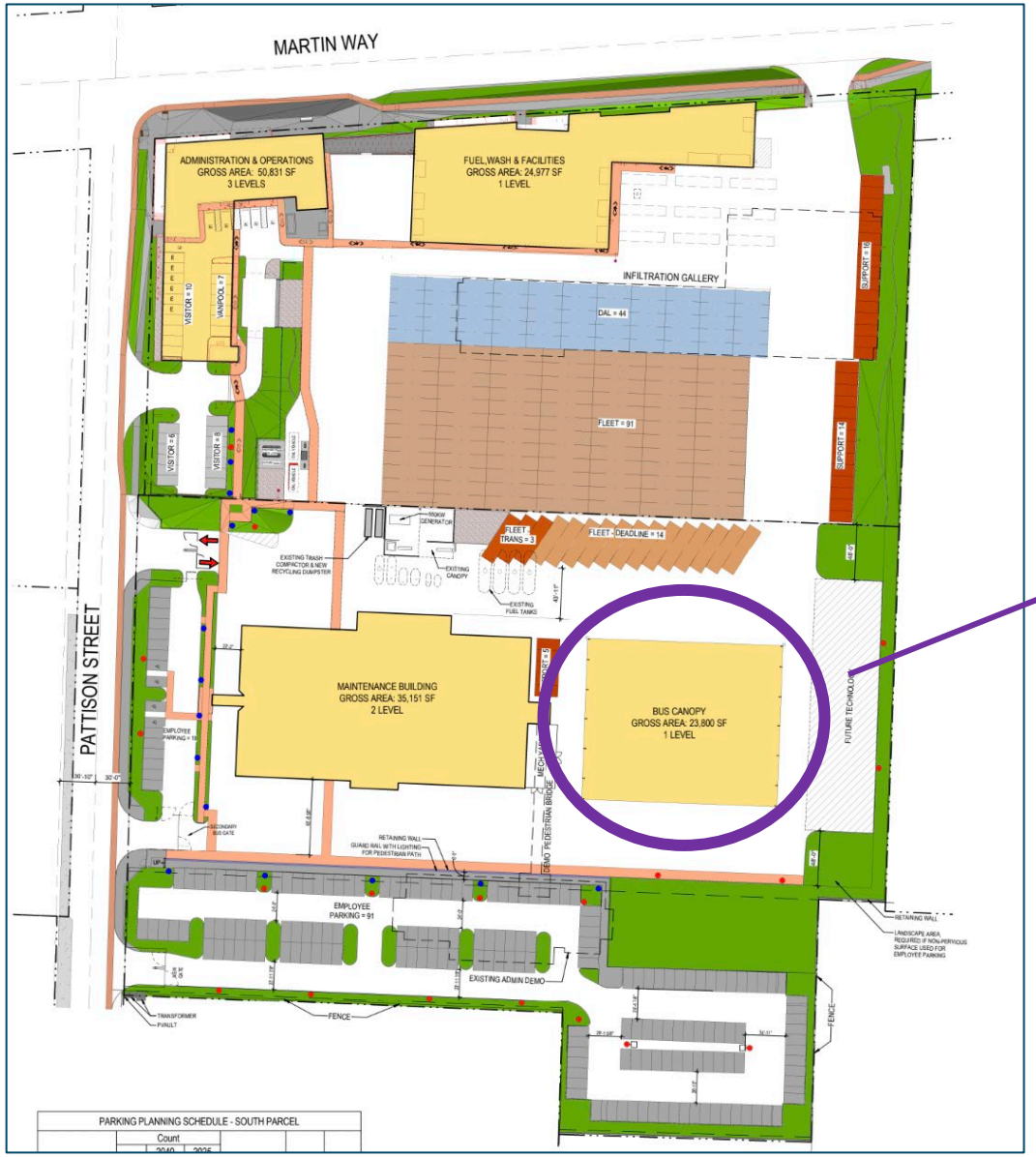
Cumulative Fuel Cost

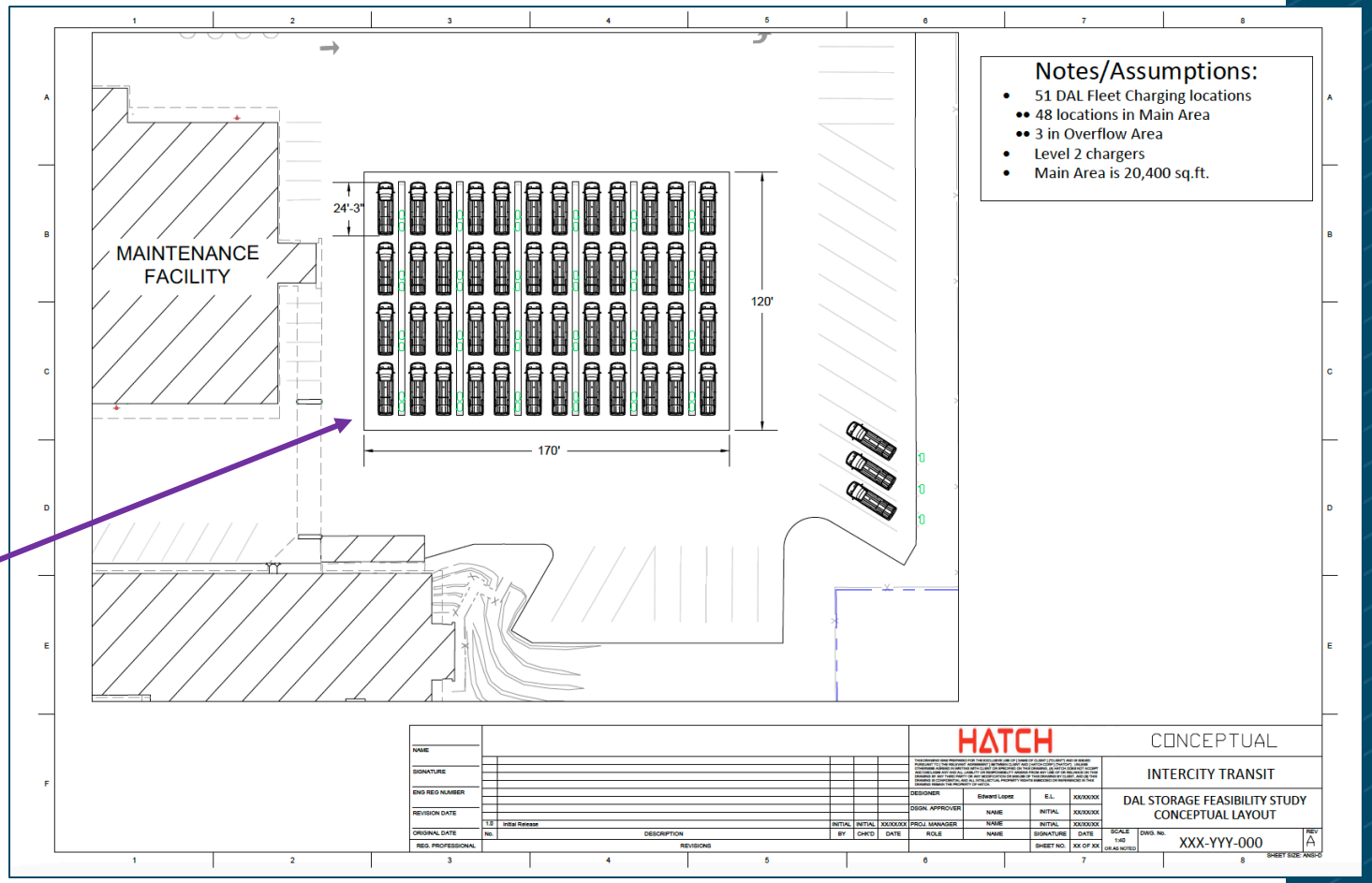
Dial-a-Lift

All ZEB Scenarios, 2023-2050



DAL Infrastructure Layout





Summary Cost Evaluation

Dial-a-Lift Service

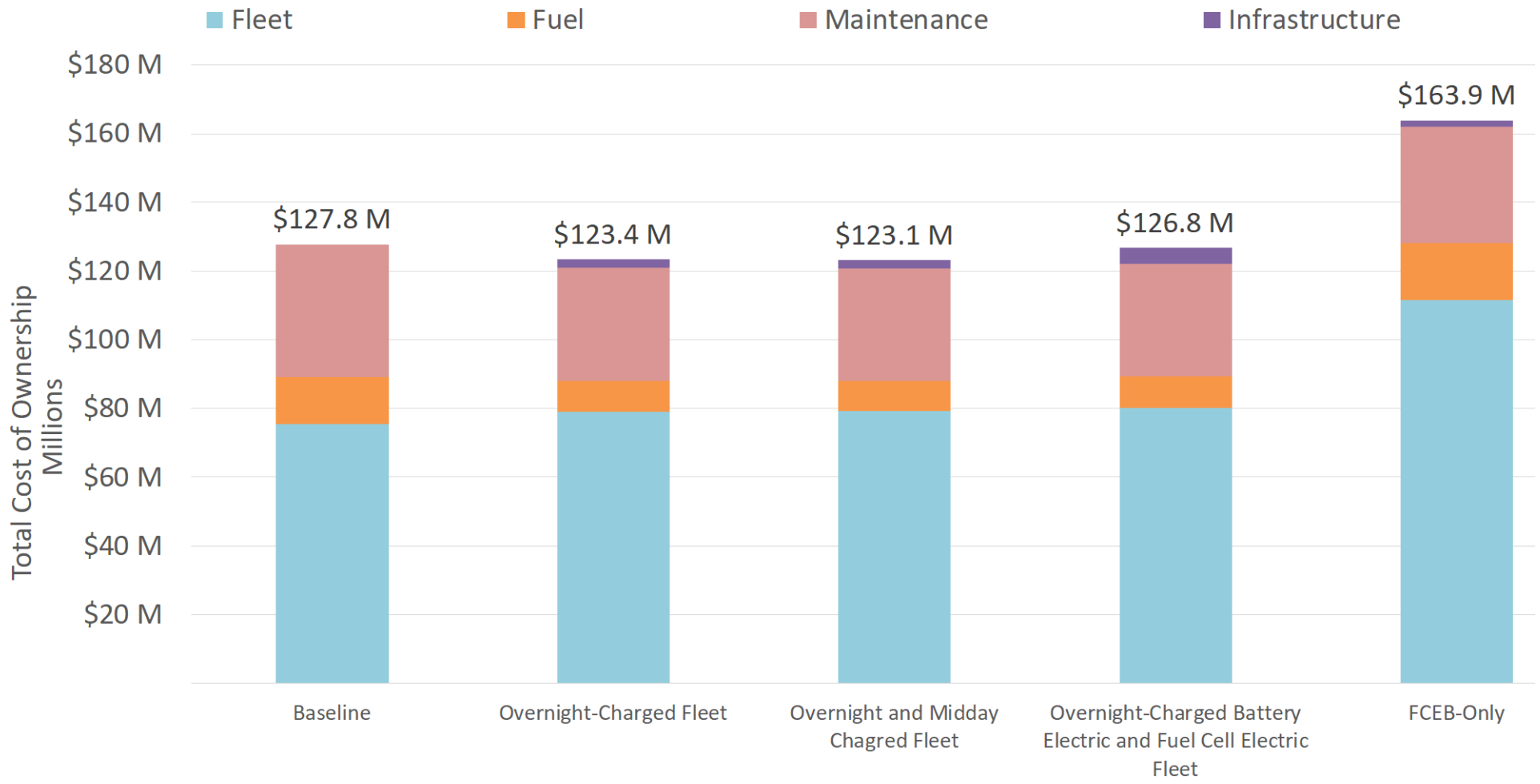
All ZEB Scenarios, 2023-2050

	Baseline	BEB Overnight Charging Only	BEB Overnight and Midday Charging	Mixed Fleet	FCEB Only Fleet
Fleet	$75.3M	$79.2M	$79.3M	$80.3M	$111.7M
Fuel	$13.9M	$8.9M	$8.7M	$9.1M	$16.3M
Maintenance	$38.6M	$32.8M	$32.6M	$32.7M	$34.0M
Infrastructure	$-	$2.5M	$2.6M	$4.8M	$1.9M
Total	**$127.8M**	**$123.4M**	**$123.1M**	**$126.8M**	**$163.9M**
Compared to Baseline	$-	-$4.4M	-$4.6M	-$951k	+$36.1M
% of Blocks Achievable with ZEBs by 2050	0%	96%	100%	100%	100%

Summary Cost Evaluation

Dial-a-Lift Service

All ZEB Scenarios, 2023-2050



Vanpool Electrification Feasibility

Intercity's Vanpool Service

- Average daily mileage : 47 miles
- Max daily commute mileage : ~200 miles
- Fleet makeup:
    - Minivans
    - 12-passenger vans

Transitioning to Zero Emission

- Zero Emission Vehicle Options :
  - No currently zero emission minivans available (only hybrid)
  - Battery electric passenger vans are available, but no fuel cell options
- Fueling Challenges
  - The majority of the vanpool vehicles are parked overnight at private residences
  - Community Van and Village Van program vans are parked at Intercity's depot
    - Vehicles could be fueled using same level-2 chargers as the DAL fleet

Non-Revenue Vehicle Market Analysis

Zero Emission Options

	Quantity	Fuel Type	Production Zero-Emission Replacement Vehicle Available?
SUV/Sedans	2	Hybrid	Yes
	16	Gasoline	
	1	Electric	
Light-Duty Trucks	8	Diesel	Yes
	2	Gasoline	
Medium-Duty Trucks	2	Diesel	Yes
	4	Gasoline	
Street Sweepers	1	Diesel	Yes
Minivans	2	Gasoline	No
Medium-Duty Van	1	Diesel	Yes
	2	Gasoline	
Forklift	1	Propane	Yes
Utility Vehicle	1	Electric	Yes

- Several all-electric pickup truck, sedan, and SUV options are available
- Two fuel cell passenger car options available (only in California)
- Both battery electric and fuel cell electric street sweepers available
- Electric forklifts and utility vehicles are widely available
- No zero emission minivan options available (only hybrid)

Thank you.

Questions?