Zero-Emission Transition Financial Analysis:

City of Corona Transit Service

Riverside County Transportation Commission
ZEB Implementation & Rollout Plan Project

About CTE

WHO WE ARE

501(c)(3) nonprofit engineering and planning firm

OUR MISSION

Improve the health of our climate and communities by bringing people together to develop and commercialize clean, efficient, and sustainable transportation technologies

PORTFOLIO

$900 million

- *Research, demonstration, deployment*
- *100 Active Projects totaling over $400 million*

OUR FOCUS

Zero-Emission Transportation Technologies

NATIONAL PRESENCE

Atlanta, Berkeley, Los Angeles, St. Paul

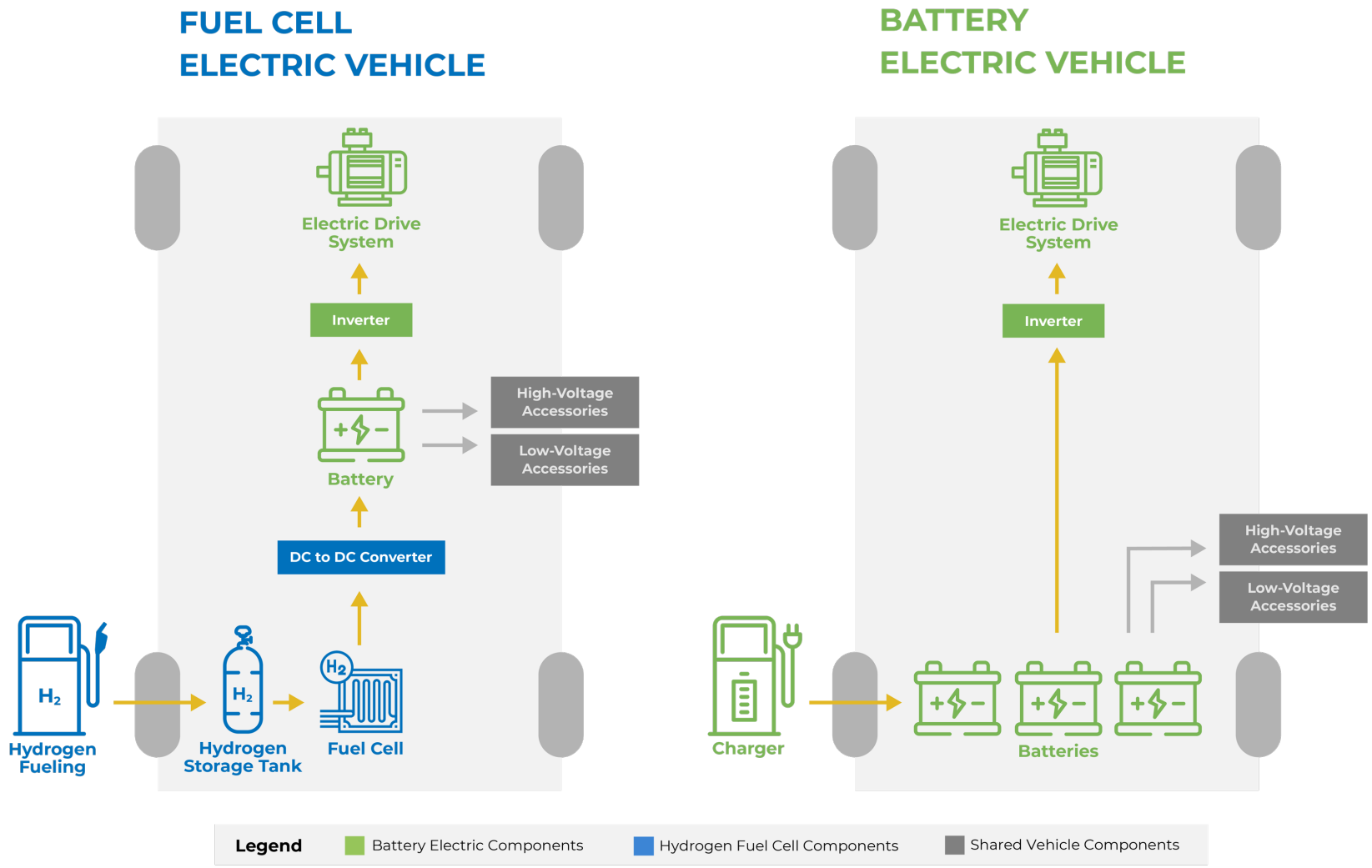
Introduction

Today's Objective is to review the financial projections for ZEB technology transition scenarios including:

- Fleet Procurements and Capital Cost
- Fuel Costs
- Maintenance Costs
- Preliminary Infrastructure Projects & Costs
- Total Cost of Ownership

Zero Emission Buses —What's Different?

- Propulsion System
  - Traction Motor instead of engine
- Energy Storage System
  - Battery instead of fuel tank
  - Hydrogen storage tanks
- HVAC
  - No "free" heat
  - Electric heater
- Time to "Re-fuel"
  - FCEB: 10 minutes
  - BEB: ~3 hours



Fleet Capital Cost Assessment

CARB Innovative Clean Transit Regulation

- 100% ZEB Fleet by 2040 is not a mandate, but a goal
- There is only a *purchasing* rule:

Starting January 1	ZEB Percentage of Total New Bus Purchases
2026	25%
2027	25%
2028	25%
2029	100%

- Small CA Transit Agencies (<100 buses) are required to submit a board-approved ZEB Rollout Plan by July 1, 2023.
- CCTS has 0 ZEB bonus credits.

Service Assessment & Feasibility Assumptions

- For fixed-route service, all large 32ft truck-style cutaways are modeled as 35ft generic BEBs.
  - These vehicles are most analogous to one another based on passenger loading and on-board energy.
  - On-route charging is required to maintain fixed-route service in **2028** with the first BEB procurement in the BEB scenario.

- All demand response service is performed by 25-26ft cutaways that will require midday or opportunity-charging at the depot.
  - Electrified cutaway service implies required schedule modifications.
  - On-route charging (pantograph or inductive) has not yet been demonstrated for this size vehicle.

Fleet Assessment Overview & Assumptions

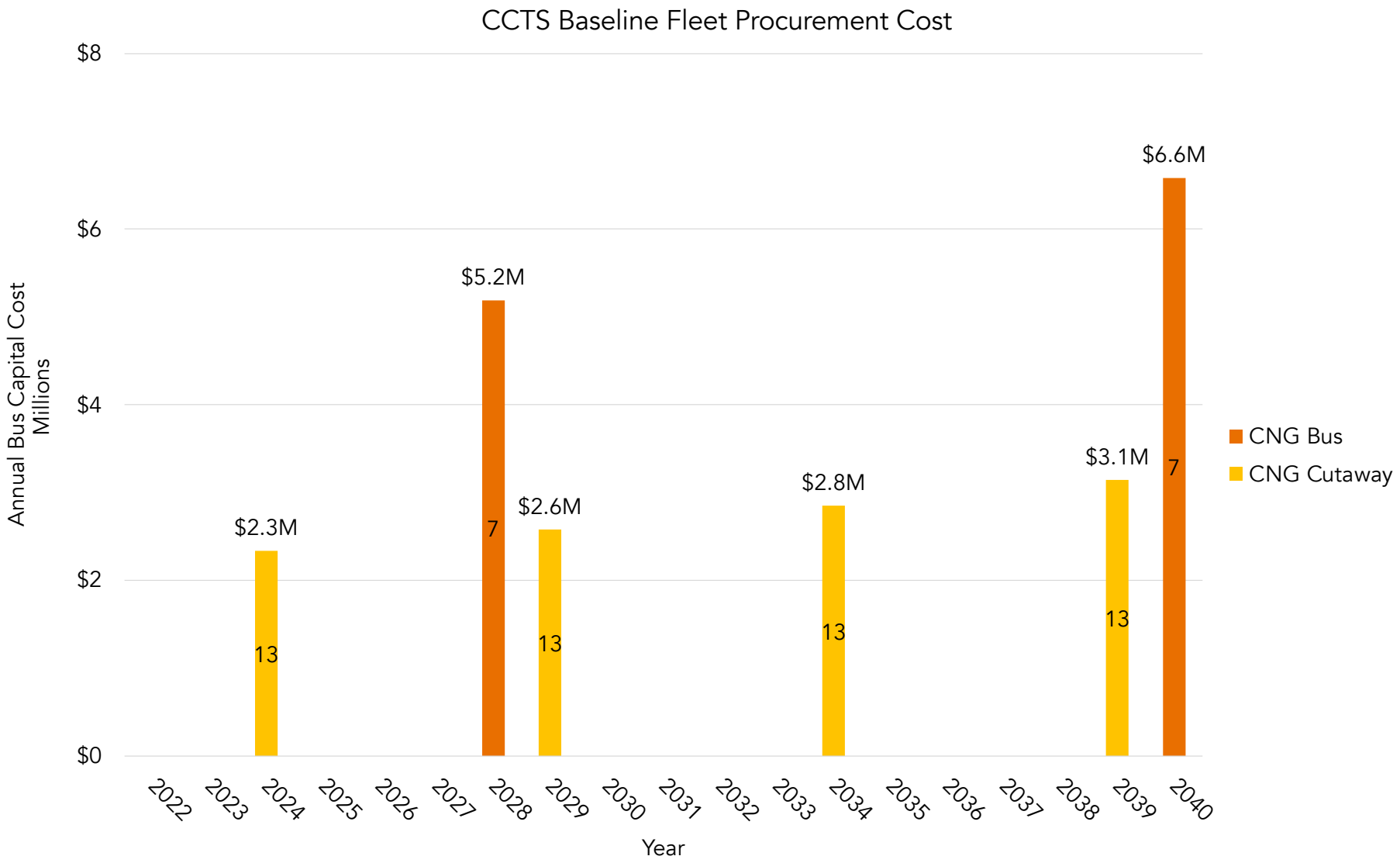
- Procurements cycles are based on the FTA minimum service life terms of the vehicle types.
  - 25-26ft cutaways are replaced on a 5 year cycle per the service life of van style cutaways.
  - 32ft truck-style cutaway are replaced on a 12 year cycle per 35ft bus service life minimum rules.

- Vehicles prices for legacy fueled vehicles are based on agency reporting and ZEV pricing is based on the 2022 CA State Contract
  - A 7.75% sales tax is included in the capital price of the vehicle.
  - An PPI inflation rate of 2% is applied year over year for the whole transition period.

- CCTS begins zero-emission vehicle purchases as required by the ICT procurement schedule.
  - 25% of total annual procurement number must be ZEV, if 25% of the total is less than .5, no ZEVs must be purchased. The first ZEB purchase is required in 2028.

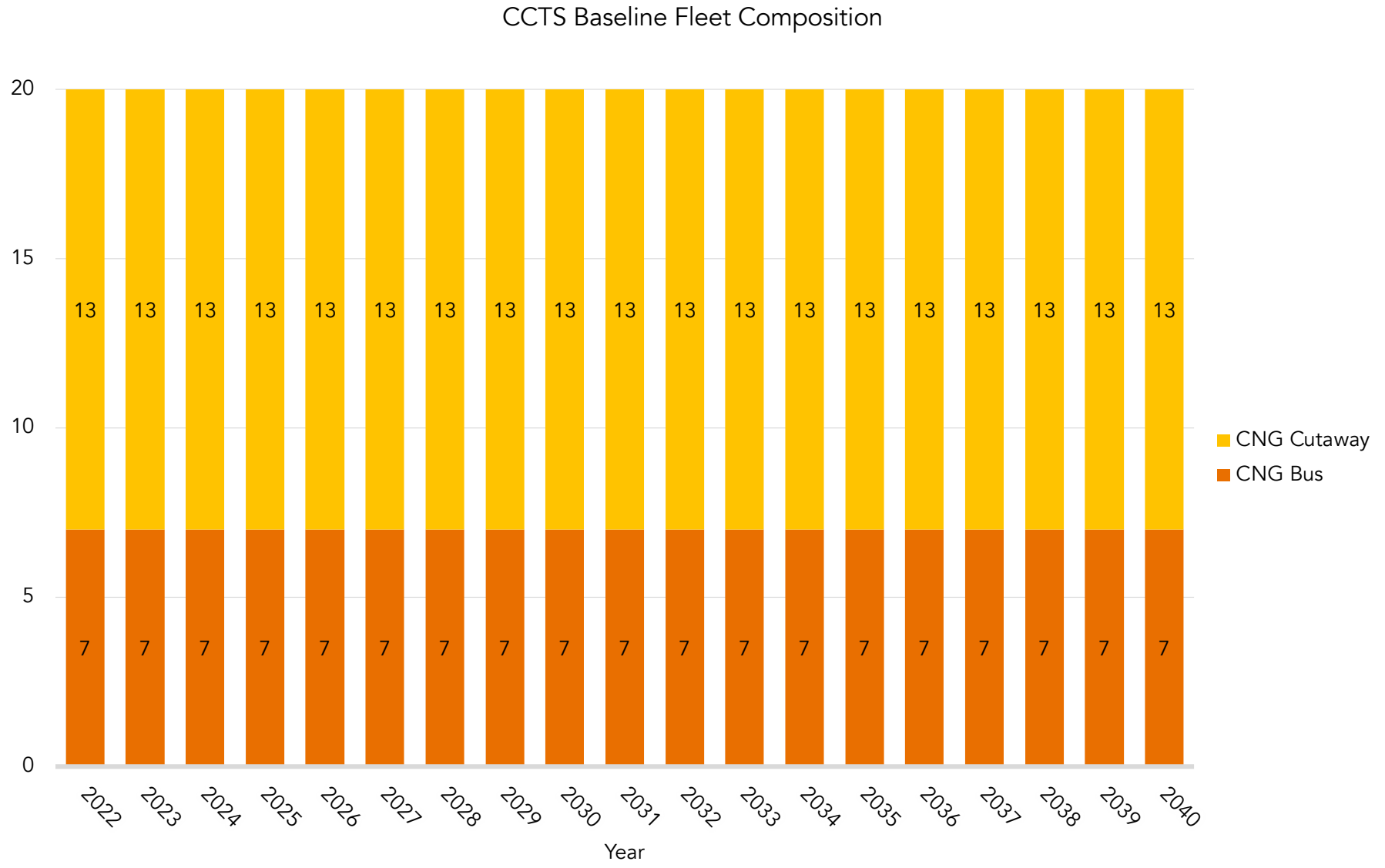
Bus Procurement Timeline & Annual Costs

Baseline



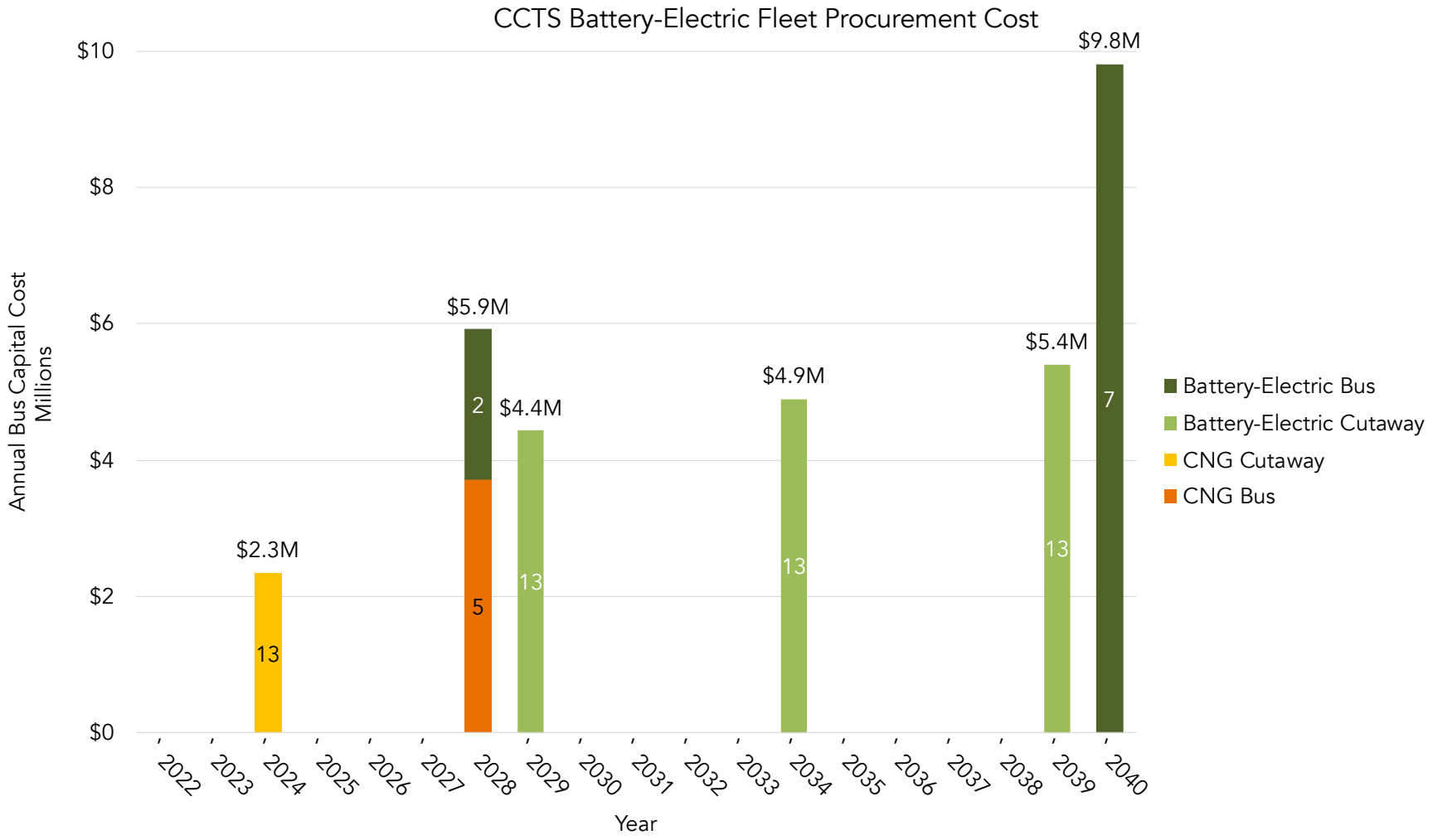
Fleet Composition

Baseline



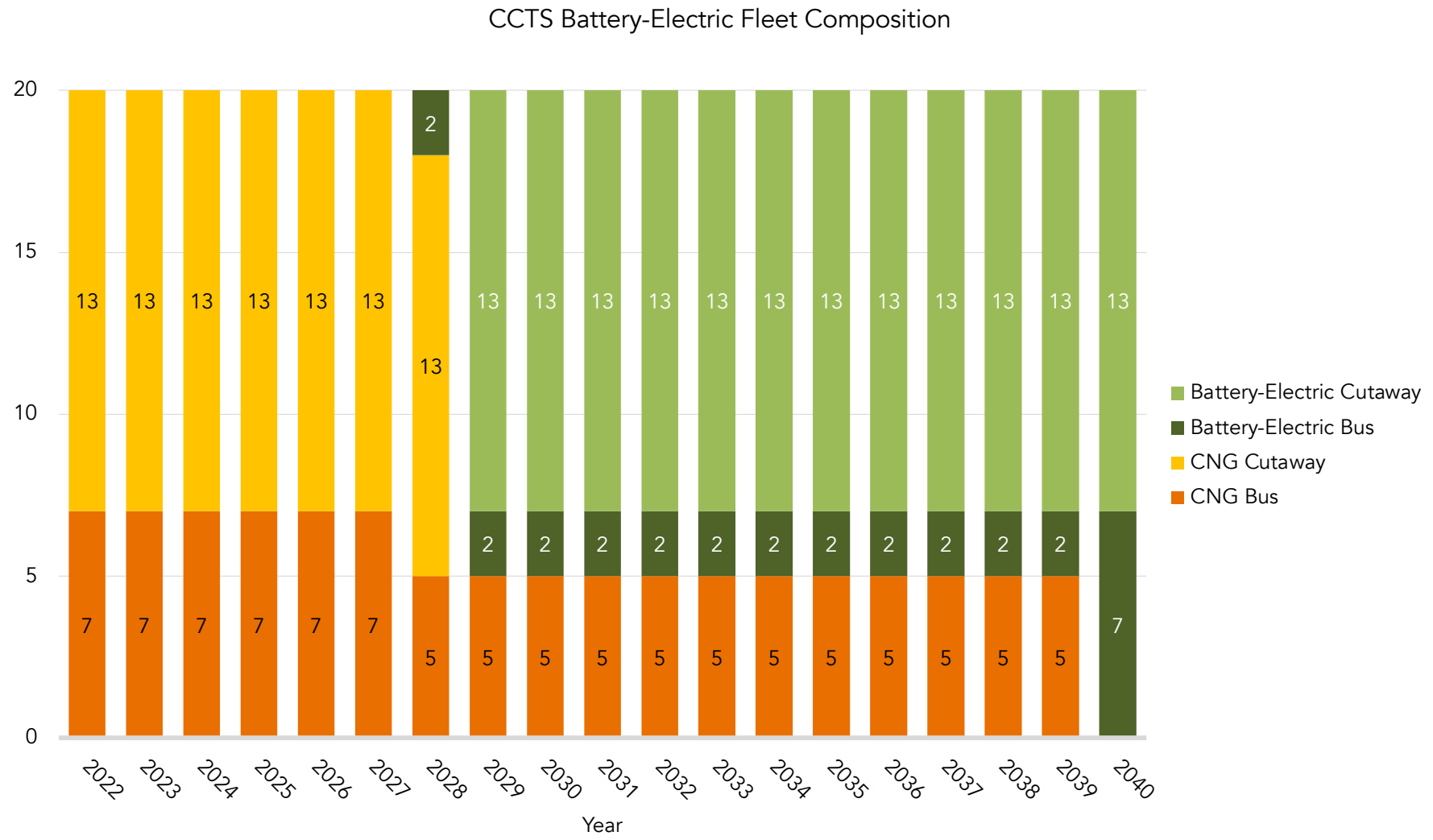
Bus Procurement Timeline & Annual Costs

BEB



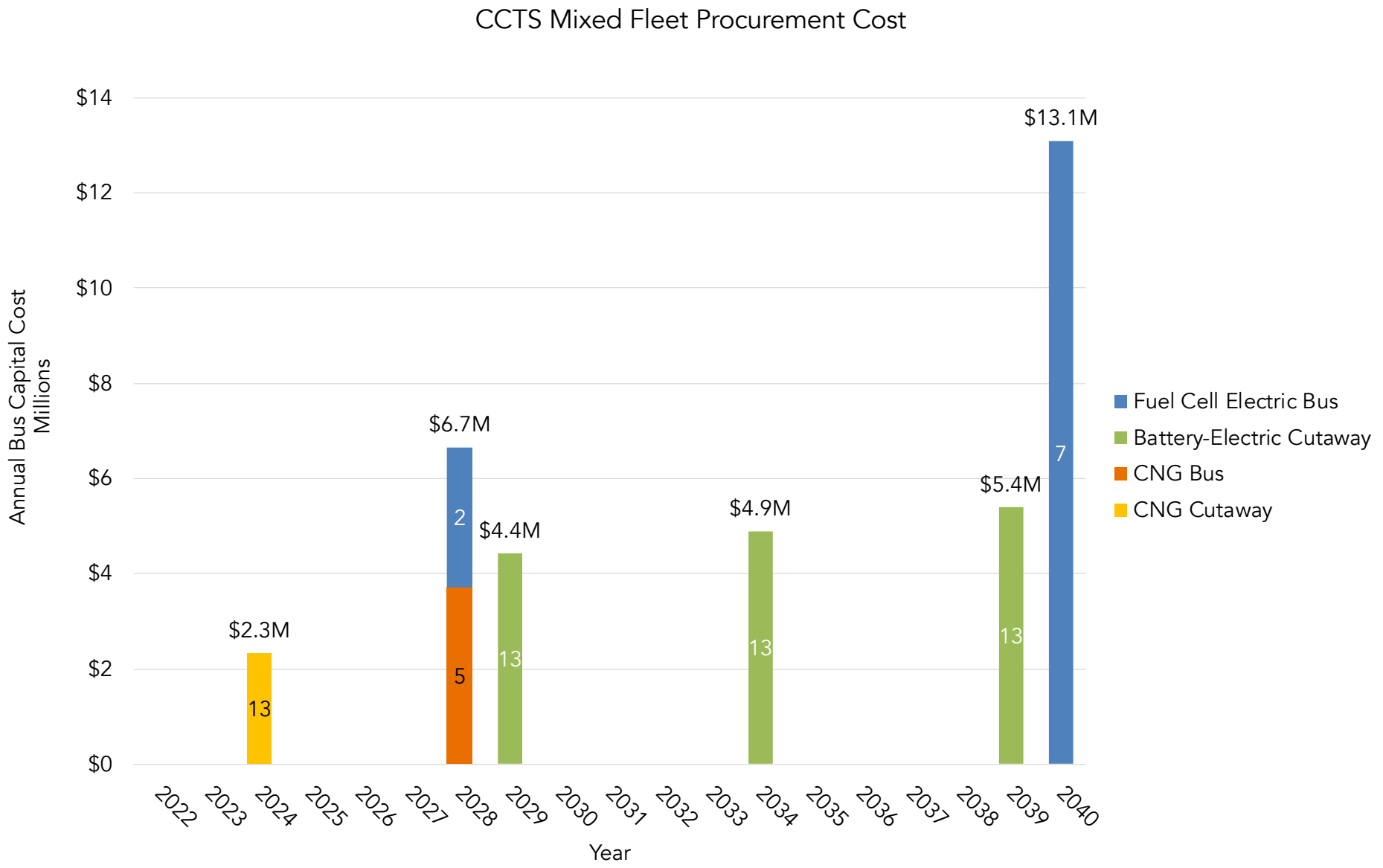
Fleet Composition

BEB



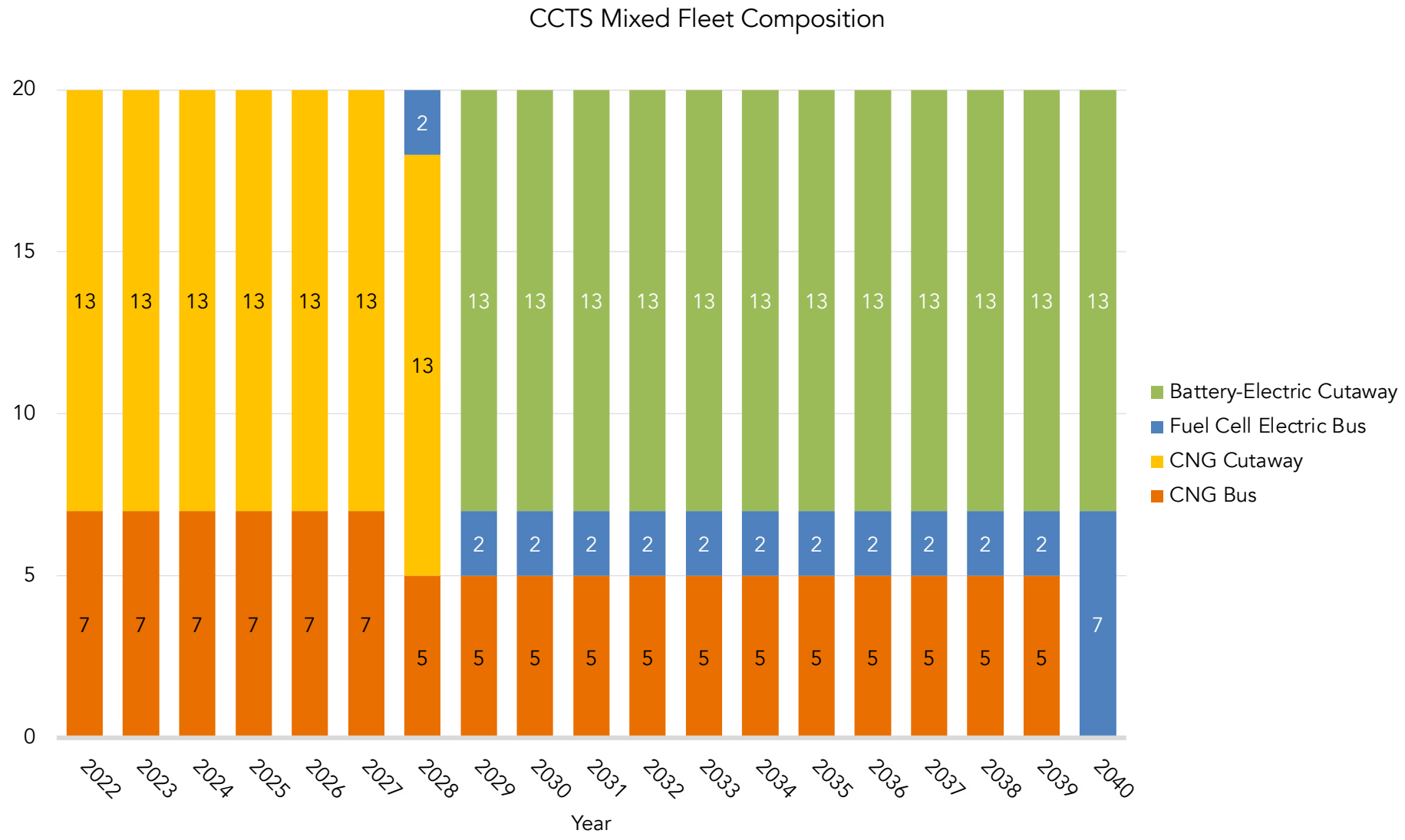
Bus Procurement Timeline & Annual Costs

Mixed Fleet



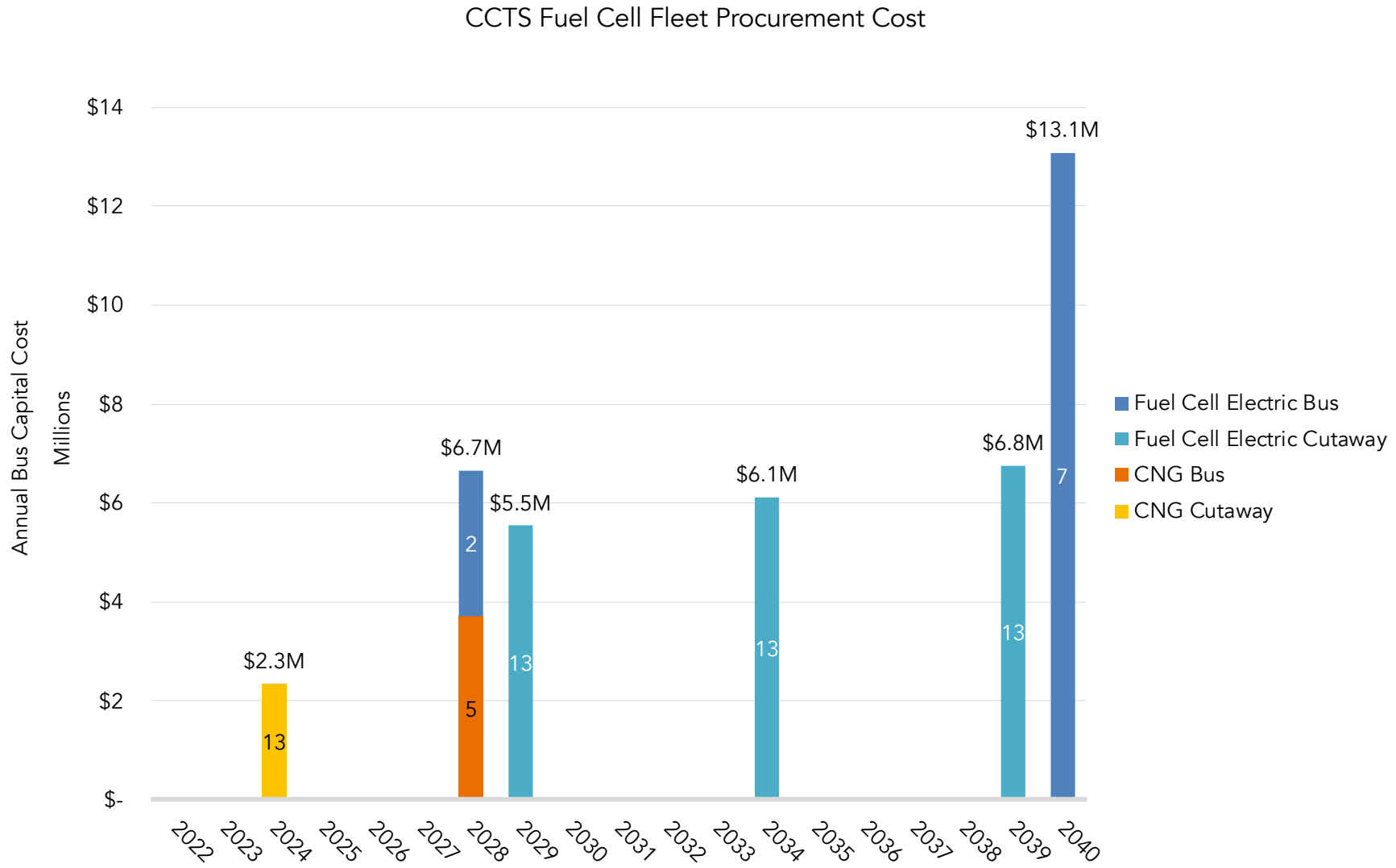
Fleet Composition

Mixed Fleet



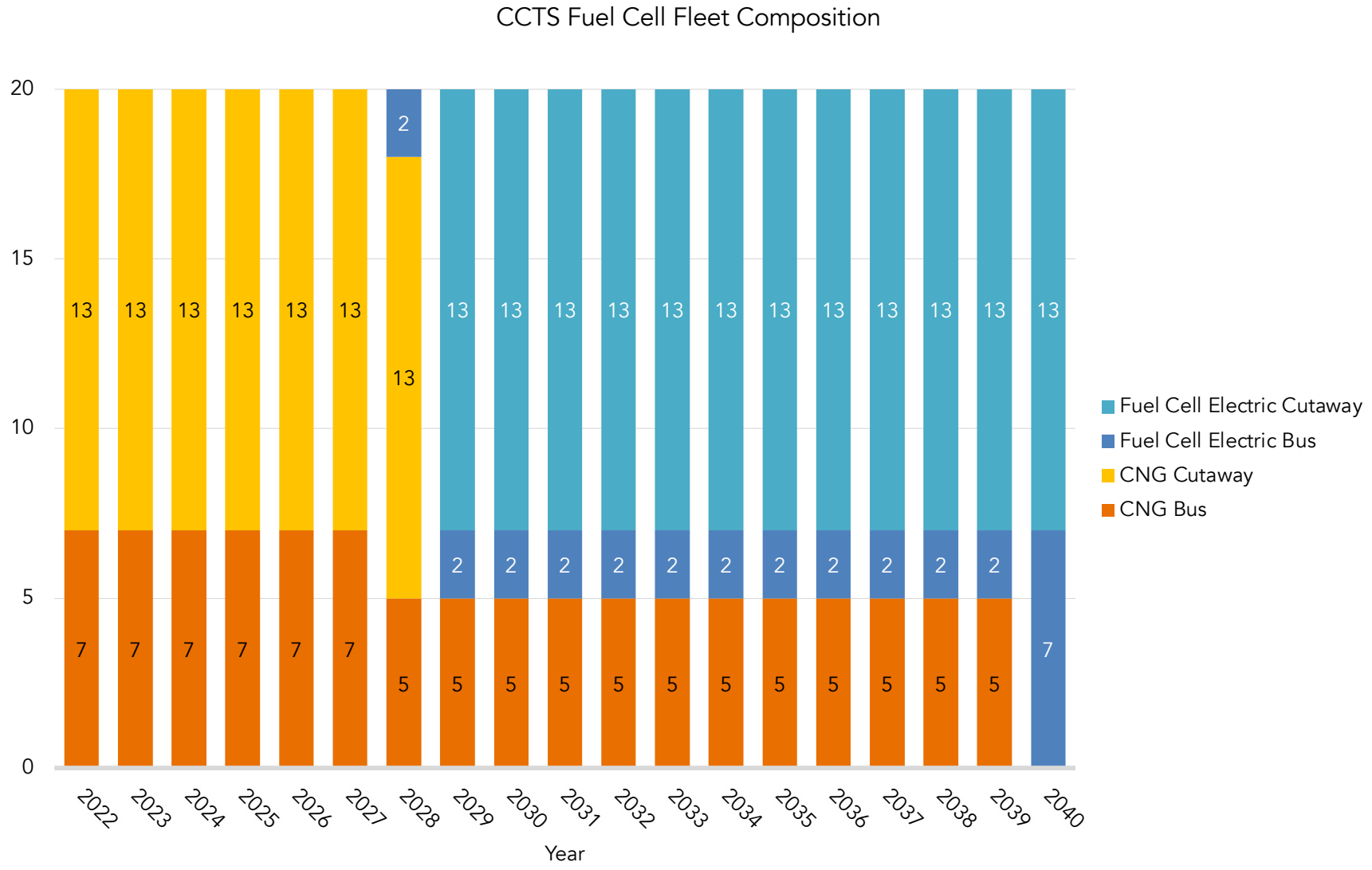
Bus Procurement Timeline & Annual Costs

FCEB



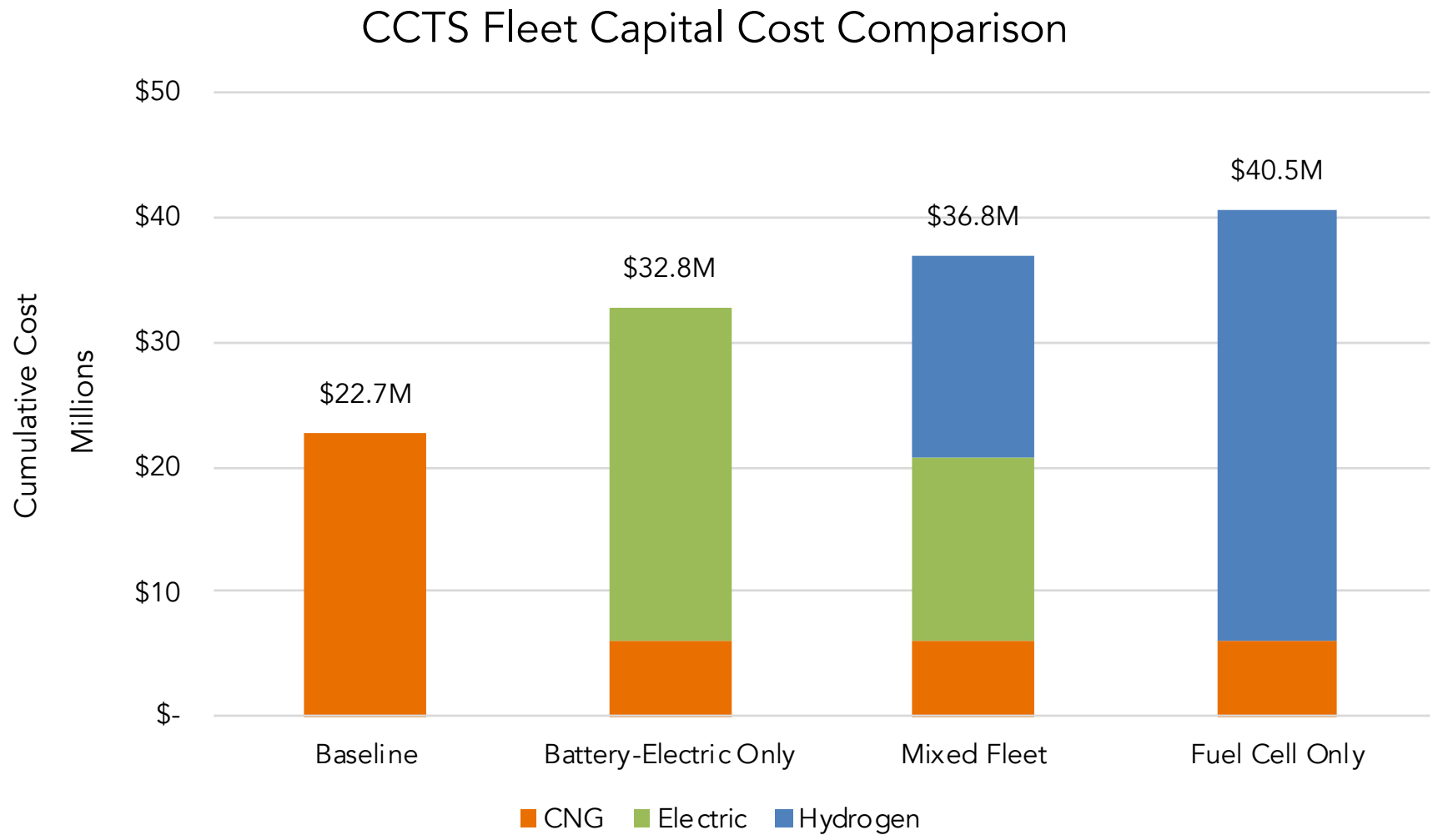
Fleet Composition

FCEB



Comparative Fleet Capital Costs

Entire Transition Period, All Scenarios



Fuel Cost Analysis

Fuel Cost Assumptions

- Assumes no change to annual fleet vehicle miles traveled.
- All costs are based on 2021 dollars, with **EIA** inflation for transportation fuels projected through 2040.

Fuel Type	Cost per unit	Avg. Cost per Mile for uniform propulsion fleet for 18-year period	Notes
CNG	$1.81/GGE	• $0.36/mile	• Average of agency-reported fuel prices across the entire fleet
H_2	$8.68/kg	• $0.69/mile	• Average of 2022 prices for CA hydrogen fuel for transit end-users contractual agreements. Price contains station O&M costs.
Electricity	SCE TOU-EV-9 rate structure	• $0.42/mile	• See next slide

Assumptions for Electricity Costs

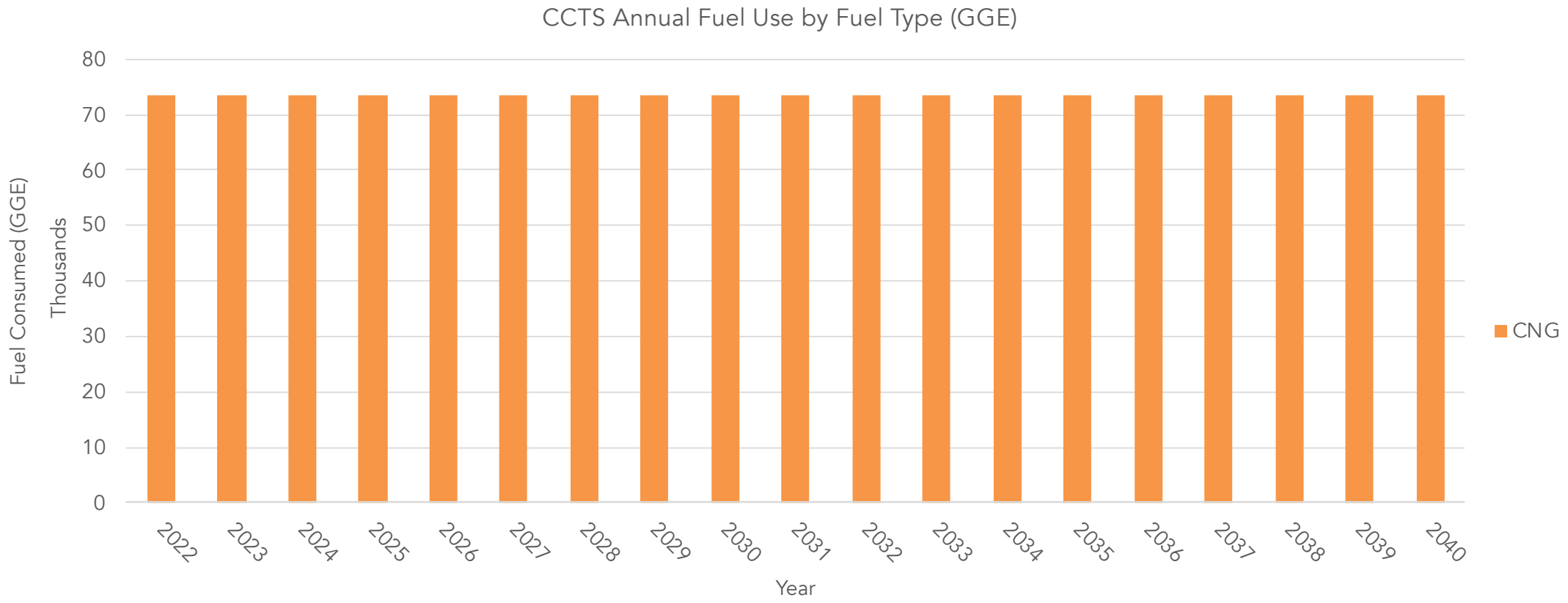
- Electricity costs based on SCE's TOU-EV-9
  - **50%** of the agency's DAR requirements can be satisfied with overnight depot charging, and **50%** can be satisfied with opportunity depot charging
  - **56%** of the agency's fixed route requirements can be satisfied with overnight depot charging, and **44%** can be satisfied with on-route opportunity charging

	TOU Rates	Summer ($/kWh) (4m)	Winter ($/kWh) (8m)	Annual
Electric Utility Rates - SCE TOU-EV-9	On-Peak	$0.47		$0.47
	Mid-Peak	$0.29	$0.33	$0.32
	Off-Peak	$0.17	$0.18	$0.18
	Super-Off		$0.11	$0.11
	Fixed Recovery Charge	$		0.00066
	$/Meter/Month	$		368.25

**Commencing March 1, 2019, no Demand Charge shall apply to Customers receiving (T) service under this Schedule.*
***Phase-In of Demand Charge shall occur as determined and authorized by the (T) Commission in SCE's next GRC Phase 2 application or any Commission proceeding | related to transportation electrification.*

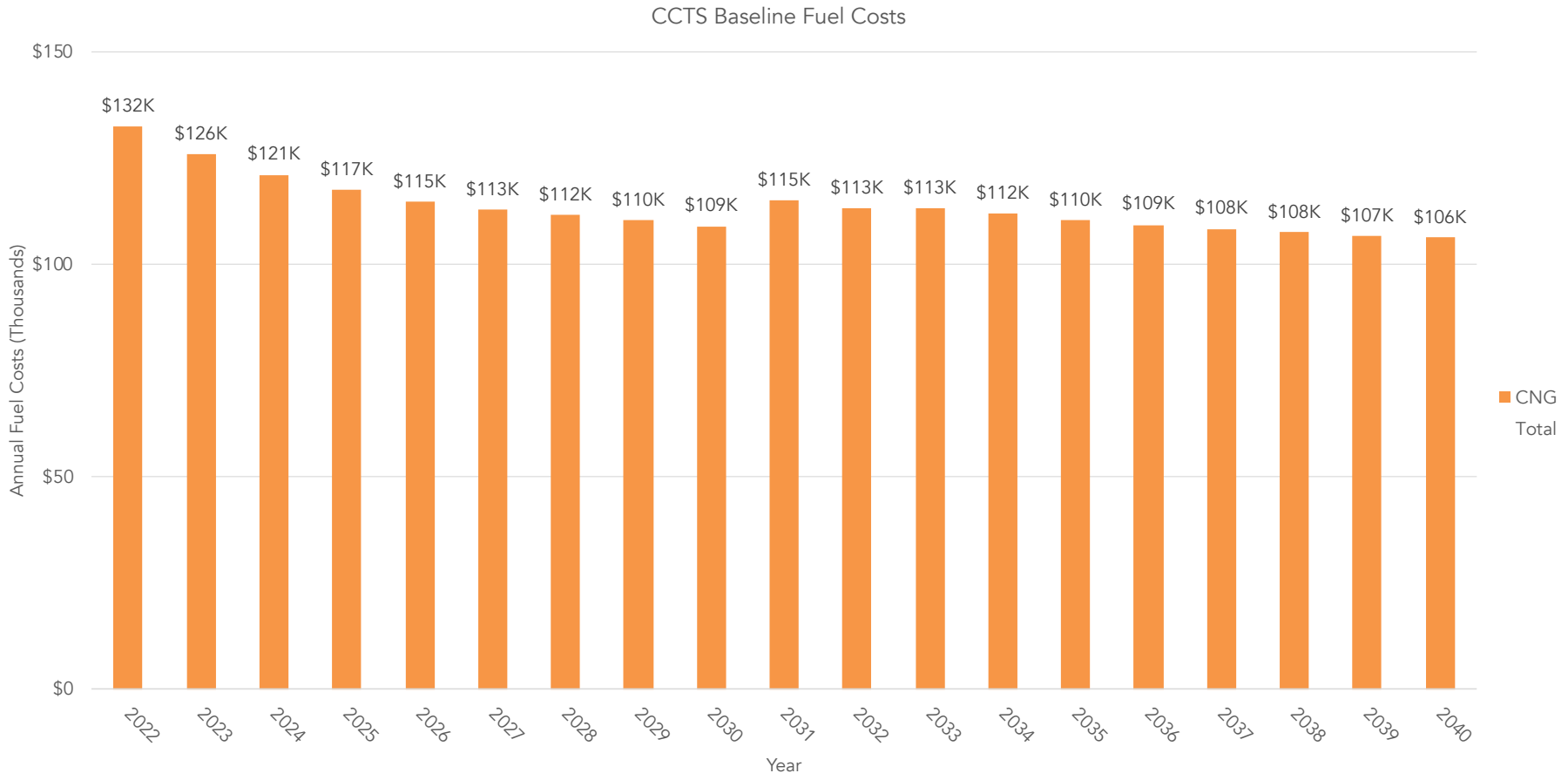
Annual Fuel Consumption

Baseline



Annual Fuel Consumption Costs

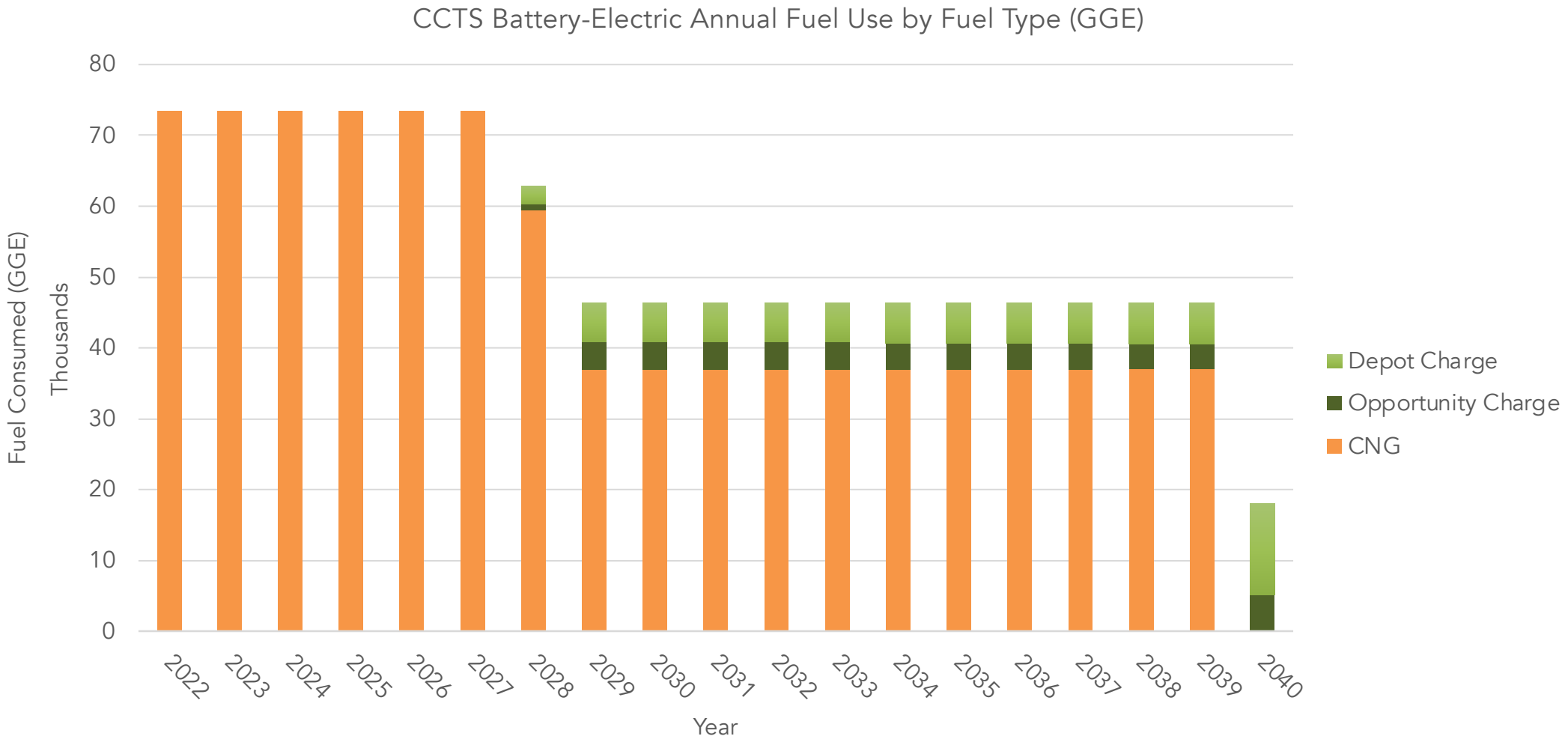
Baseline



The average fuel cost per mile for all fuels utilized in the course of the transition period for this scenario is $0.36/mile.

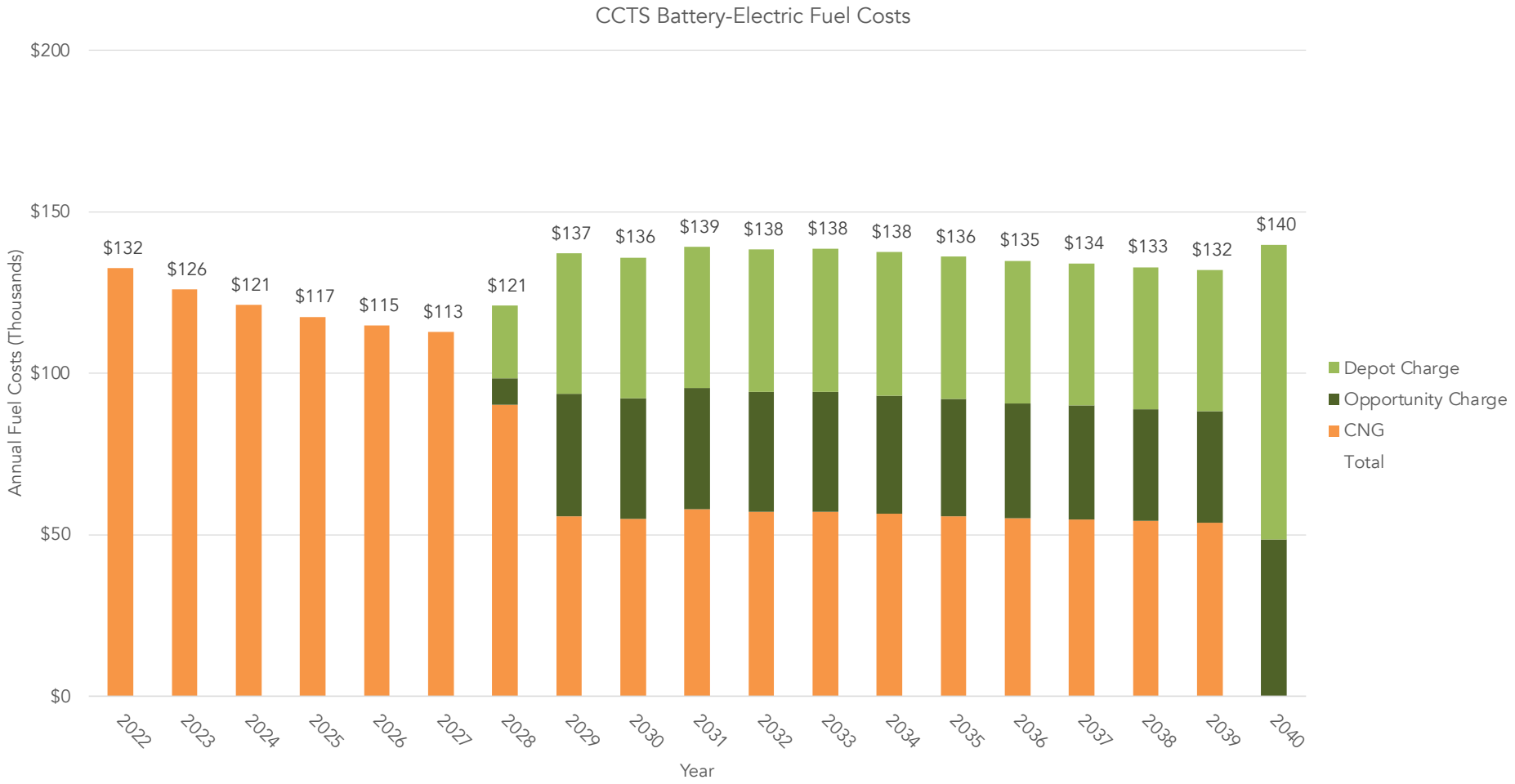
Annual Fuel Consumption

BEB



Annual Fuel Consumption Costs

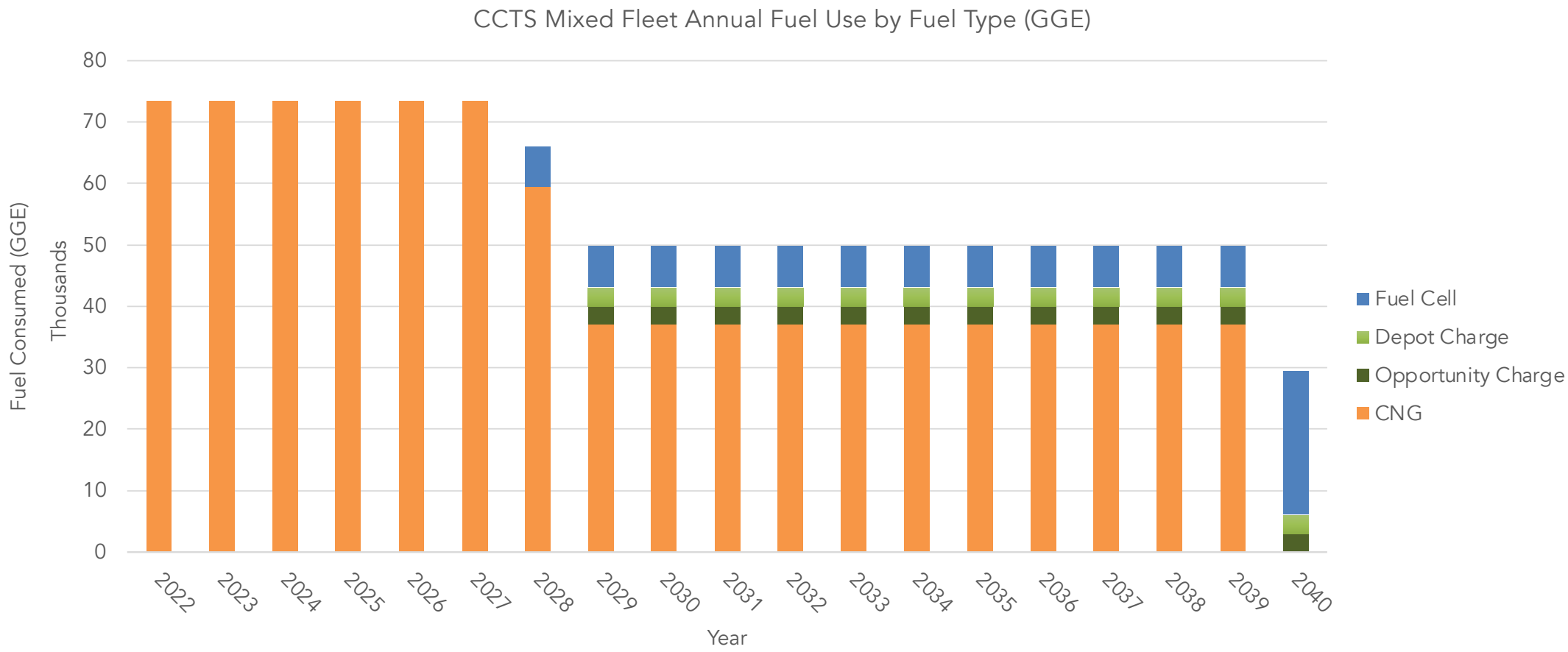
BEB



The average fuel cost per mile for all fuels utilized in the course of the transition period for this scenario is $0.41/mile.

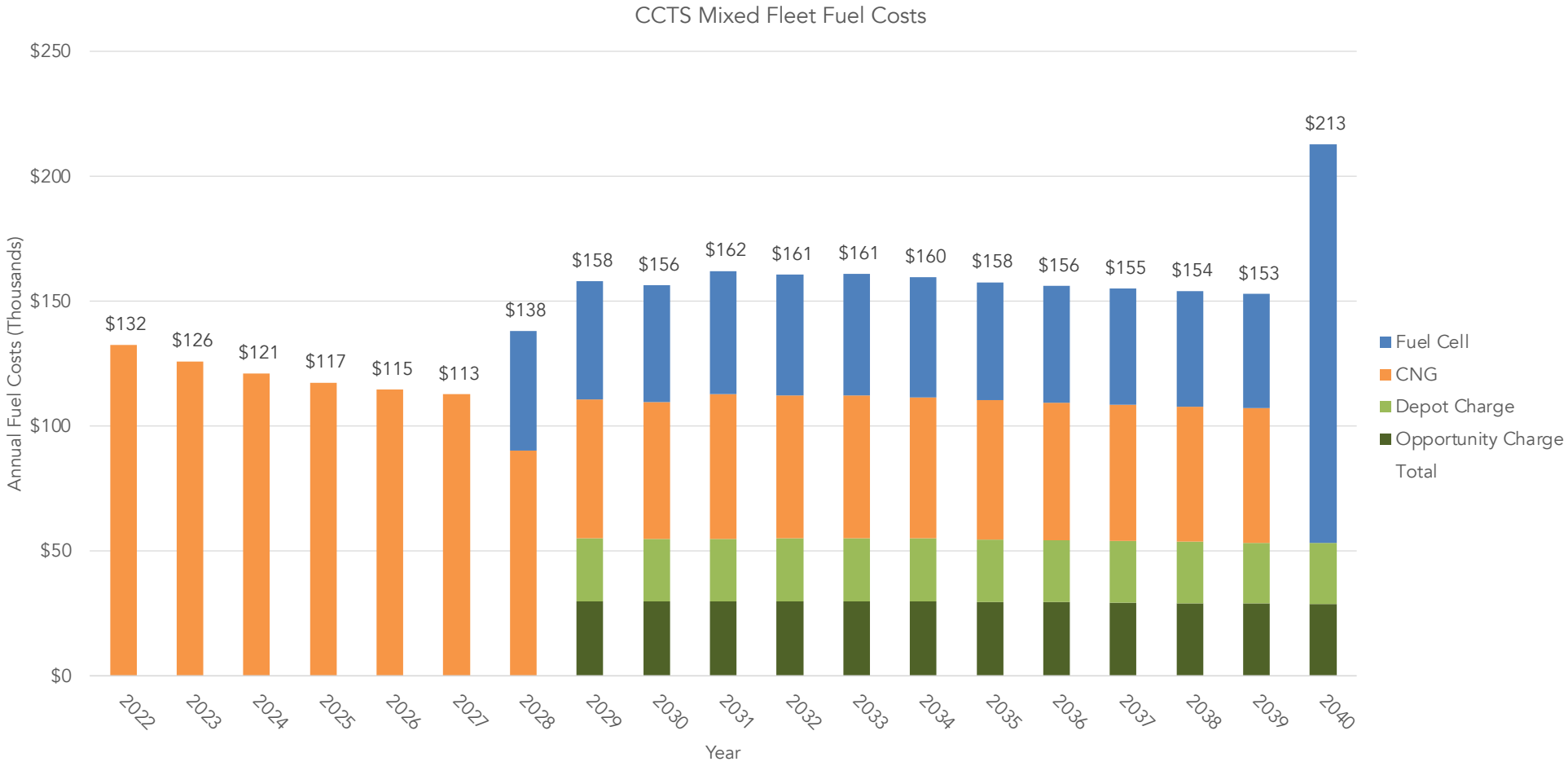
Annual Fuel Consumption

Mixed Fleet



Annual Fuel Consumption Costs

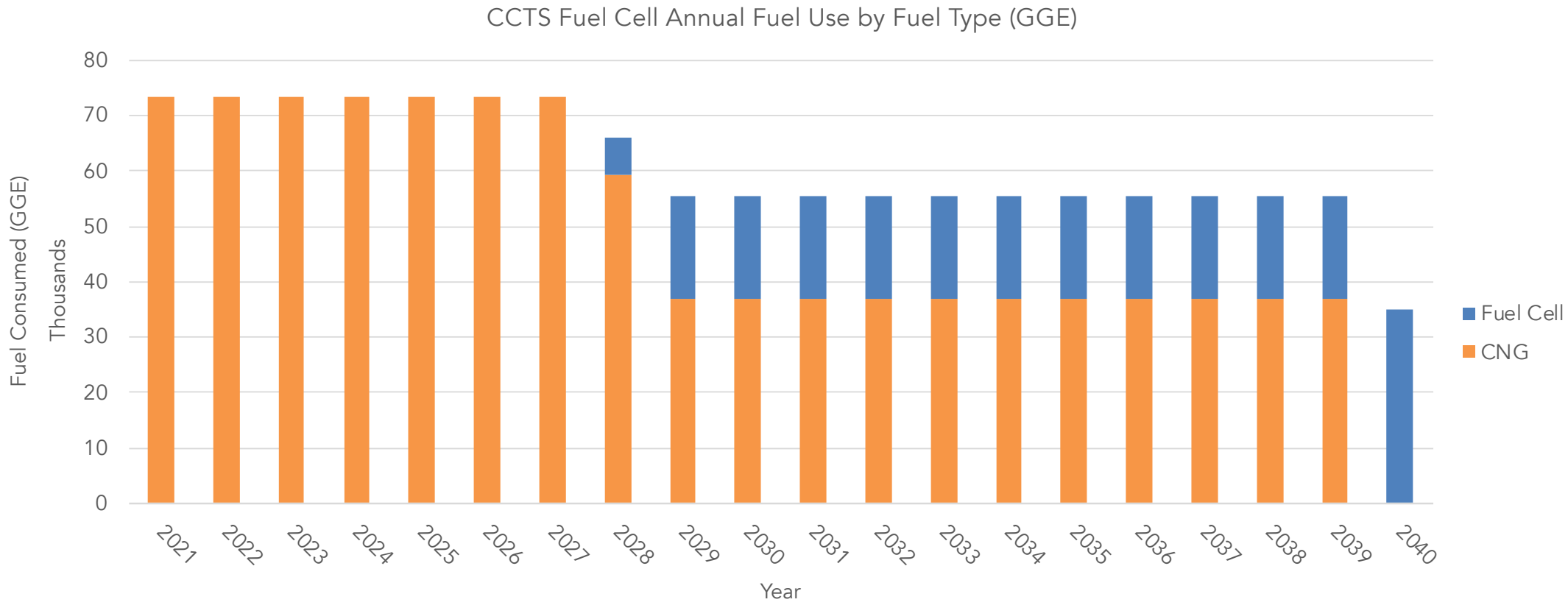
Mixed Fleet



The average fuel cost per mile for all fuels utilized in the course of the transition period for this scenario is $0.46/mile.

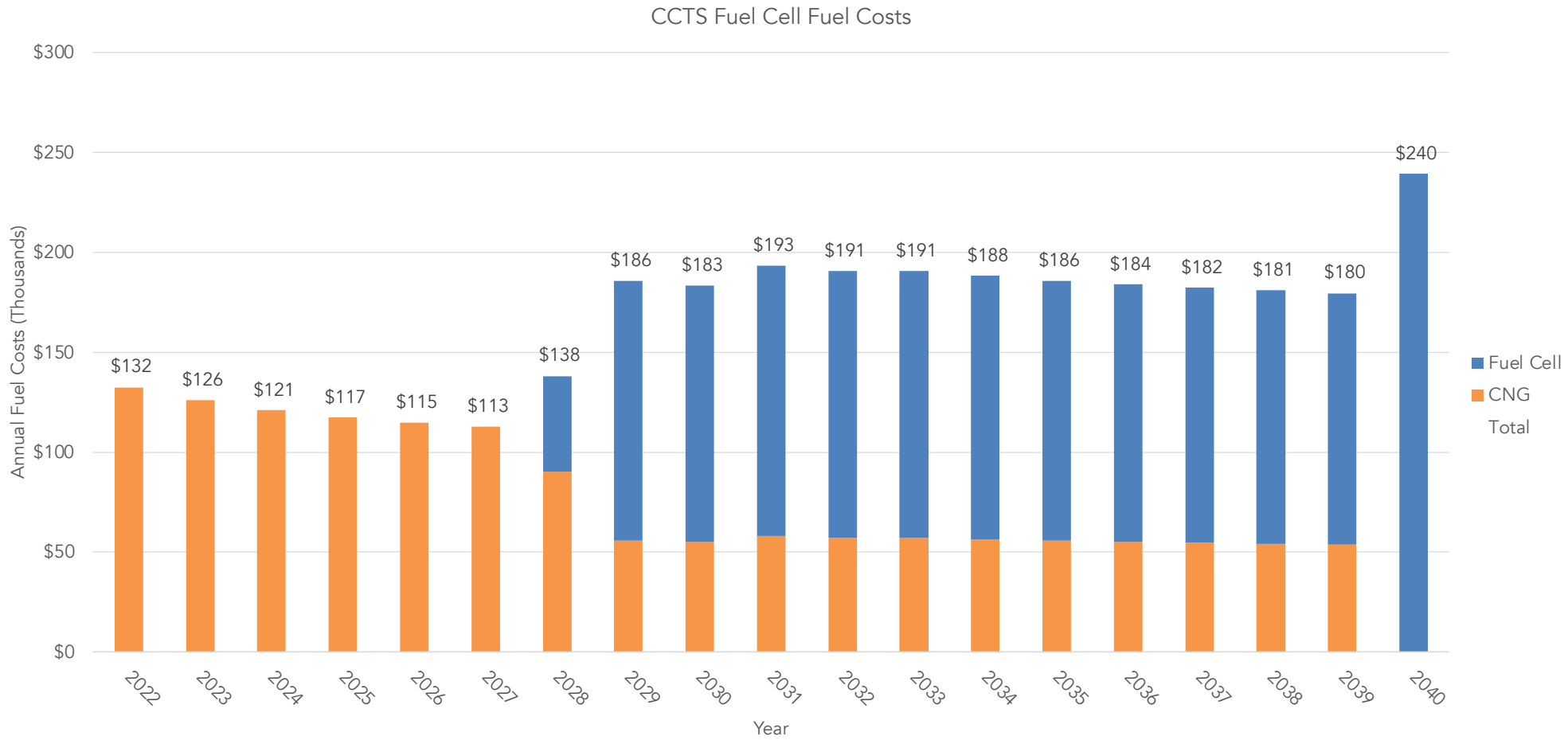
Annual Fuel Consumption

FCEB



Annual Fuel Consumption Costs

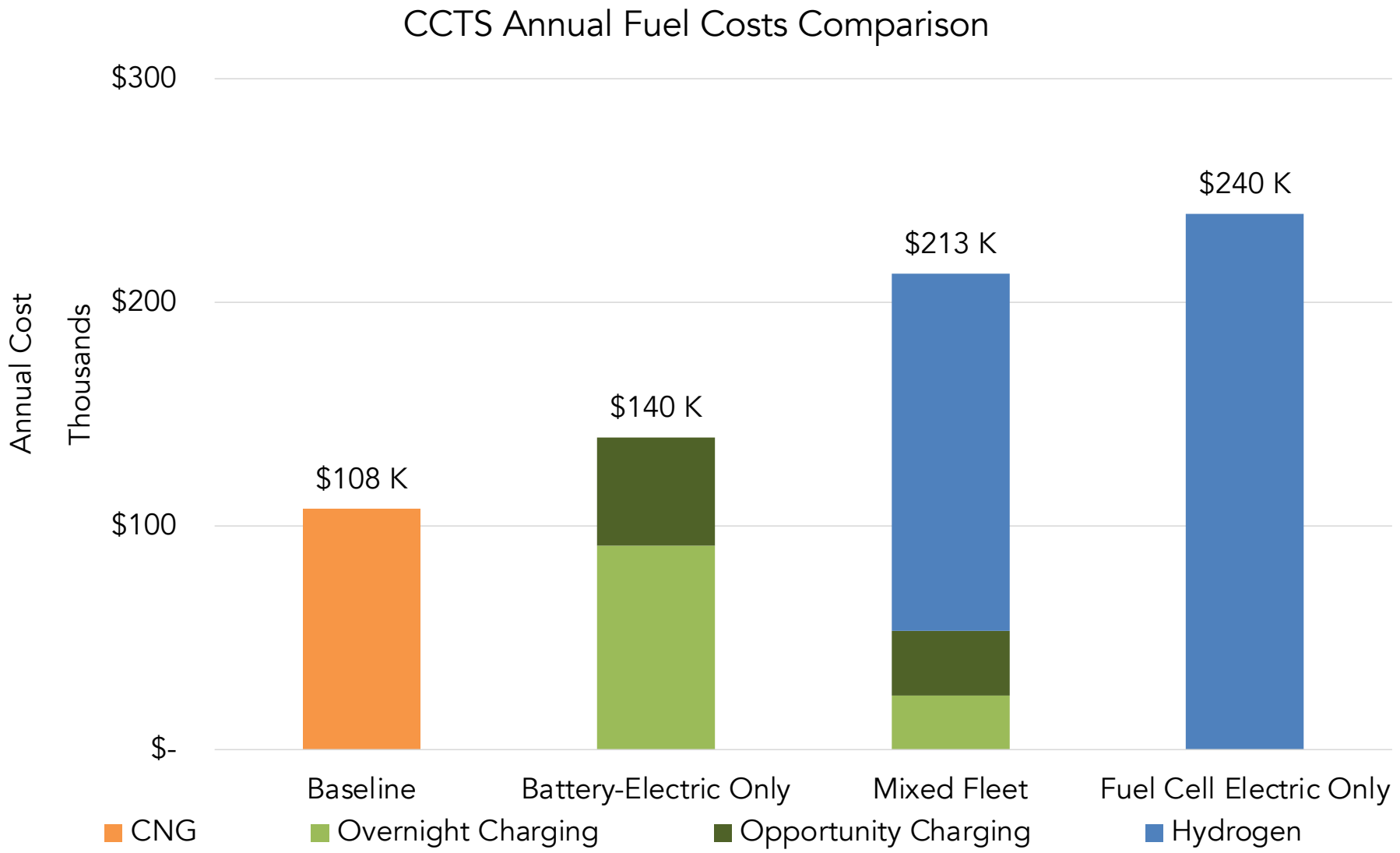
FCEB



The average fuel cost per mile for all fuels utilized in the course of the transition period for this scenario is $0.52/mile.

Comparative Annual Fuel Costs

For Transitioned Fleet 2040, All Scenarios – Single Year of Operations



Maintenance Cost Analysis

Maintenance Cost Assumptions

Annual Vehicle Parts & Labor

- Basic calculation framework is established by NREL reports of per-mile costs for standard buses.
- Calculation items based on mileage-weighted averages from the NREL study data, adjusted to year 2021 dollars.
- Applied a common service life and curb weight for each operator for each class of vehicle.
- This maintenance assessment includes only vehicle maintenance costs for the transition.
  - Hydrogen and CNG infrastructure maintenance is included in the fuel price in the fuel assessment.
  - Charger maintenance is included in the infrastructure assessment.
  - Many other operational and administrative costs are not included.
- Inflation is applied to the costs per mile at 3% per year per the CPI Index.

Maintenance Costs Composition

NREL Category and ATA VMRS Items	CNG Cost per Mile	BEB Cost per Mile
Exhaust System Repairs (43)	$0.00706	$0.00000
Fuel System Repairs (44)	$0.01909	$0.00000
Power Plant Repairs (45)	$0.04035	$0.00694
Electric Propulsion Repairs (46)	$0.00000	$0.03376
Air Intake System Repairs (41)	$0.00507	$0.00013
Cooling System Repairs (42)	$0.02025	$0.01631
Hydraulic System Repairs (65)	$0.00017	$0.00000
General Air System Repairs (10)	$0.00658	$0.00472
Transmission Repairs (27)	$0.00532	$0.01045
HVAC System Repairs (01)	$0.01559	$0.01495
Axle, Wheel, and Driveshaft Repairs (11, 18, 22, 24)	$0.00964	$0.01157
Electrical System Repairs (30, 31, 32, 33)	$0.04318	$0.04318
Lighting System Repairs (34)	$0.00692	$0.00692
Tire Repairs (17)	$0.02918	$0.02918

NREL Category (with ATA VMRS codes)	Adjusted Model Formulation
Brake System Repairs (13)	CNGs at $0.0014 per curb weight ton-mile (CWTM). BEBs were assumed to be 45% of CNGs based on ICT Appendix G
Preventive Maintenance Inspections (101)	$1425/$1500 per vehicle (cutaway/standard) plus $0.000072 per CWTM
Car, Body, and Accessory Systems Repairs (02, 50, 71)	Replaced by a new 'Combined Mechanical' category
Frame, Steering, and Suspension Repairs (14, 15, 16)	Replaced by a new 'Combined Mechanical' category
Combined Mechanical (02, 11, 18, 22, 24, 50, 71)	$0.0072 per CWTM

Maintenance Cost Assumptions

Annual Vehicle Maintenance Parts & Labor

Legacy Vehicle Type	Maintenance Cost (Per Mile)
Gas Cutaway	$ 0.35
CNG Cutaway	$ 0.35
30’/35’/40’ CNG Bus	$ 0.38

Zero-Emission Vehicle Type	Maintenance Cost (Per Mile)
Battery Electric Cutaway	$ 0.32
30’/35’/40’ Battery Electric Bus	$ 0.34
Fuel Cell Electric Cutaway	$ 0.51
30’/35’/40’ Fuel Cell Electric Bus	$ 0.56

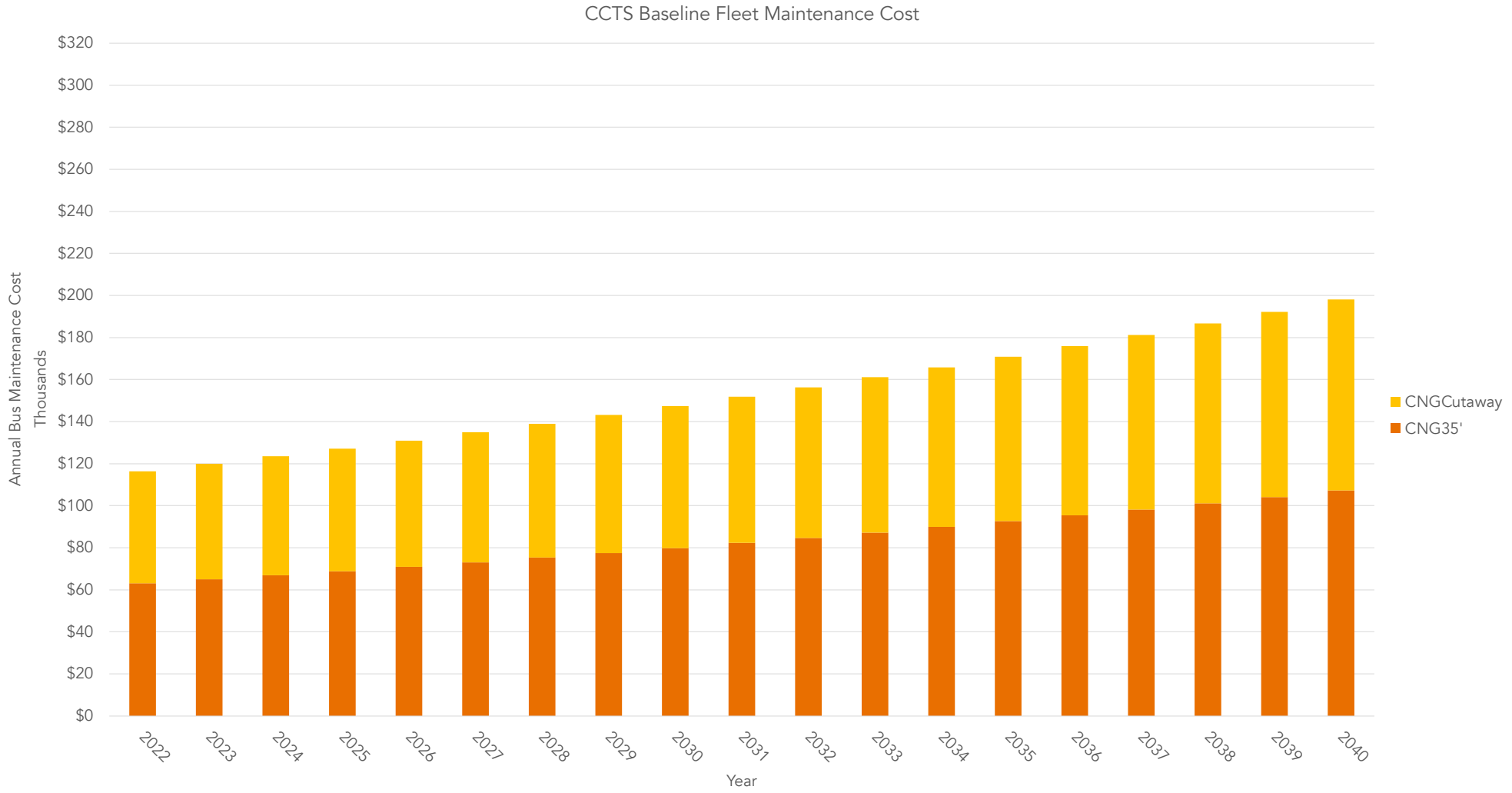
Maintenance Cost Assumptions

Capital Expenditure in Maintenance Parts & Labor

Vehicle Type	Overhaul (FC/Transmission) Cost Per vehicle life	Battery Warranty Cost Per vehicle life
CNG Cutaway	$0	$0
30’/35’/40’ CNG Bus	$30,000	$0
Battery Electric Cutaway	$0	$24,000
30’/35’ 40’ Battery Electric Bus	$0	$75,000
30’/35’/40’ Fuel Cell Electric Bus	$40,000	$17,000
Fuel Cell Electric Cutaway	$0	$10,000

Annual Maintenance Costs

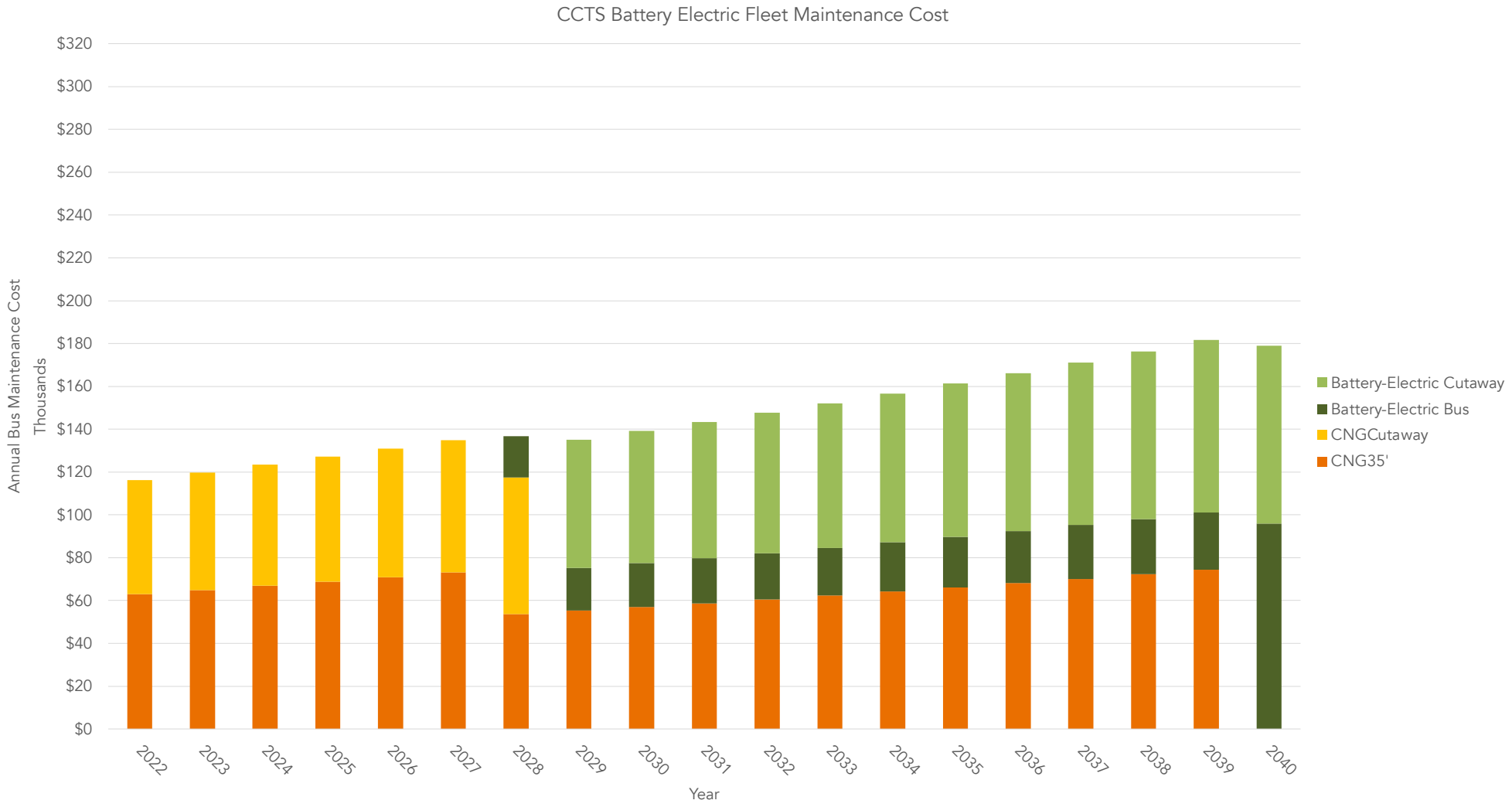
Baseline



Capital expenditure for vehicle battery warranties and fuel cell & CNG overhauls for the course of the transition is approx. **$420K** and covers the cost of this maintenance practice for **66** vehicles.

Annual Maintenance Costs

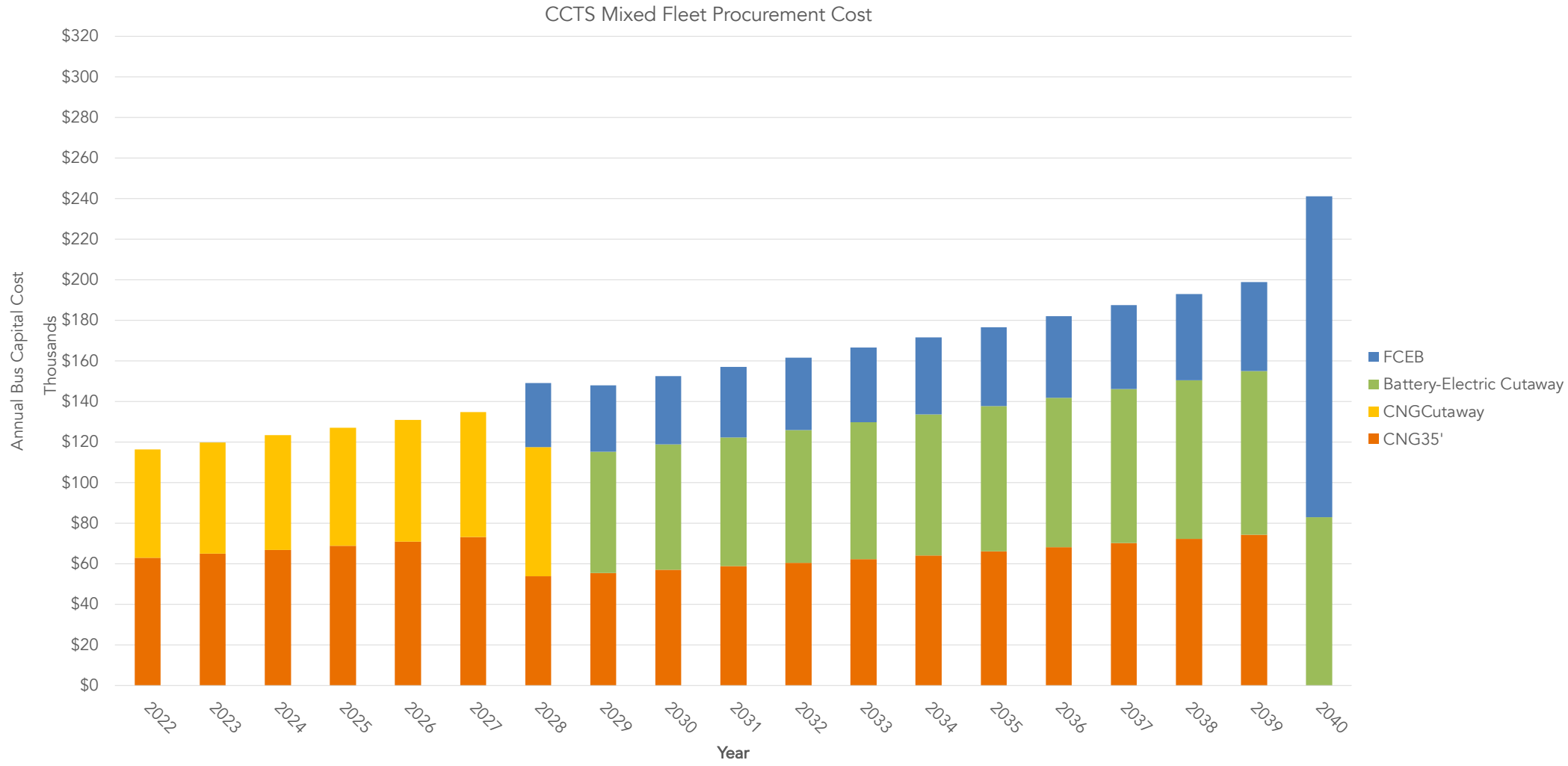
BEB



Capital expenditure for vehicle battery warranties and fuel cell (if applicable) & CNG overhauls for the course of the transition is approx. **$1.8M** and covers the cost of this maintenance practice for **66** vehicles.

Annual Maintenance Costs

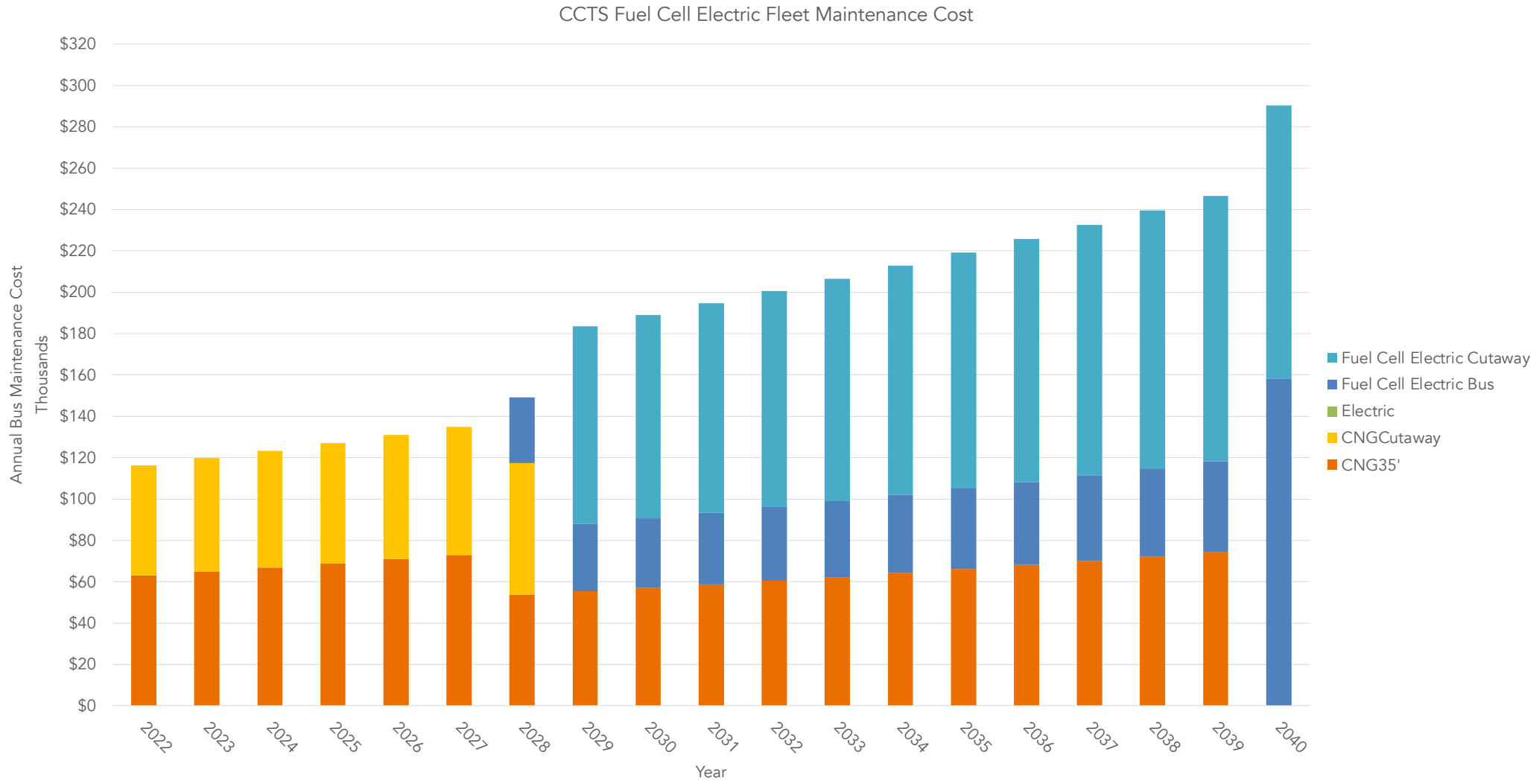
Mixed Fleet



Capital expenditure for vehicle battery warranties and fuel cell (if applicable) & CNG overhauls for the course of the transition is approx. **$1.6M** and covers the cost of this maintenance practice for **66** vehicles.

Annual Maintenance Costs

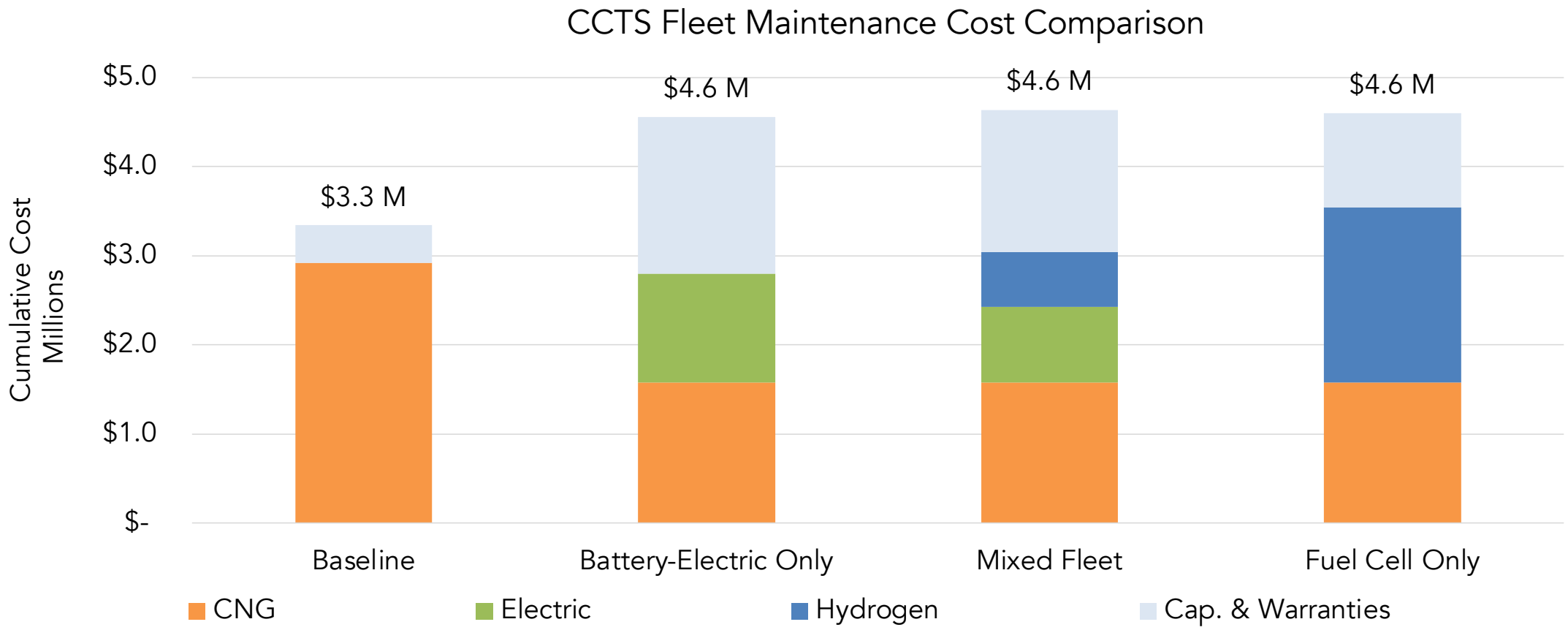
FCEB



Capital expenditure for vehicle battery warranties and fuel cell (if applicable) & CNG overhauls for the course of the transition is approx. **$1.1M** and covers the cost of this maintenance practice for **66** vehicles.

Comparative Maintenance Costs

Entire Transition Period, All Scenarios



Preliminary Facilities Cost Analysis

Facilities Concept Assumptions

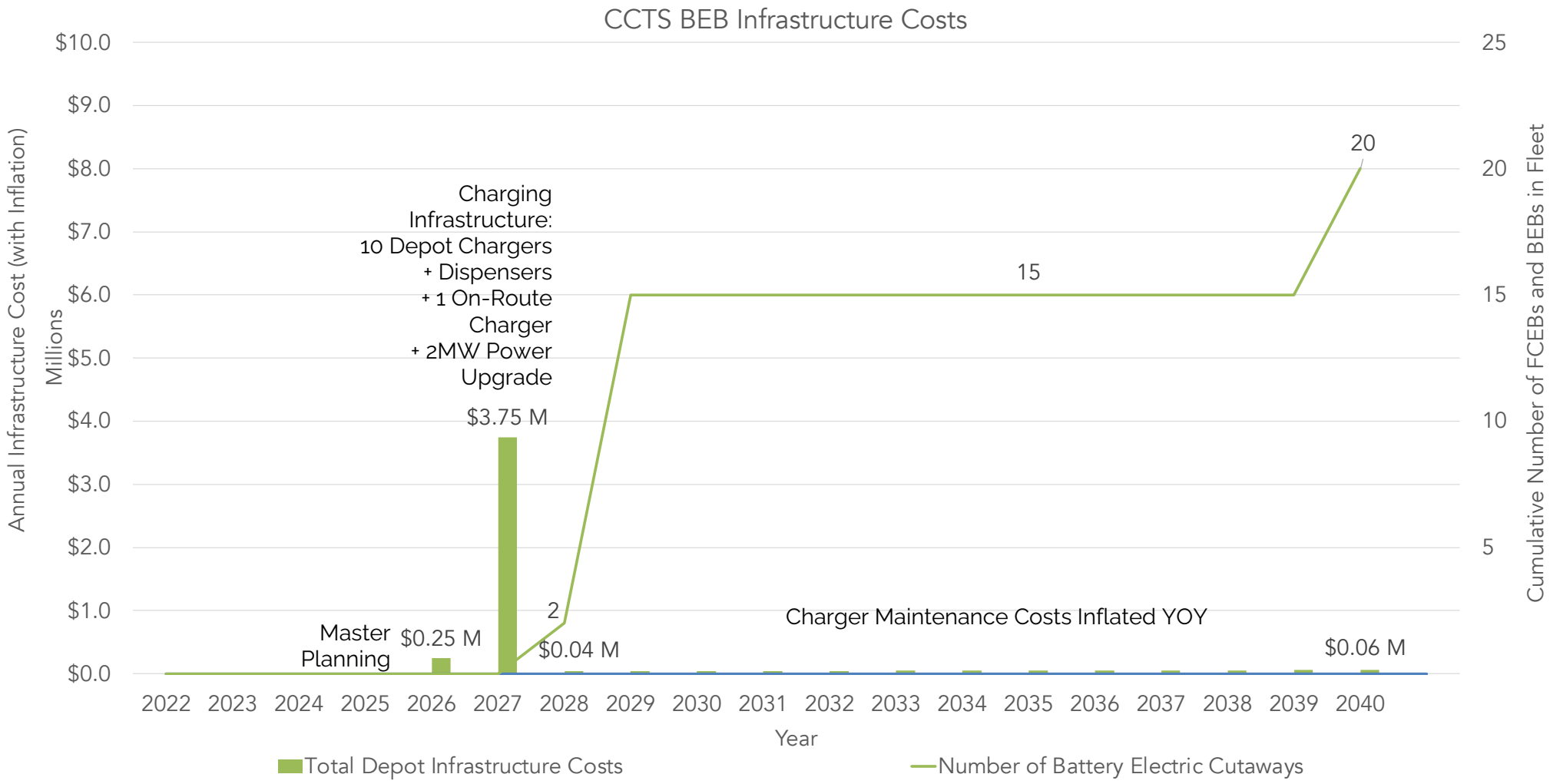
- No land acquisition costs are included in the project costs.
- Infrastructure for baseline is not included since it is a continuation of today's operations.
- Assume 100% of buses will operate, so every bus has a dispenser.
- Assumes 2 dispensers per 150 kW charger and a 2 bus to 1 charger ratio
  - Only one transit bus can charge at a time.
  - Two cutaways can charge simultaneously at one charger, each charging at 75kW.
- Depot & Station MW capacity is assumed to start at 0.
- On-Route chargers assume each charger can serve 4 buses per hour to allow for each bus to have 15 minutes on the charger in any given hour.
  - Each on-route charger has just one dispenser (assumed to be pantograph- usable only by transit buses).
- Costs are applied in **the year prior** to non-ZEBs are replaced with ZEBs requiring the infrastructure to represent the actual year of expenditure for the RCTC implementation plan.

Facilities Cost Assumptions

- Construction projects are inflated 5.4% per year per **Caltrans Construction Index (CCI).**
- Hydrogen fueling projects are determined based on annual consumptions and known fueling technologies. All operators fueling solutions are decided based on fuel consumption need and approximately right-sized.
- Hydrogen infrastructure maintenance and operations is covered in the price of fuel in the fuel assessment.
- Charger maintenance is included as a $3,000/per charger per year inflated at 3% per year.
- Infrastructure project pricing is determined through averages of recent CTE deployment projects as well as transit client procurement and industry product insights (proprietary).
  - IBI Group will explore site assessments and infrastructure recommendations for each operator's *selected* transition scenario further in tasks 4.3 & 4.4.

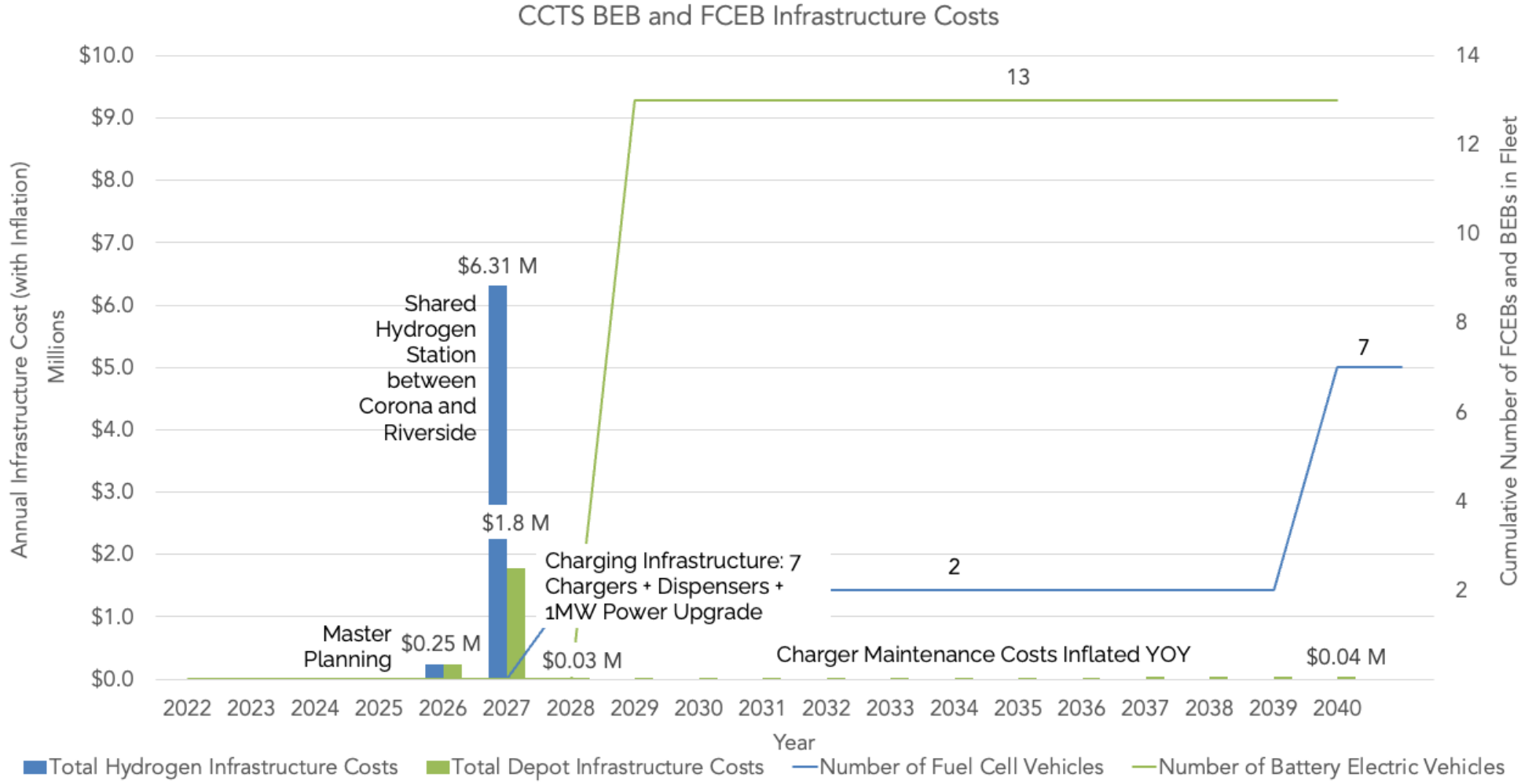
Annual Infrastructure Timeline & Costs

BEB



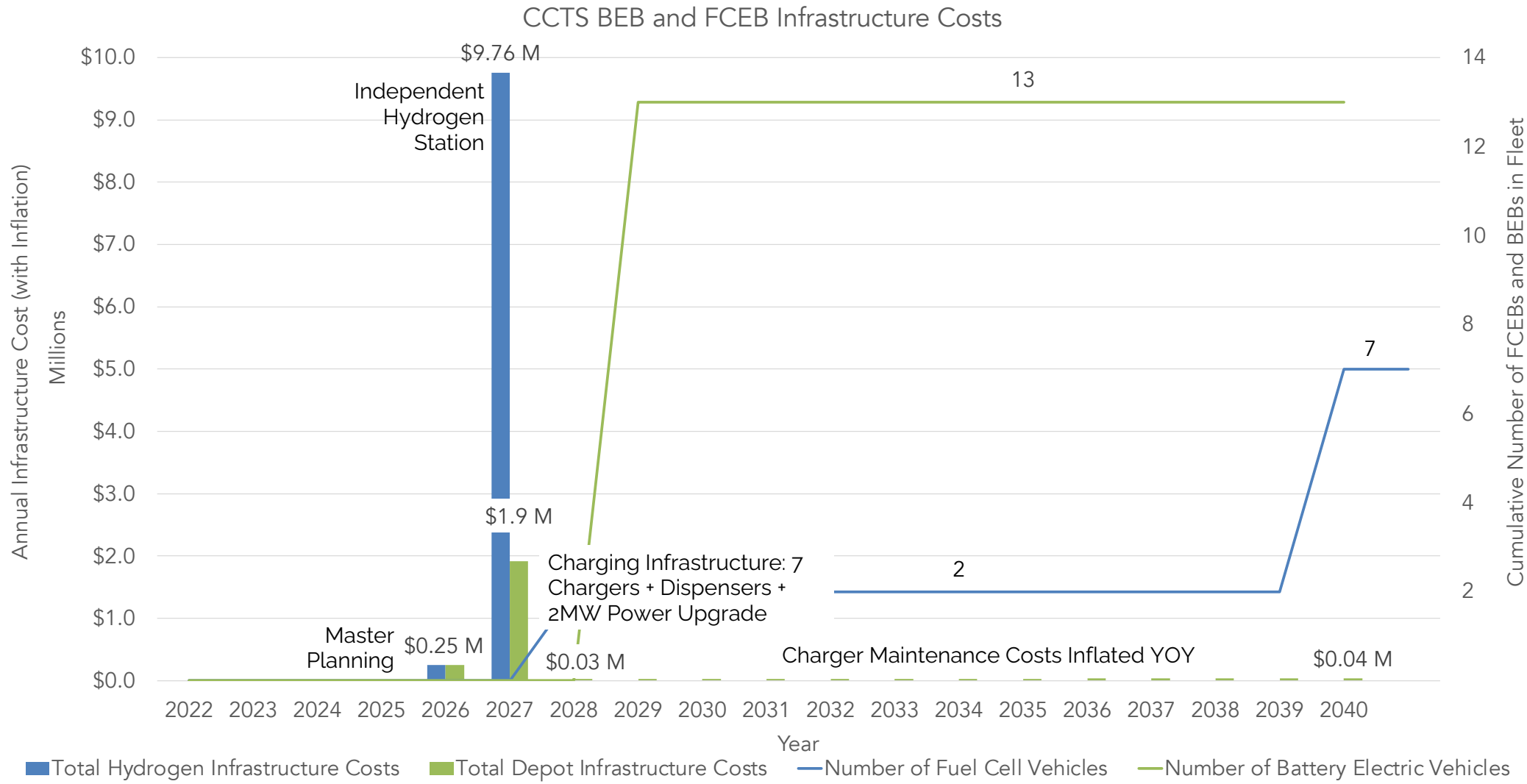
Annual Infrastructure Timeline & Costs

Shared Hydrogen Infrastructure Serving Mixed Fleet



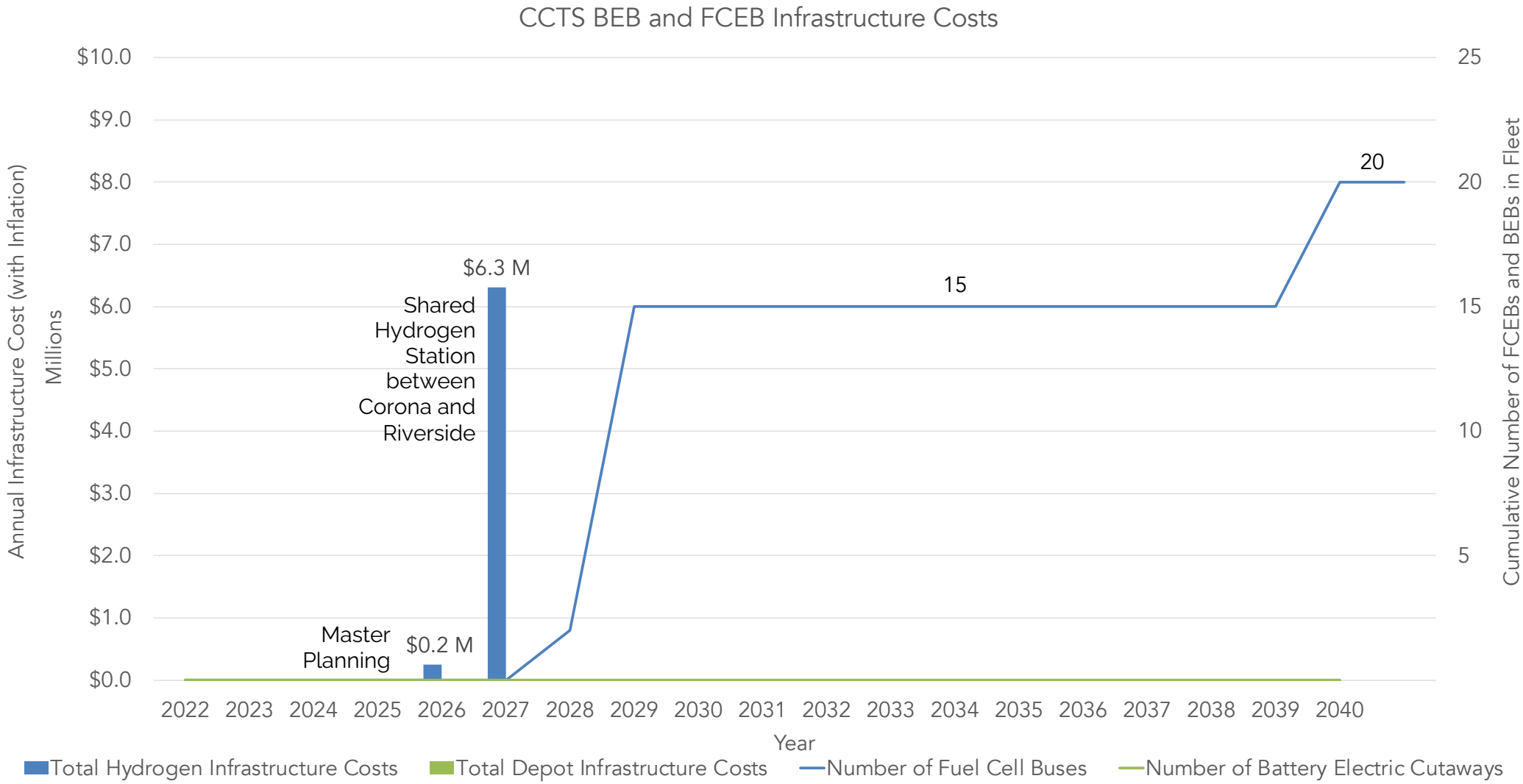
Annual Infrastructure Timeline & Costs

Independent Hydrogen Infrastructure Serving Mixed Fleet



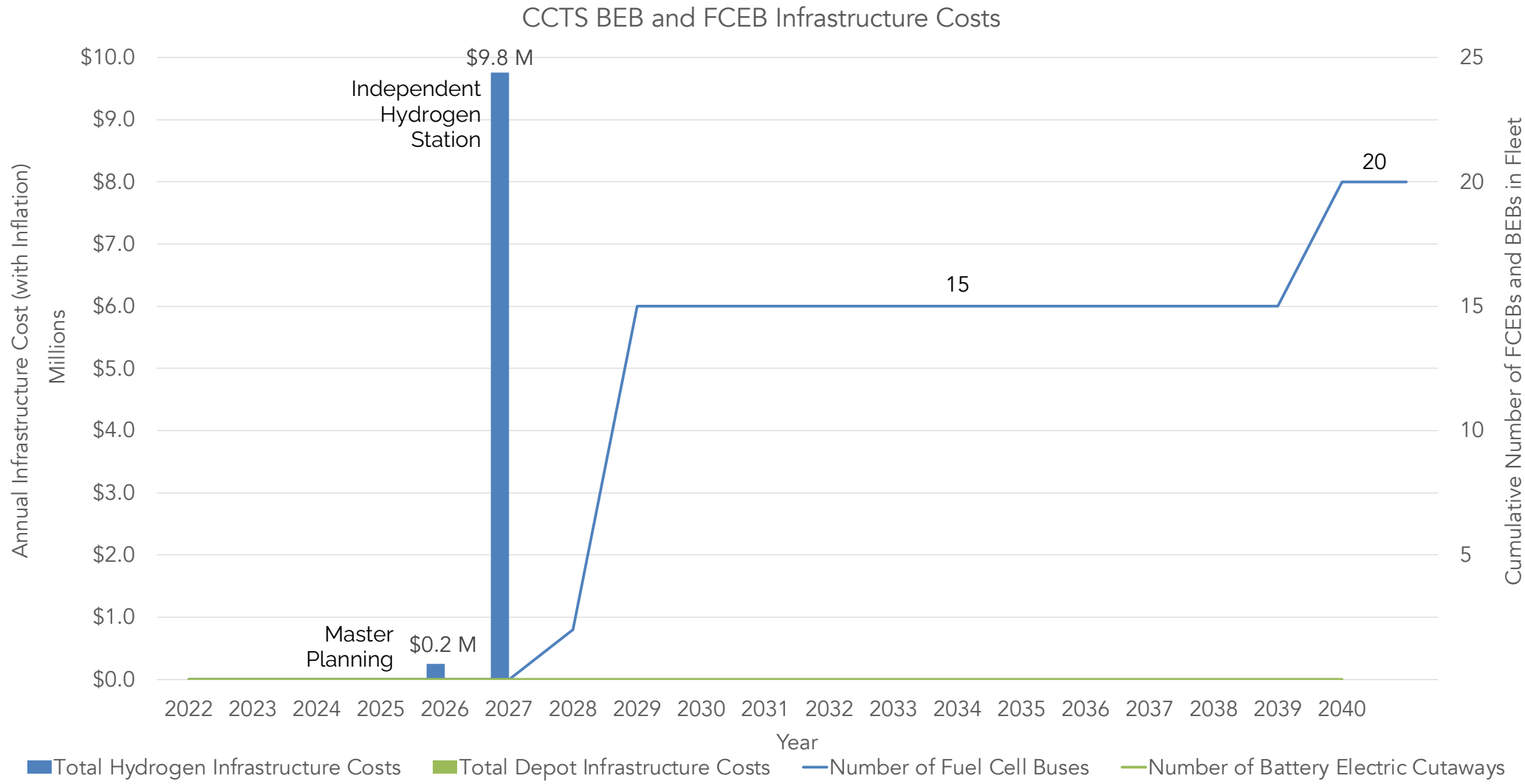
Annual Infrastructure Timeline & Costs

Shared Hydrogen Infrastructure Serving Fuel Cell Fleet



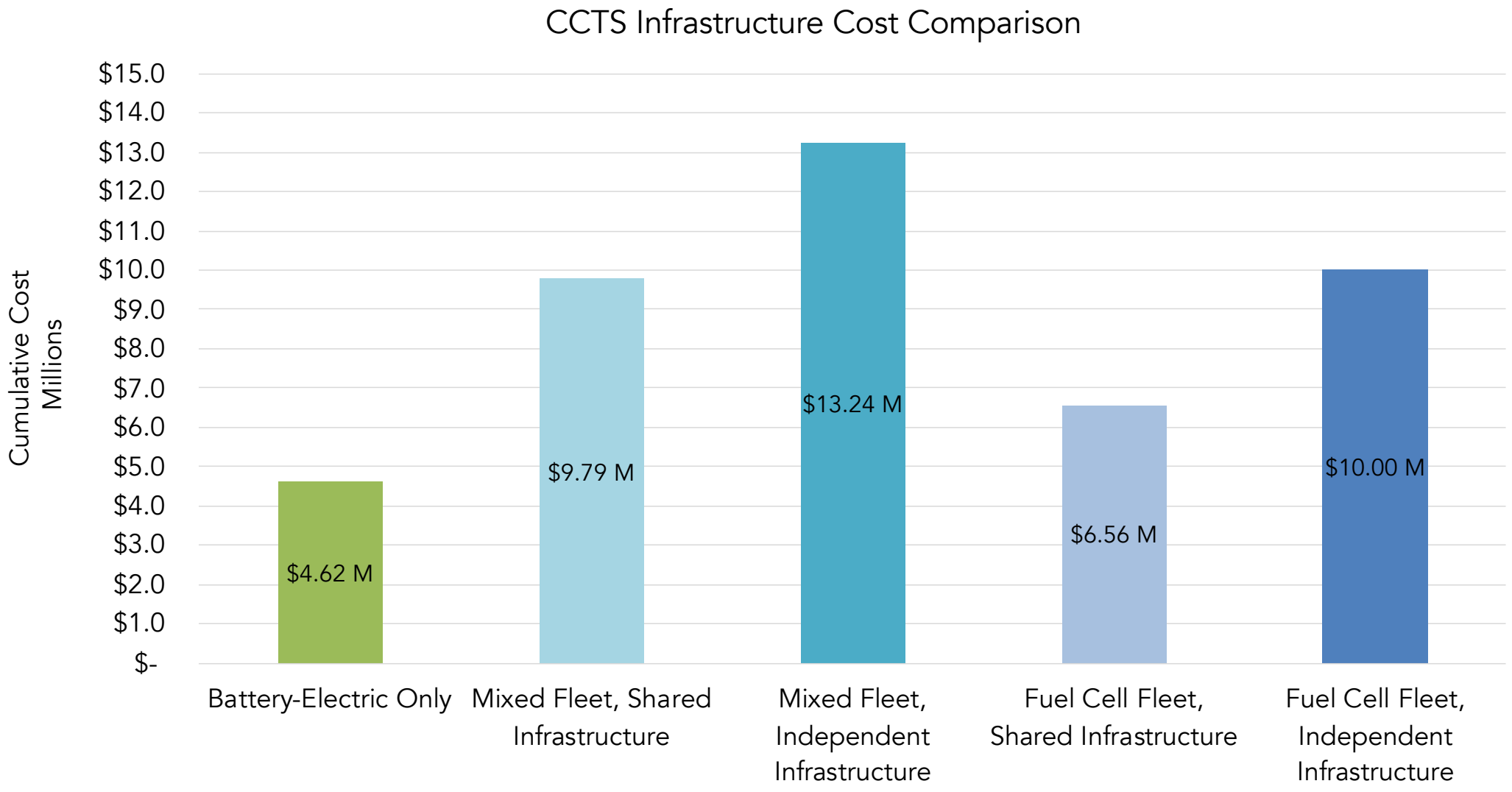
Annual Infrastructure Timeline & Costs

Independent Hydrogen Infrastructure Serving Fuel Cell Fleet



Comparative Infrastructure Costs

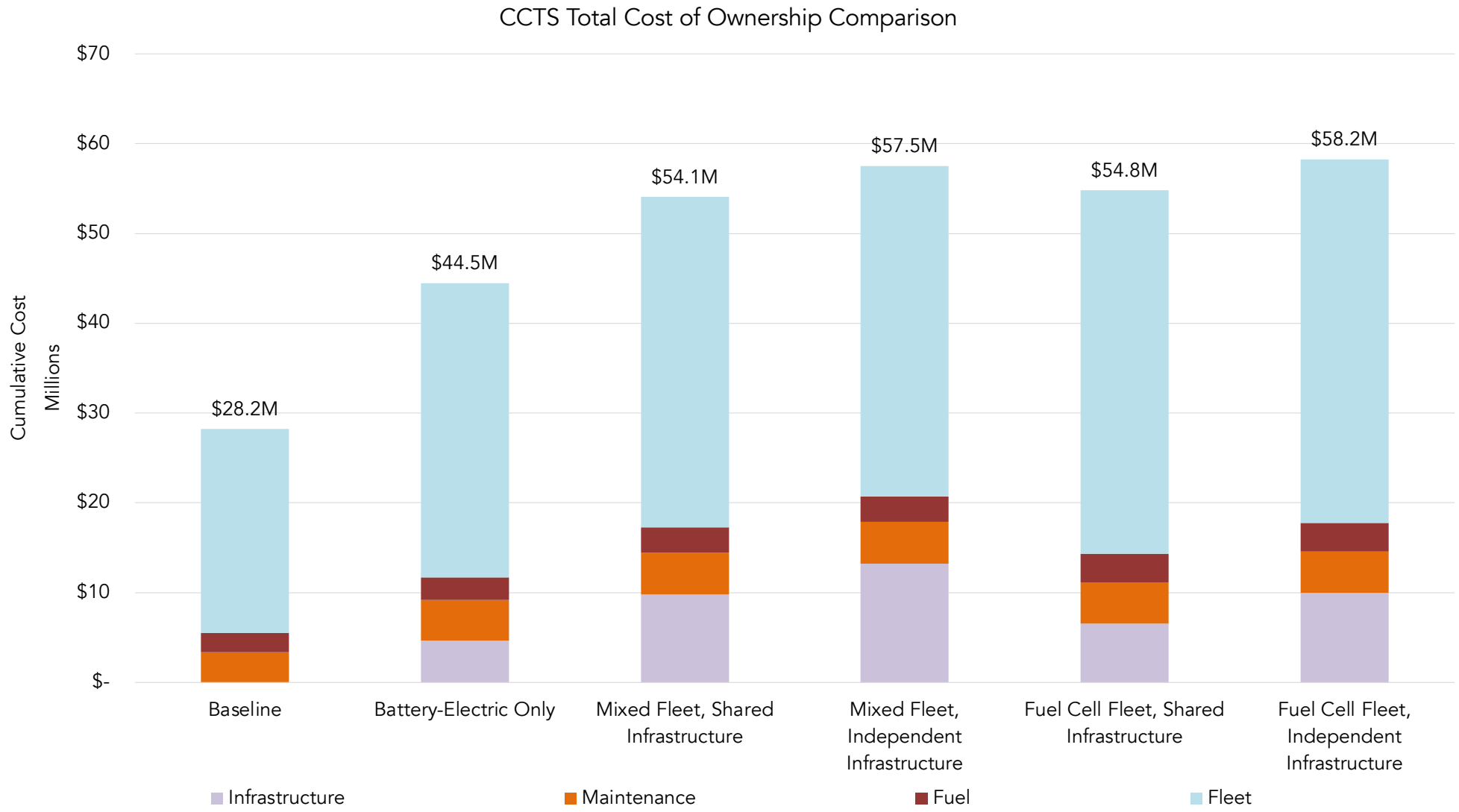
Entire Transition Period, All Scenarios



Total Cost of Ownership Analysis

Comparative Total Cost of Ownership

Entire Transition Period, All Scenarios – Cumulative Costs



Other Considerations

- These analyses are based on the Existing Conditions Report published in October 2022.
- Transition plans are living documents that are meant to be revisited as the market matures.
- There are operational costs and impacts that may increase the need for personnel such as ZE project managers, operations staff, trainings, grants managers, which are not included in this analysis.
- Scheduling changes are not included in this assessment. Operators can review operational modifications that may simplify their transitions to ZEV.
- Prices used in the analysis are a snapshot of today's market, while they are evidence-based predictions, the hydrogen market is nascent and will likely see large pricing drops with increased supply and commercialization.

Other Considerations Continued

- While shared infrastructure offers cost savings, there is potential for increased deadhead with shared infrastructure.
- EV Rate Schedules do have end dates projected, so electricity prices are likely to rise.
- Selecting a single technology can increase operational simplicity and cost savings.
- Selecting multiple technologies does make a fleet more resilient to grid-down or fuel supply shortage scenarios.

Next Steps for ZEB Transition Planning Project

- Study Session for Board Members – February 15
- Corona Staff Recommendations
- Council Meeting for Technology Selection – March 15
- ICT Rollout Plan Approval – June 7
- Implementation Plan with Selected Transition(s) for all operators – October 11