ZEB Transition Planning Kickoff

Lawrence Transit

Center for Transportation and the Environment (CTE),

NV5

Project Team Introductions

CTE

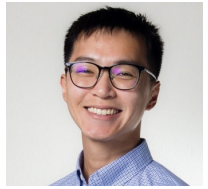
Steve Clermont, Senior Managing Consultant/Director of Planning and Deployment

Maggie Maddrey, Managing Consultant

Shannon Russell, Lead Managing Associate

NV5

Brent Johnson, Vice President, Clean Transportation



Arthur Tseng, Clean Transportation Project Manager

About CTE

Who We Are

501(c)(3) non-profit 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

$1B+

- Research, Demonstration, Deployment
- 100+ active projects totaling $365m+

Our Focus

Zero-Emission Transportation Technologies

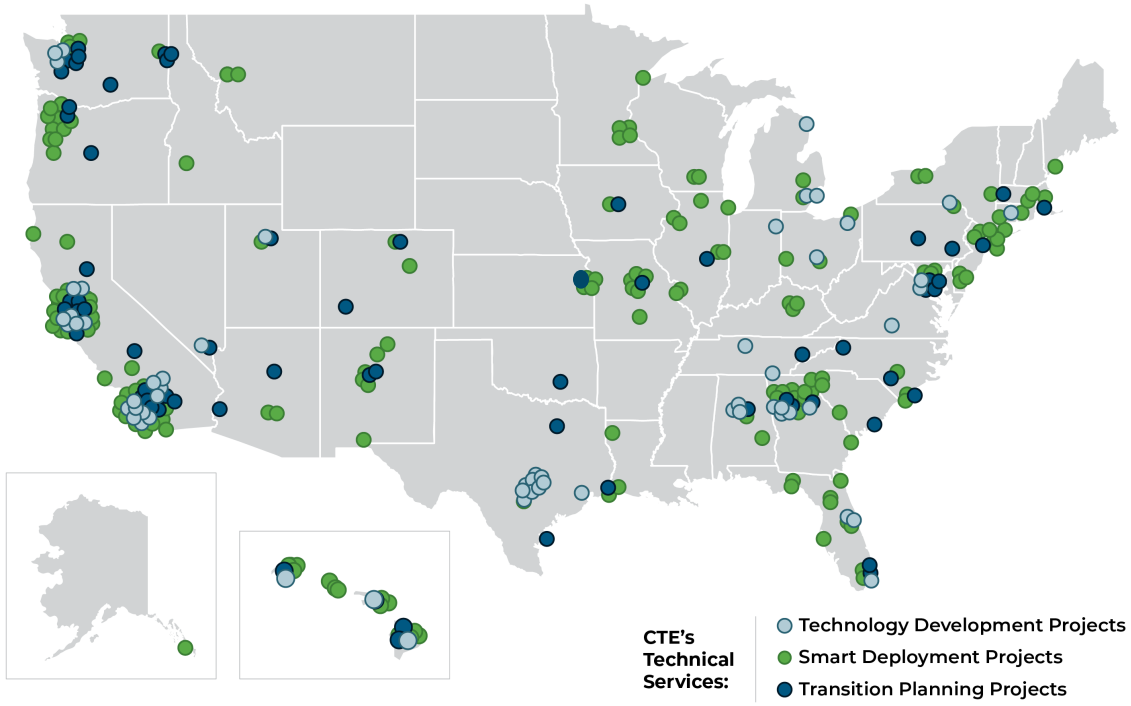
National Presence

Atlanta, Berkeley, Los Angeles, St. Paul

About CTE

CTE's Zero-Emission Projects

- CTE has provided technical and management support or transition planning assistance to nearly **100 transit agencies** that have either deployed, or will soon deploy, more than **430 zero-emission buses**.
- CTE has supported the completion of nearly **40 transit fleet transition planning projects**.



ABOUT NV5

- 70-Year History
- 100+ Offices
  - Execution in all 50 states
  - Headquartered in Hollywood, FL
- 4,000+ Employees
- Specialized Capabilities Across 6 Verticals
  - Construction Quality Assurance
  - Infrastructure Engineering
  - Utility Services
  - Environmental Health Sciences
  - Buildings & Technology
  - Geospatial Technology
- Recognized Nationwide Leader
  - North America's largest provider of end-to-end geospatial solutions

Innovative engineering and consulting to meet the growing demand for energy production, reliability, and efficiency.

WORLDWIDE

4,000+ employees

100+ offices

ENR Engineering News-Record #22 Top 500 Design Firms 2023

ENR Engineering News-Record #12 Top 100 Pure Designers 2023

ENR Engineering News-Record #13 Top Power Design Firms 2023

Project Goals

- Development of a Zero Emission Transition Plan for Lawrence Transit's fixed-route and paratransit revenue fleet showing 100% conversion to zero-emission technology by 2035.
- Understand the barriers, constraints, risks associated with transitioning to zero emission.

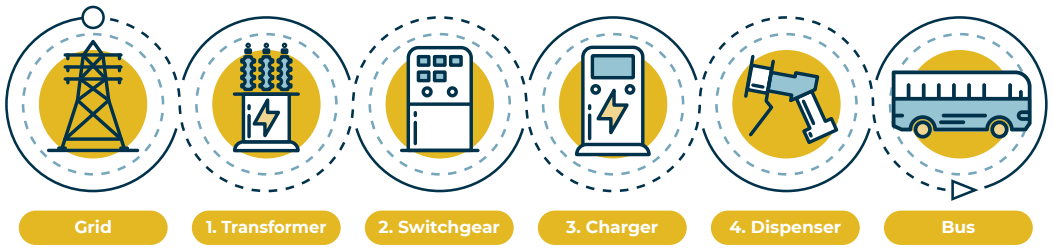
Battery Electric Buses & Fuel Cell Electric Buses

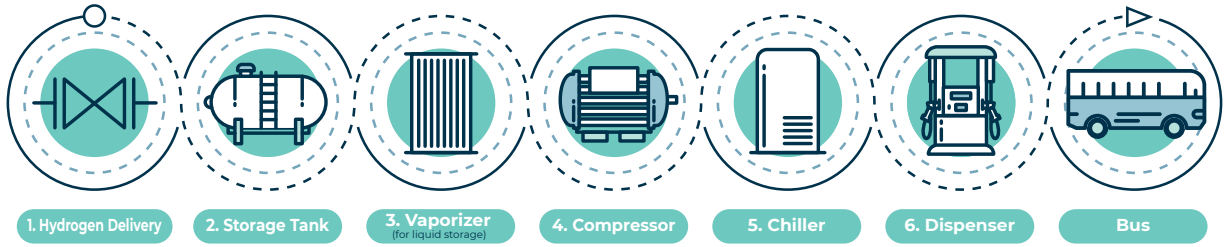
Battery Electric Buses (BEB)

- **Fleet sizes** will be determined by service assessment
- Fueling time **significantly longer** than ICE buses and FCEBs
- Fuel costs expected to be lower

Fuel Cell Electric Buses (FCEB)

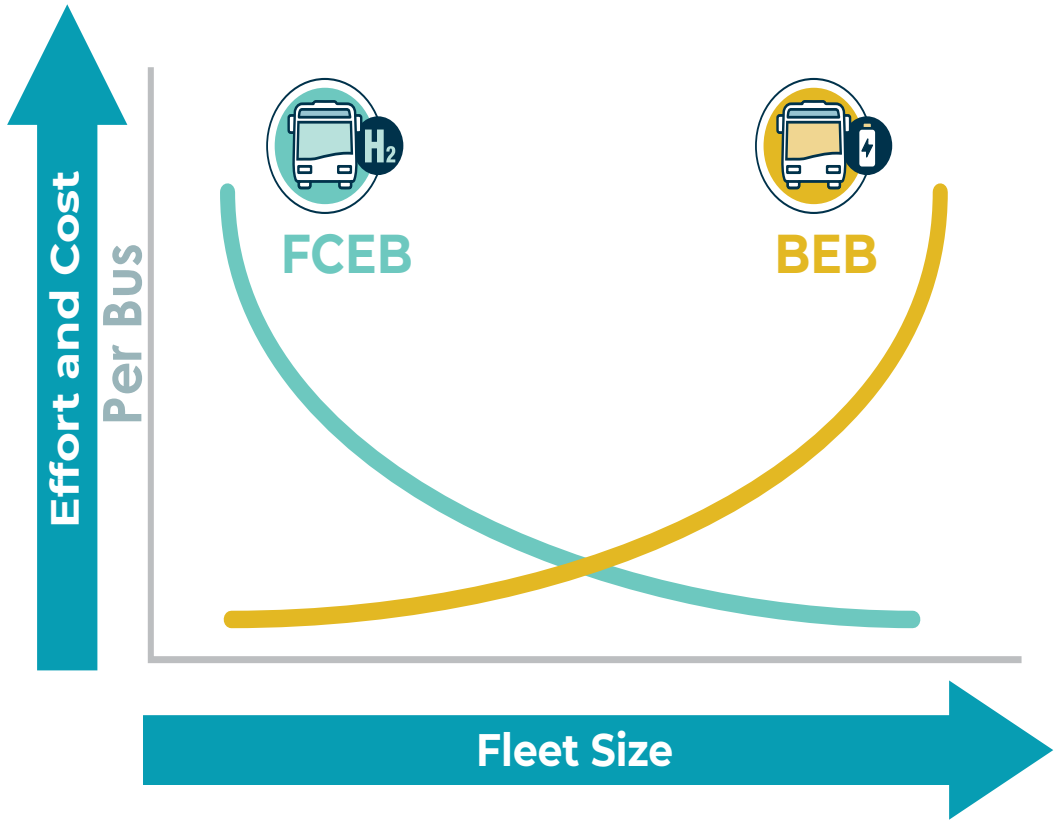
- Comparable range to ICE bus – **1:1 replacement ratio**
- Fueling time **comparable** to ICE bus
- Fuel cost **significantly higher** than fossil fuel
- Fewer entrants in market compared to BEBs



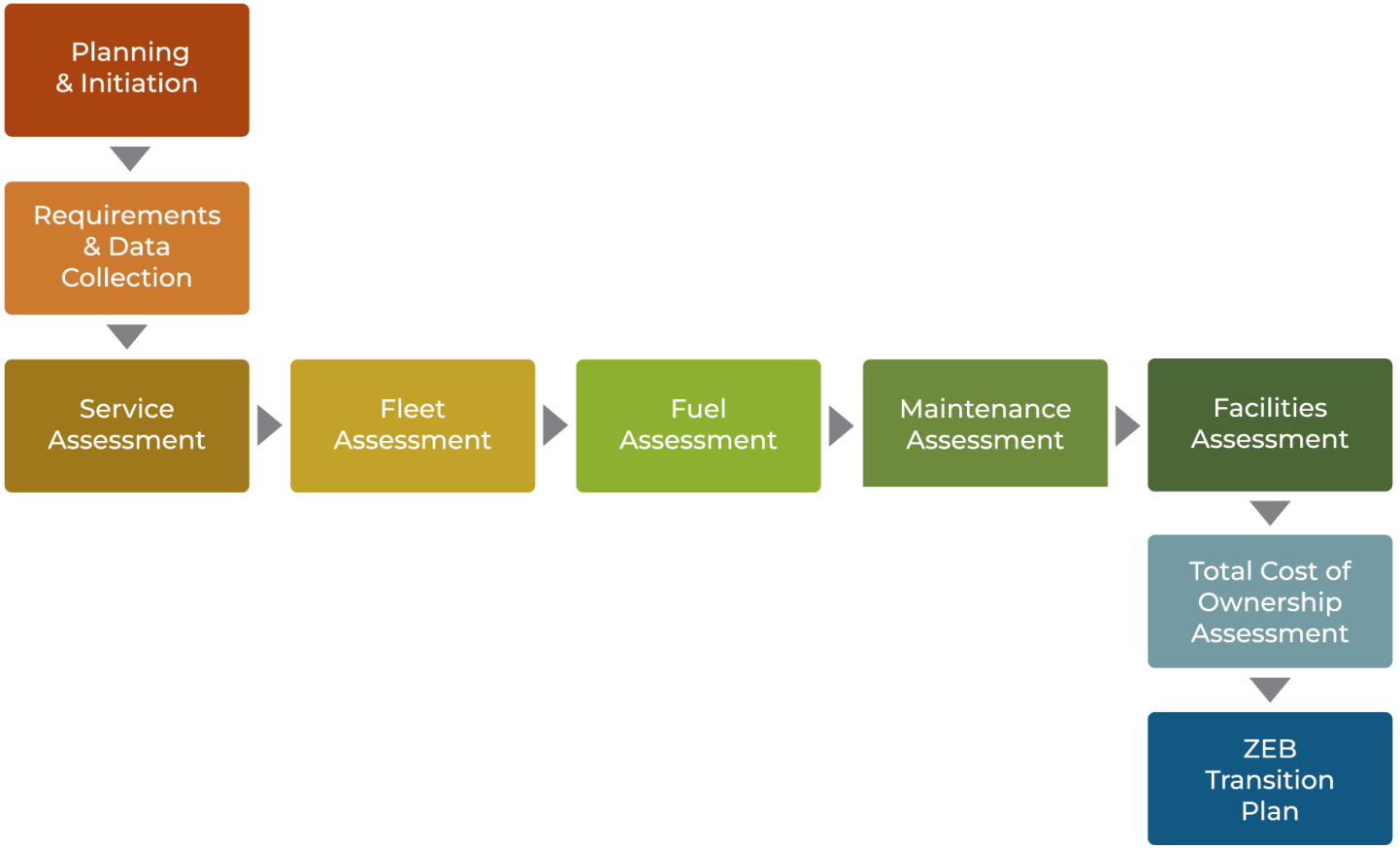


ZEB Infrastructure Scalability

- **BEB:**
  - Infrastructure costs increase per BEB when scaled up
  - More equipment, infrastructure, and space is needed to support larger fleets
- **FCEB:**
  - Infrastructure costs reduce per FCEB when scaled up
  - High initial cost for H2 fueling stations can be leveraged over many FCEBs in larger fleets



ZEB Transition Planning Methodology



ZEB Transition Planning Methodology

Requirements and Data Collection

- Collect fleet, service, and facilities information to define the “As Is” or baseline scenario.
  - Updated route and block data
  - Vehicle information – fixed route and paratransit fleets

FIXED ROUTE

Division	Active or Contingency	Bus Group (Fuel type-length-paratransit or fixed)	Bus Series or Bus ID	Series Range	Bus Class [ft]	Make	Fuel Type	First Service Year
DIV-1	Active	Hybrid 30' Fixed Route	700s	701-702	30'	Gillig	Diesel - Hybrid	2007
LTS	Active	Gillig Low Floor Electric	600-604	600-604	40	GILLIG	Electric	2022
LTS	Active	Gillig Low Floor Electric	605-606	605-606	40	GILLIG	Electric	2024
LTS	Active	Light-Duty 2021 Ford E450	809-813	809-813	14	El Dorado		2020
LTS	Active	Light-Duty 2022 Ford E450	814-815	814-815	14	Ford/Creative Bus Sales		2022
LTS	Active	2011 Gillig Low Floor Hybrid	900-902	900-902	34	Gillig		2011
LTS	Active	2011 Eldorado EZ Rider II	903-905	903-905	30	El Dorado		2011
LTS	Active	2015 Gillig low floor	906-907	906-907	26	Gillig		2015
LTS	Active	2015 Gillig low floor Hybrid	908	908	26	Gillig		2015
LTS	Active	2020 Gillig Low Floor	909-911	909-911	26	Gillig		2020

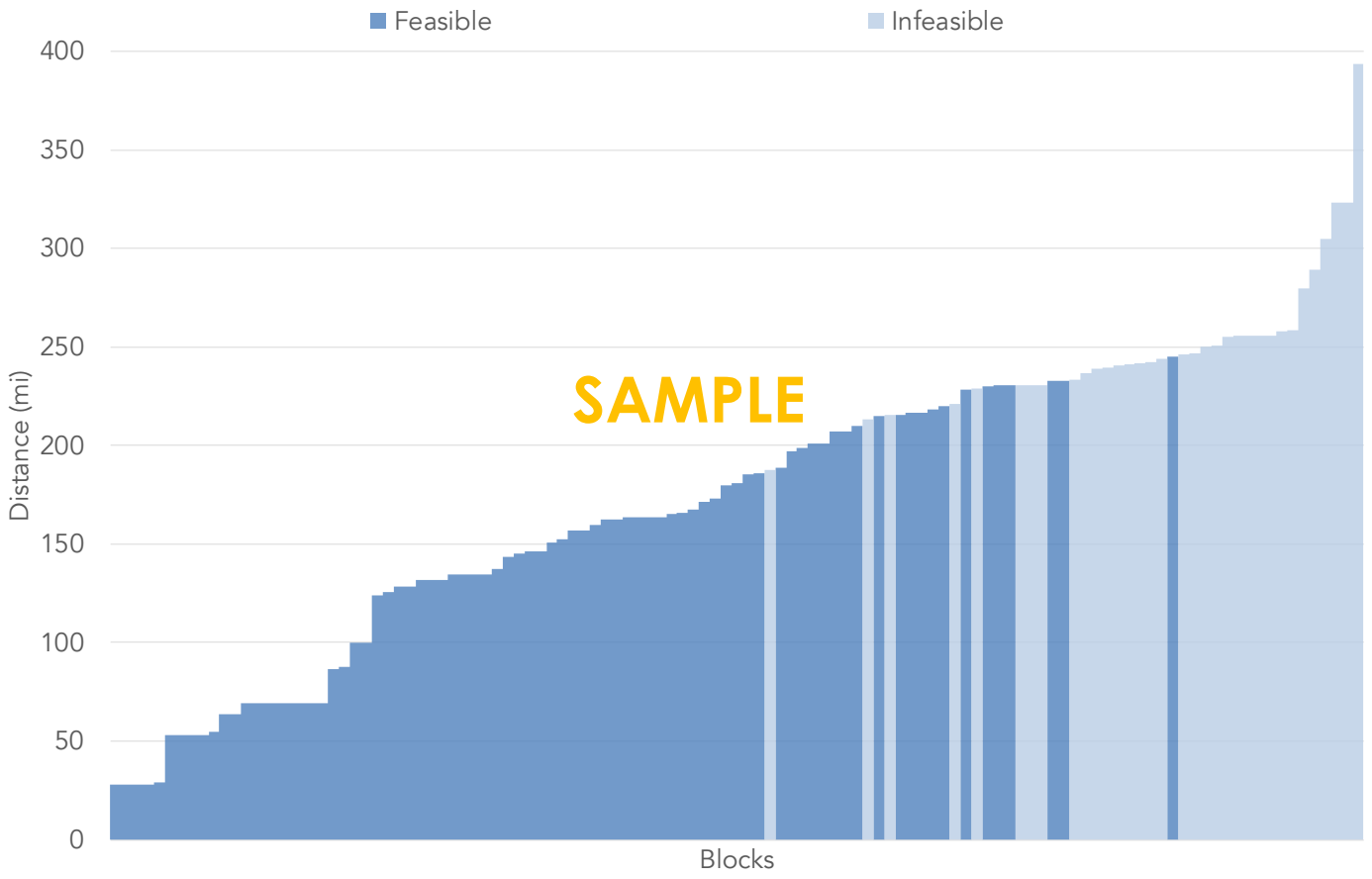
Known Procurements

Purchase Year	First Service Year	Make	Fuel Type	Number of Buses Purchased	Bus ID or Series Being Replaced	Notes
2021	2022		Battery electric	4	0701-02, 0901-02	
2024	2025	Proterra Electric Transit Bus	Electric	2		
2024	2025	Optimal Electric Cutaways	Electric	2		

ZEB Transition Planning Methodology

Service Assessment

- Use CTE's route modeling and bus simulation methodology to calculate expected energy efficiency, by route per service block.
- Examine service blocks to determine if current BEB technologies have sufficient range to replace an agency's fleet on a 1:1 basis.
- Analyze alternative solutions that allow for 100% ZEB fleet transition.
- Assess impacts to transit service and analyze need for potential service changes



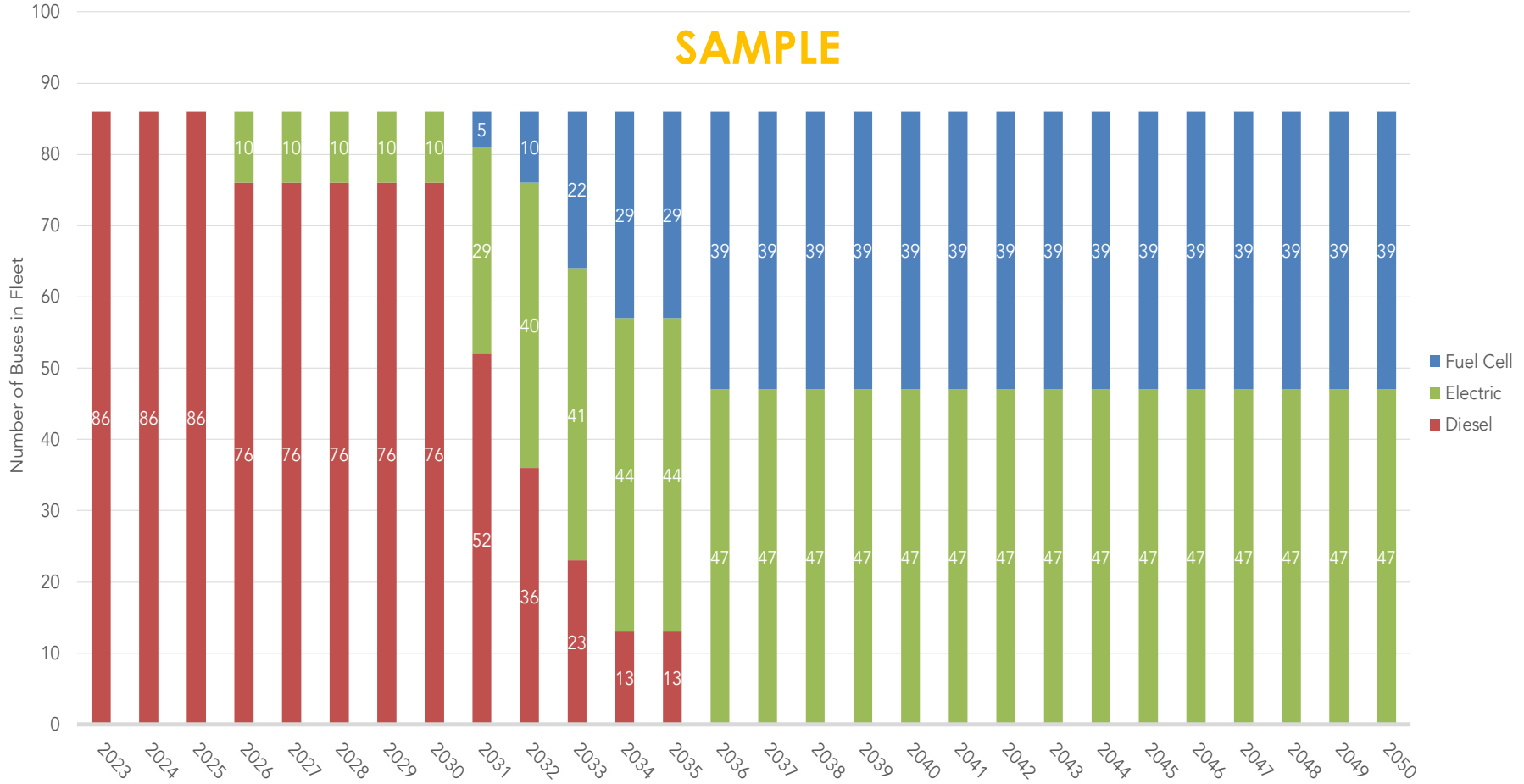
ZEB Transition Planning Scenarios

- **Baseline Scenario:** Current Lawrence Transit fleet composition and transit service; this will be used for comparison with other ZEB transition scenarios.
- **ZEB Transition Scenarios:**
  - BEB Depot-Only Charging
  - Mixed Fleet (BEBs and FCEBs)
  - FCEB-Only
  - Potential Alternate Scenario: Depot-Charged BEBs w/ midday charging
  - Potential Alternate Scenario: On-Route Charged BEBs

ZEB Transition Planning Methodology

Fleet Assessment

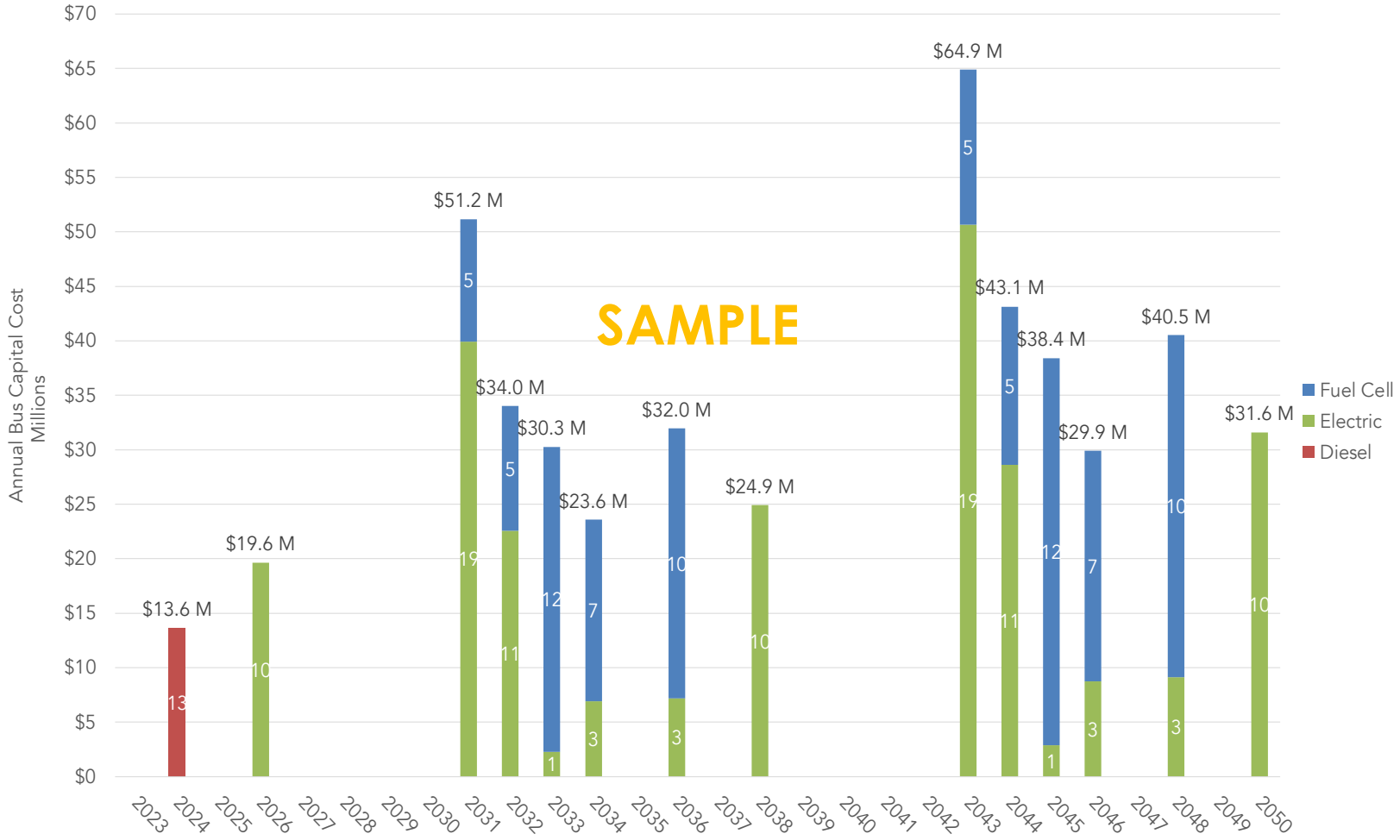
- Develop a projected timeline for replacement of current buses with ZEBs consistent with the agency's fleet replacement plan and results of service assessment.



ZEB Transition Planning Methodology

Fleet Assessment

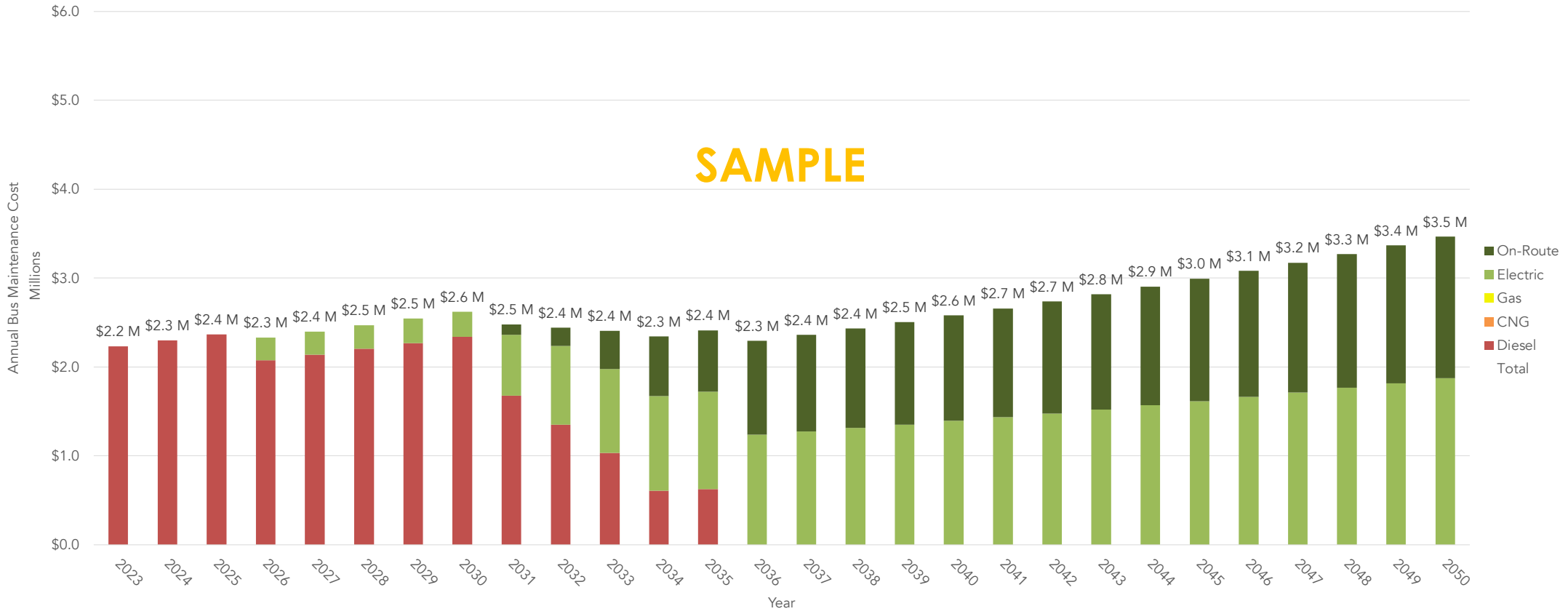
- Project fleet capital cost over the transition period.



ZEB Transition Planning Methodology

Maintenance Assessment

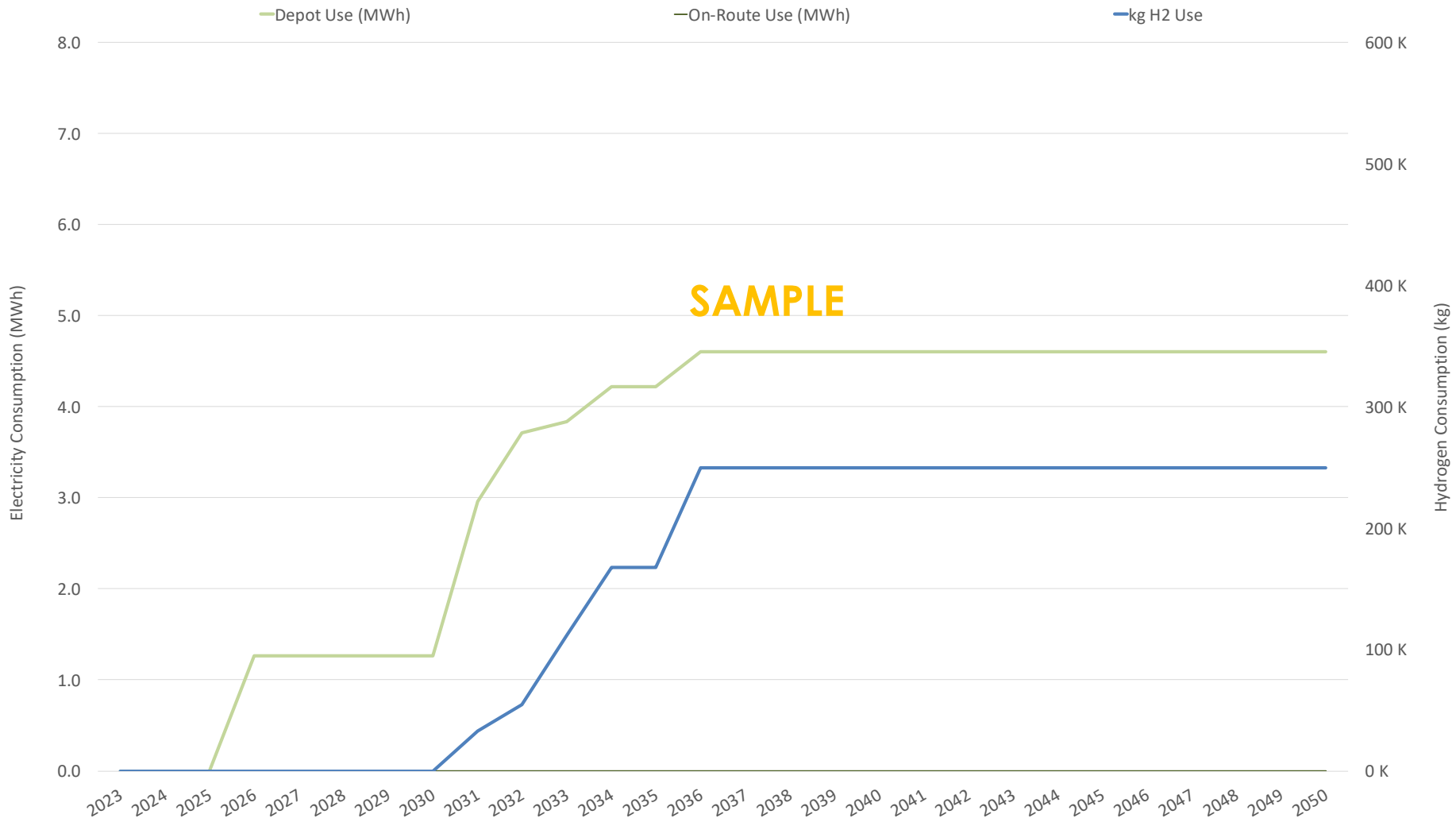
- Analyze labor and materials costs for ZEB maintenance over the transition period, compared to the Baseline.
- Analyze major component replacements for each technology type.



ZEB Transition Planning Methodology

Fuel Assessment

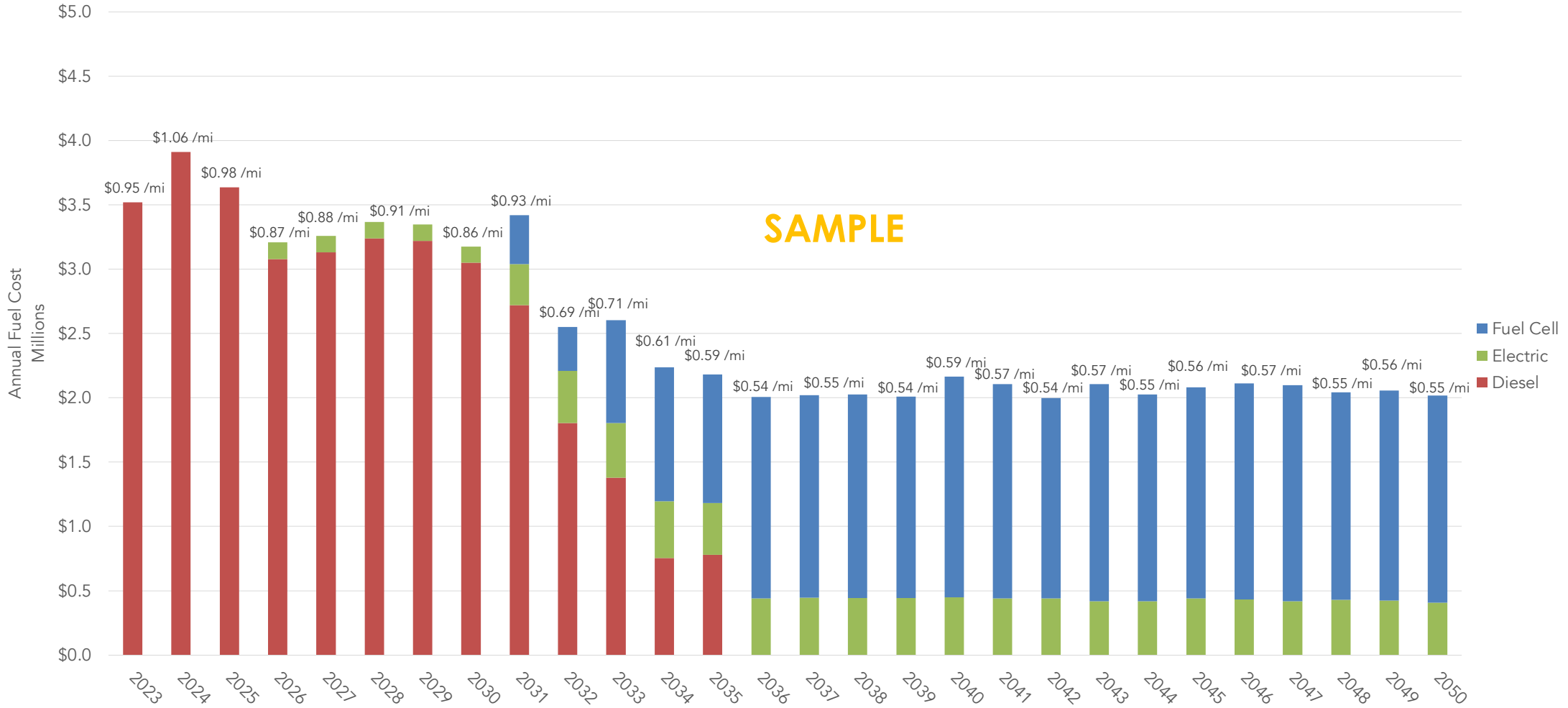
- Analyze daily, monthly, and annual fuel consumption and demand requirements.



ZEB Transition Planning Methodology

Fuel Assessment

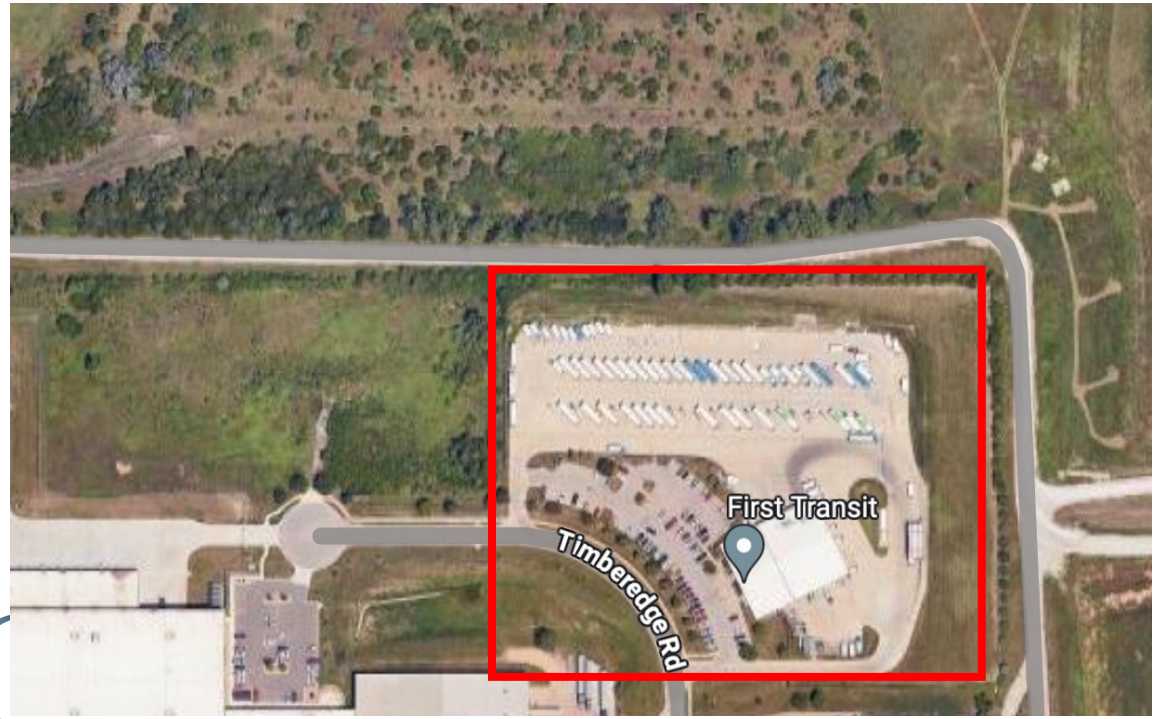
- Develop forecasts for annual fueling costs.

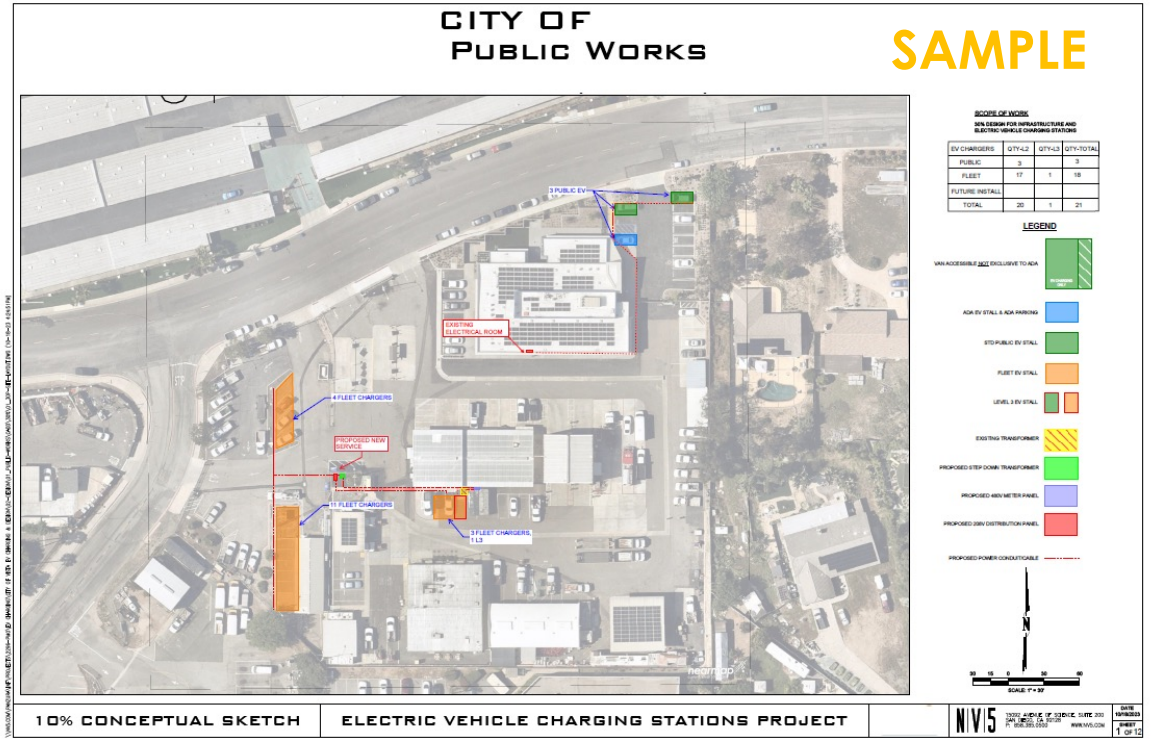


ZEB Transition Planning Methodology

Facility Assessment

- Analyze requirements for charging infrastructure and hydrogen fueling infrastructure.
- Coordinate with Evergy to discuss power availability and constraints at the site.
- Assess capital costs for equipment and infrastructure design, construction, and installation costs.
- Develop high-level timeline for various facility and infrastructure projects.
- Develop concept drawings for EV and hydrogen fueling infrastructure at the maintenance facility.

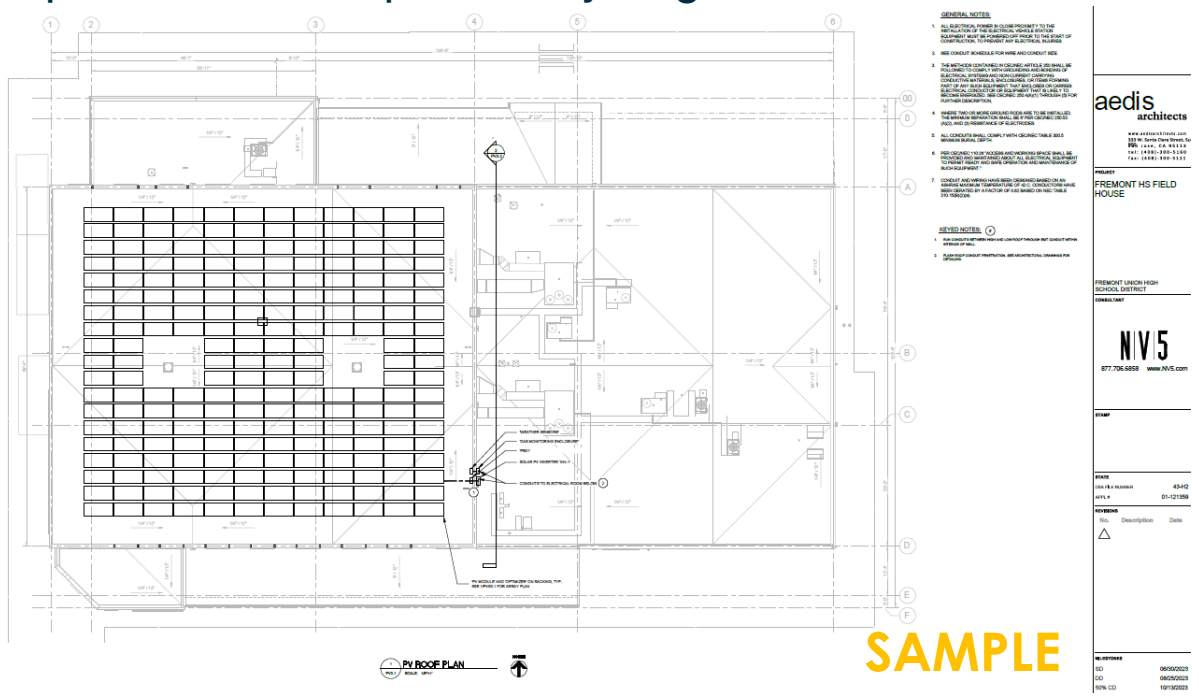




ZEB Transition Planning Methodology

Facility Assessment - Solar / BESS Analysis

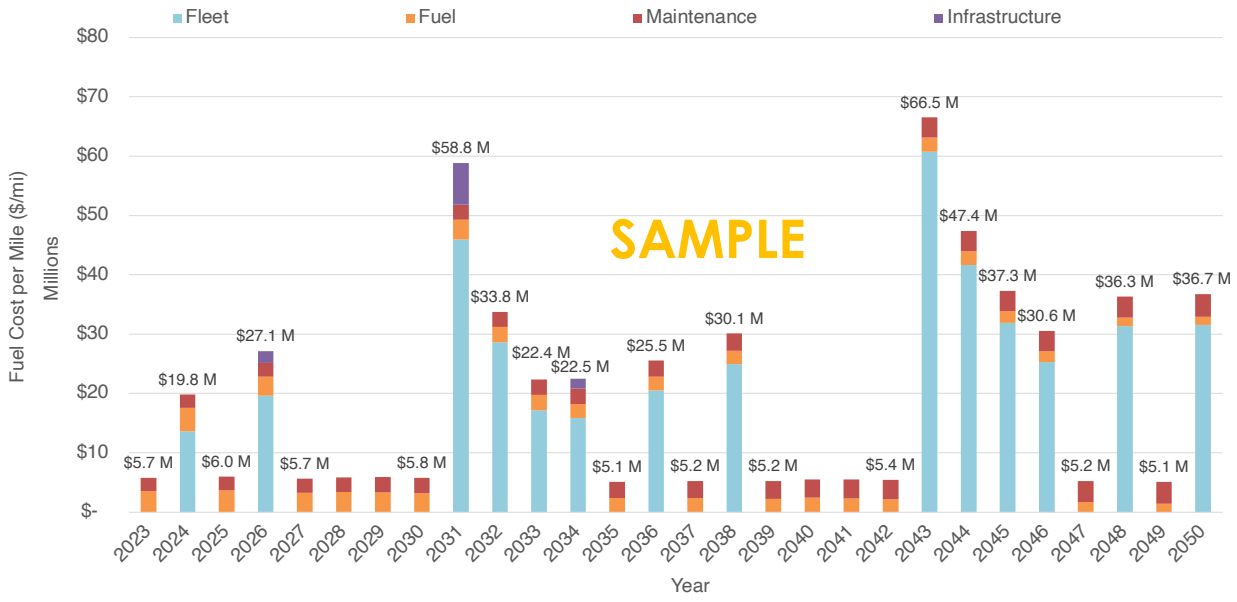
- Conduct detailed modeling of PV systems to produce conceptual layouts, sizing and production modeling for the maintenance facility.
- Estimate utility energy costs before and after implementation of solar and/or BESS systems.
- Develop lifecycle cost modeling for PV + BESS.
- Consider PV + electrolytic systems to access hydrogen production capabilities, capital cost impact on infrastructure, and operation cost impact on hydrogen fuel.

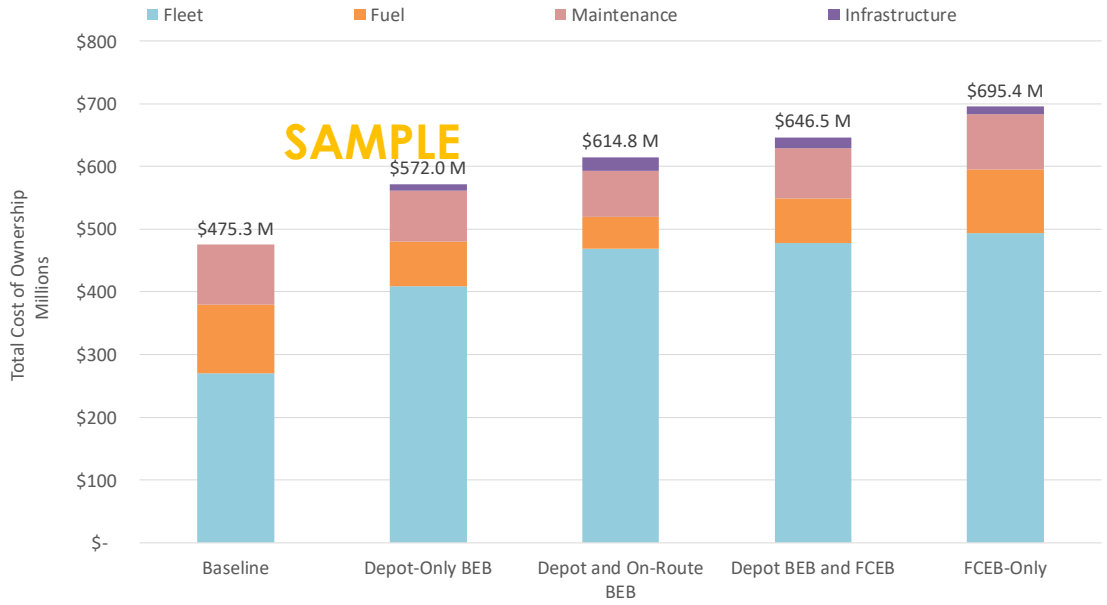


ZEB Transition Planning Methodology

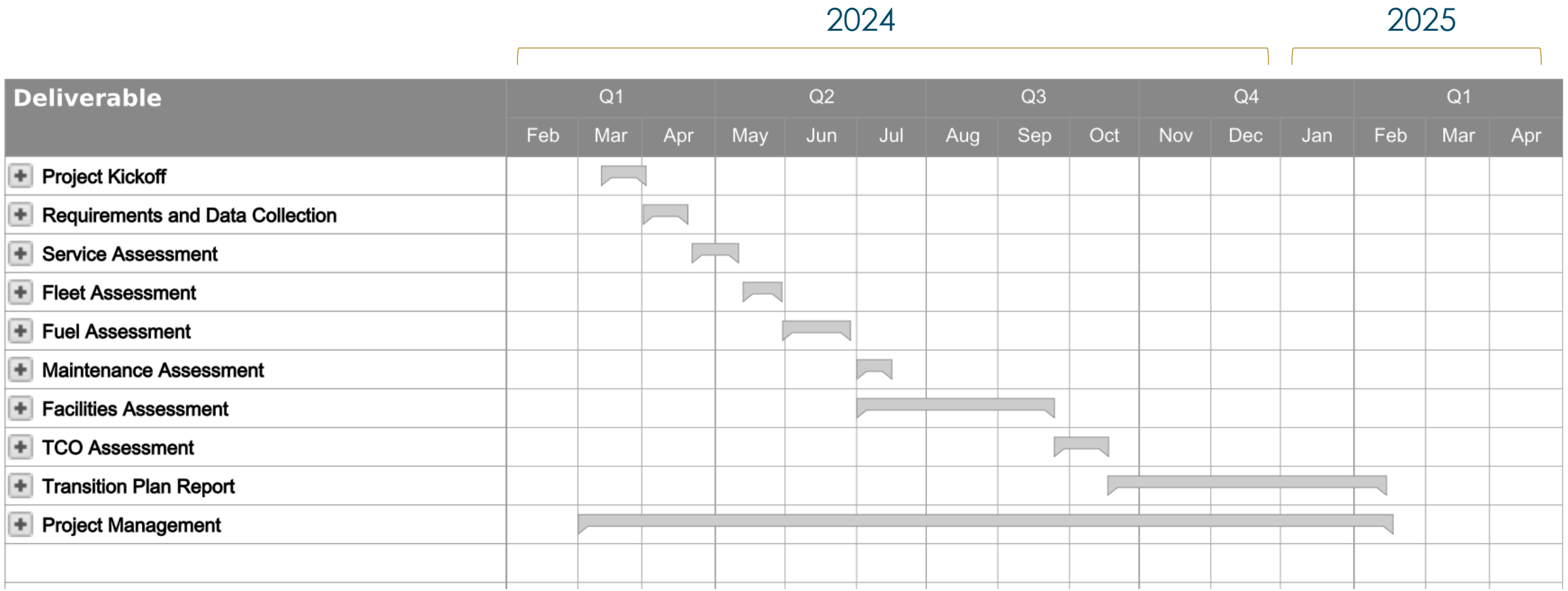
Total Cost of Ownership (TCO) and Final Report

- Summarize results of all assessments to provide total cost of ownership breakdown of costs over the transition timeline for each scenario.





ZEB Transition Planning Timeline



ZEB Transition Planning Next Steps

Project Activities

- Set regular project meetings with the core Lawrence project team
- Lawrence/Transdev to provide outstanding data
- Begin Service Assessment

Thank you.

Questions?