Exhibit 1

CITY OF GLENDALE, CALIFORNIA

Municipal Electric Vehicle

Fleet Electrification Study

Presented by Center for Transportation and the Environment
December 2024

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List of Acronyms

ACC	Advance Clean Cars
ACF	Advanced Clean Fleet
AFLEET	Alternative Fuel Life-Cycle Environmental and Economic Transportation
BEV	Battery Electric Vehicle
CARB	California Air Resources Board
CEC	California Energy Commission
CO	Carbon Monoxide
CMS	Charge Management System
CTE	Center for Transportation and the Environment
CVRP	Clean Vehicle Rebate Project
DC	Direct Current
DCFC	Direct Current Fast Charger
DOE	Department of Energy
EIA	Energy Information Administration
EPA	Environmental Protection Agency
EV	Electric Vehicle
FCEB	Fuel Cell Electric Bus
FCEV	Fuel Cell Electric Vehicles
GGE	Gasoline Gallon Equivalents
GHG	Greenhouse Gas
GH2	Green Hydrogen
GPD	Glendale Police Department
GVWR	Gross Vehicle Weight Rating
GWP	Glendale Water and Power
HVAC	Heating, Ventilation, and Air Conditioning
HVIP	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project
ICE	Internal Combustion Engine
JPL	Jey Propulsion Laboratory
kW	Kilowatt
kWh	Kilowatt Hour
kWh/mi	Kilowatt-hour/mile
LAX	Los Angeles International Airport
LCFS	Low Carbon Fuel Standard
LH2	Liquid Hydrogen
LSV	Low Speed Vehicle
MW	Megawatt
MWh	Megawatt-hours
NOx	Nitrous Oxides
OEM	Original Equipment Manufacturer
O&M	Operations and Maintenance
SCIP	Southern California Incentive Project
SOC	State of Charge

SORE	Small Off-Road Engines
SOx	Sulfur Oxides
SUV	Sport Utility Vehicle
TOU	Time-of-Use
WECC	Western Electricity Coordinating Council
WTW	Well-to-Wheel
ZE	Zero-Emission
ZEV	Zero-Emission Vehicle

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Executive Summary

In 2021, the City of Glendale, California (the City) engaged the Center for Transportation and the Environment (CTE) to perform a fleet electrification study to evaluate the requirements, operational considerations, and costs to transition all vehicles in the municipal fleet to 100% electric vehicles (EV) by either 2035 or 2040. The results of the study were intended to inform the City of the estimated costs, benefits, constraints, and risks of the transition to an EV fleet and will guide future planning and decision-making.

The City initiated a new contract with CTE in February 2024 to update the study including the market analysis, refine the duty-cycle analysis to optimize the number of chargers required, reassess the infrastructure needs based on the real-world duty-cycle analysis, address the requirements of the state of California's vehicle regulations, and update the results in a final report.

The Advanced Clean Fleet (ACF) regulation applies to state and local fleets and covers vehicles with a gross vehicle weight rating greater than 8,500 lbs. Beginning on January 1, 2024, fleets must ensure that 50 percent of their annual vehicle purchases are zero emission vehicles (ZEVs). Beginning on January 1, 2027, 100 percent of annual vehicle purchases must be ZEV. This report includes the full study and all updated results.

Baseline

As of November 2024, The City owns and operates a fleet of 820 active vehicles, which is the basis for the analysis. As shown in Figure E1, the City vehicles are categorized as light-, medium-, and heavy-duty, pursuit, emergency, and non-road vehicles.

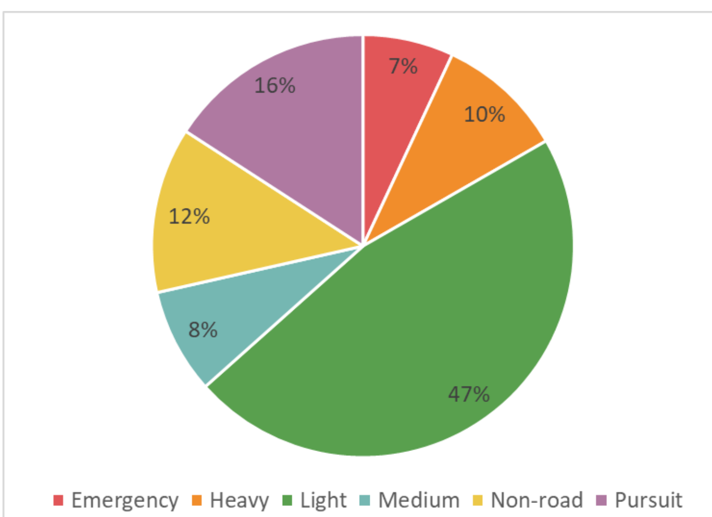

Figure E1. Glendale Fleet Distribution by Vehicle Category

Each Vehicle Category consists of several types of vehicles, as shown in

Table E1.

Table E1. Fleet composition by Vehicle Category and Type

Light		Medium		Heavy		Emergency		Pursuit		Non-road	
1 ton Pickup	57	Truck	16	Heavy Truck	10	Command Vehicles	13	Motorcycle	27	Bunker Rake	6
1/2 ton Pickup	39	Dump Truck	12	Refuse Truck	38	Emergency Specialty	12	SUV	103	Mowers	10
3/4 ton Pickup	46	Flatbed Truck	11	Street Sweeper	6	Fire Engine	16			Forklifts	11
Compact Pickup	53	Manlift Truck	12	Crane Truck	7	Ladder Truck	4			Lifts	4
Minivan	41	Cargo Van	15	Dump Truck	11	Rescue	12			Construction Equipment	25
Motorcycle	2			Manlift Truck	6					Roller	2
Refuse Truck	6			Roll-off Truck	2					Misc Equipment	7
Sedan	76									Utility Sweeper	6
SUV	36									Utility Vehicle	33
Van, Cargo	24										
Van, Passenger	3										
	383		**66**		**80**		**57**		**130**		**104**

The City operates 661 of these vehicles out of 6 primary facilities; Public Works Yard, City Hall Complex, Glendale Water & Power (GWP) Utility Operations Center, Integrated Waste Yard, Fire Station 21, and the Glendale Police Department. The remaining 159 vehicles are spread out among smaller facilities across the City. This distribution is shown in Figure E2. While the study considers all vehicles in the City fleet, the infrastructure and electricity demand assessments focused on the six primary parking facilities.

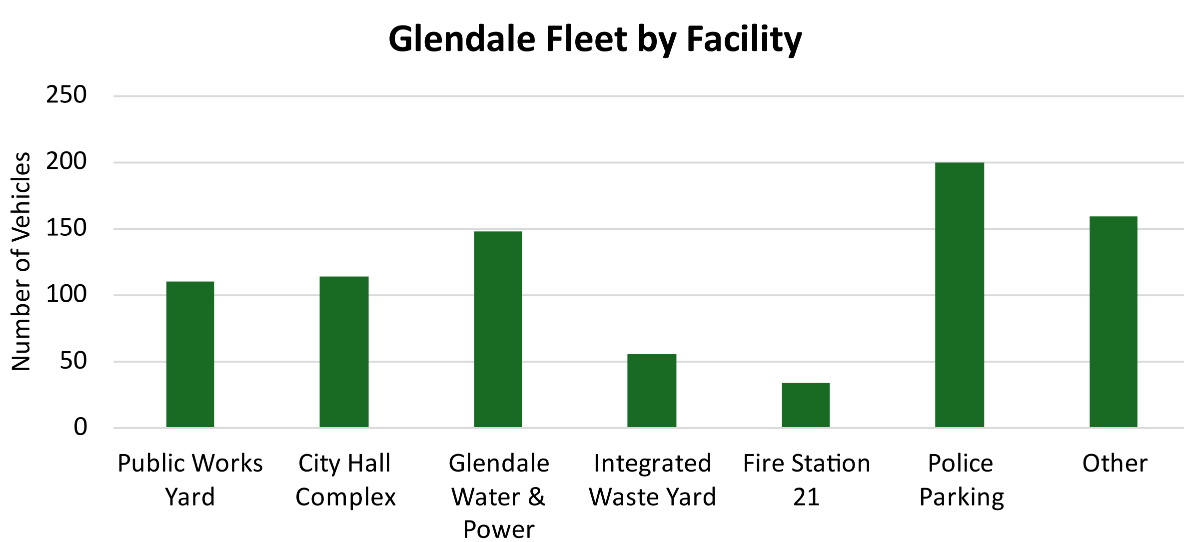

Figure E2. Glendale Fleet Distribution by Facility

In all cases, we provide a "Baseline Scenario" for comparison. The Baseline scenario represents the replacement of the City's fleet with the same fuel type as the current vehicle, or no further electrification. This helps to demonstrate the incremental costs associated with the transition to EVs.

Market Analysis

Vehicle availability is one of the most important factors for transition feasibility. The market for electric vehicles varies greatly depending on the type of vehicle. The City's fleet is made up of a diverse array of vehicles, all of which have varying degrees of electric models currently available. Below is a summary of the findings and challenges for each vehicle category:

<u>Light-Duty Vehicles:</u> The light-duty vehicle category, including sedans, SUVs, vans, pickups, and motorcycles, is well-suited for EV adoption, with most vehicles ready for transition upon reaching their service life. However, compact and heavier (three-quarter-ton, 1-ton, 1.5-ton) are not yet available as EVs, posing a challenge for the City. The City may need to delay replacement until appropriate EV models are introduced—with Ford planning heavier models by 2027 or 2028—or consider replacement with available half-ton EV pickups or van-style cab and chassis.

<u>Medium-Duty Vehicles:</u> Medium-duty electric vehicles are available but cost 2–4 times more than diesel equivalents. While the City could transition to EVs soon, high costs and long lead times are challenges. Rebates from California Air Resources Board (CARB)'s Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) can help offset costs, but funds are limited and not guaranteed, so the City should prioritize applications when planning purchases.

<u>Heavy-Duty Vehicles:</u> Heavy-duty trucks are motor vehicles that refer to truck Class 7 - 8, which have a gross vehicle weight rating of 26,001+ lbs. As with medium-duty EVs, the primary challenge is the high capital cost. EV models exist for specific applications such as refuse and street sweepers as well as general cab and chassis, but high capital costs hinder immediate transition.

<u>Emergency Vehicles:</u> Emergency vehicles include light-, medium- and heavy-duty vehicles outfitted for emergency response duties including fire engines, rescue, and command support. The ZEV market for these vehicles are currently limited to fire engines and standard light-duty EVs that could be outfitted for command support. Electric fire engines with traditional internal combustion engines (ICE) are available but face challenges such as limited true zero emission (ZE) range, higher costs, shorter service life, and operational constraints. Ladder trucks are unlikely to have EV options for decades.

<u>Pursuit Vehicles:</u> Glendale Police Department (GPD) faces challenges transitioning to EVs due to limited charging time, high-demand patrol cycles, unsuitable current EV models, and lack of data on performance and costs. The current market for pursuit rated SUVs is limited without aftermarket outfit, and no EV motorcycles meet pursuit requirements currently. Policies for vehicles taken home and long-

range needs for disaster response vehicles also complicate the transition. GPD prefers delaying EV adoption until the market matures and better solutions are available.

Non-Road Vehicles: Non-road vehicles are used for a variety of reasons including park maintenance, construction, public works projects, electric and water services, traffic safety, etc. The City can begin transition for some of its non-road fleet in the near-term and already uses electric utility vehicles. EV options are available for smaller vehicles, allowing near-term transitions for most of this fleet while heavier equipment develops.

Operational Challenges: The City's fleet is largely suitable for a transition to EVs, but Police and Fire Department vehicles pose challenges. Fire engines, while available in EV models, are costly, have shorter service lives, and don't fit Glendale's operational needs, especially for long-distance travel or mutual aid deployments. Similarly, ladder trucks won't be EV-compatible for decades due to battery limitations without technology developments or alternative fuels like hydrogen. GPD faces issues with transitioning its patrol vehicles, which require continuous operation with minimal charging time, and current EVs don't meet the size and durability needs of these vehicles. Additionally, there are concerns about the conspicuousness of EVs used for surveillance and potential battery degradation from frequent high-level charging. The transition of pursuit motorcycles is also complicated by the lack of suitable models for police use. Other city vehicles, such as those used by GWP, face challenges for disaster response and staff vehicles taken home. Given these operational constraints, both departments recommend delaying a full EV transition until technology and infrastructure can better meet their needs.

Feasibility & Fleet Assessment

In the Feasibility and Fleet Assessment, CTE determined an appropriate transition to EVs by incorporating both the feasibility and the suitability of an EV replacement for each asset type. Feasibility measures whether an EV replacement can perform to Glendale's operating requirements with its available battery capacity. Suitability measures whether the replacement EV model is available, commercially viable, and ready for purchase. When an asset is due for replacement, it should only be electrified if the available EV is both feasible and suitable.

CTE analyzed Glendale's fleet inventory data, including vehicle types, fuel economies, and usage metrics, to determine the operating requirements for each vehicle. Next, CTE assessed the EV market for suitability in replacing each fleet vehicle, evaluating factors like availability, commercial viability, and technology readiness. CTE assigned a "suitability score" to each vehicle type according to the criteria in

Table E2. Vehicles with a suitability score of 5 or higher were deemed ready for purchase, and CTE recommends that Glendale only buy vehicles with this score.

Table E2. Electric Vehicle Suitability Scoring Assumptions

	Score	Definition
Eligible for transition	5	**Very High Suitability – (Widespread Adopters)** Meets all commercial availability criteria, can likely be a 1:1 replacement with proper charging infrastructure, vehicle options from more than 5 OEMs available. Costs estimated at 1.6x that of baseline vehicles.
Not eligible for transition	4	**High Suitability – (Limited Adopters)** Meets all commercial availability criteria, can likely be a 1:1 replacement with proper charging infrastructure. Costs ~2x that of baseline.
	3	**Medium Suitability – (Early Adopter)** Meets all commercial availability criteria except for "cost effective." Costs between 2x to 3x that of baseline vehicle. Available for purchase, few commercial deployments, but past the prototyping stage. May not be a 1:1 replacement.
	2	**Low Suitability – (First Customer)** – Can be ordered but may not be able to be immediately entered into production. In pilot/prototyping stage of development.
	1	**Not yet available for purchase**

CTE used the operating requirements for each vehicle type and the available EV options, combined with the suitability scores, to determine whether each purchase was feasible for a switch to EV. Feasibility defines whether the purchased EV can perform under Glendale's operating conditions. If the EV had the necessary energy capacity to meet Glendale's operating requirement, the EV purchase was feasible.

CTE developed a purchase schedule for both ICE and EV vehicles, outlining fleet composition and procurement costs for the EV transition versus the baseline scenario. Costs are based on Glendale's current pricing and 2024 EV costs. If no EV cost was available for an EV, CTE estimated costs at 1.6 times the baseline to account for upfits and customizations. Inflation was included (3%).

The timing of replacing ICE vehicles with EVs is based on four primary factors:

- Asset Replacement Schedule: is the vehicle ready for replacement based on age?
- Duty Cycle Feasibility: can the replacement EV feasibly meet the daily duty cycle?
- Vehicle Availability and Suitability: is the EV commercially available and is it a suitable replacement?
- Glendale Transition Goals and Compliance: What procurement strategy allows the City to reasonably achieve a 100% zero emission fleet over time and comply with regulations?

Figure E3 presents the annual procurements of both EVs and ICEs. CTE made some modifications to delay purchases of a few vehicles to procure a feasible EV. Based on the replacement schedule determined by service life and purchasing feasible and suitable EV replacements, Glendale will purchase 20% EVs in 2025. Due to the replacement of the pursuit SUVs with ICE or hybrid vehicles, in 2028 only 26% EVs are purchased. By 2031, 100% of purchases will be EV, except for 2039 where an ICE ladder truck is purchased due to the projected lack of suitable EV models.

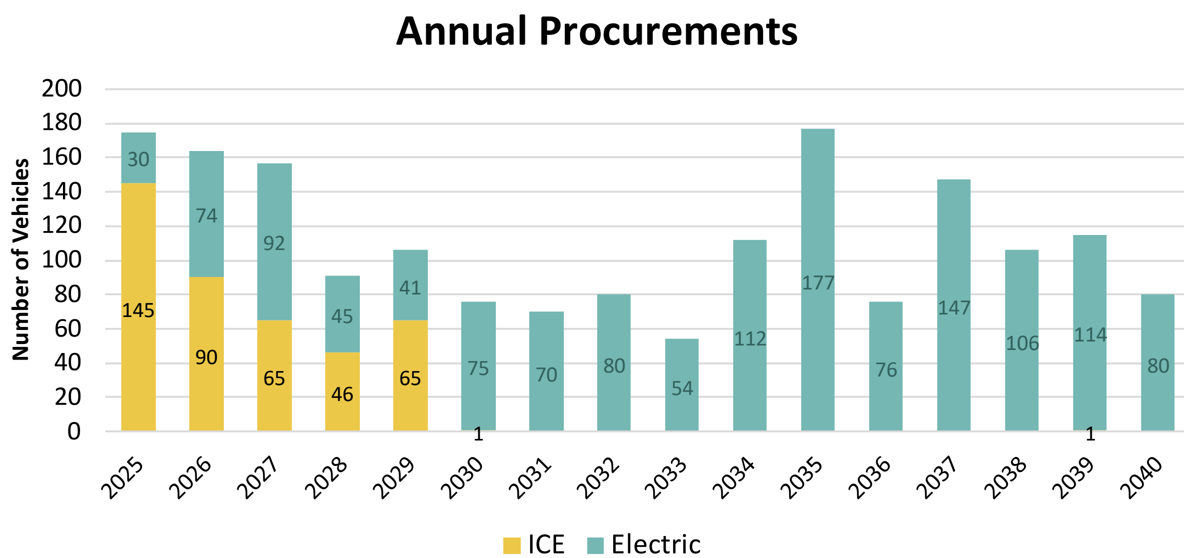

Figure E3. Glendale Procurements by Year

The ACF regulation requires 50% ZE purchase in 2025 and 2026, and 100% ZE purchase starting in 2027. Currently, the exact list of exempt vehicles and configurations is unknown; CARB will release a final list by January 1, 2025. There are no heavier pickups available as an EV (Class 2b-3); however, heavier pickups are not exempt due to the options provided on CARB's list which include the Ford Lightning or a van-style cab and chassis. Glendale has expressed that upfitting van-style chassis has not worked in the past; therefore, CTE did not include those as viable options for EV heavy pickups.

To evaluate the ACF compliance of the recommended purchase schedule, CTE divided Glendale's vehicle categories into exempt and non-exempt categories. Based on this categorization, the purchase schedule is shown in

Table E2. **The current purchase schedule does not meet ACF purchase requirements until 2030 without additional exemptions or purchase delays due to the lack of ZE heavy pickups until approximately 2028-2030.** As shown in Table E3 below and highlighted in red, there are 45 ICE vehicles scheduled for purchase in 2025 that CARB does not consider exempt. Glendale may consider these options for compliance in the short term:

1. **Delay purchase of vehicles** to decrease the percentage of ICE vehicles purchased each year.
2. **Replace some Class 2b-3 pickups with available EV models** such as a ½ ton pickup, a van-type cab and chassis, or a heavier Class 4 trucks.
3. Explore other avenues for **ACF exemptions.**[1]

This may change as CARB releases its official exemption list.

Table E3: Purchases by ACF Status

		2025	2026	2027	2028	2029	2030	2031
Exempt, Emergency	ICE	60	30	47	32	34	1	0
ACF, non-exempt	ICE	**45**	**19**	**3**	0	**19**	0	0
ACF, configuration exempt short term	ICE	32	6	0	1	0	0	0
Exempt, <8500 lb.	ICE	3	35	0	12	12	0	0
Different regulation	ICE	5	0	15	1	0	0	0
Exempt, Emergency	Electric	0	0	0	0	0	25	23
ACF, non-exempt	Electric	21	11	22	14	10	21	3
ACF, configuration exempt short term	Electric	0	0	19	16	10	7	16
Exempt, <8500 lb.	Electric	8	54	17	8	19	12	25
Different regulation	Electric	1	9	34	7	2	10	3
Total Percent EV Purchase		17%	45%	59%	49%	39%	99%	100%
ACF, excluding exempt vehicles		**32%**	**37%**	**88%**	100%	**34%**	100%	100%
ACF, including exempt vehicles		21%	31%	93%	97%	51%	100%	100%

[1] October 2024 ACF Exemption Guidance

Figure E4 shows the fleet composition over the transition period. Glendale does not achieve 100% electrification by 2040 due to the delayed transition of emergency vehicles and the lack of suitable EV models for the heaviest fire equipment. The 12 ICE vehicles that remain in 2040 are all fire engines and ladder trucks.

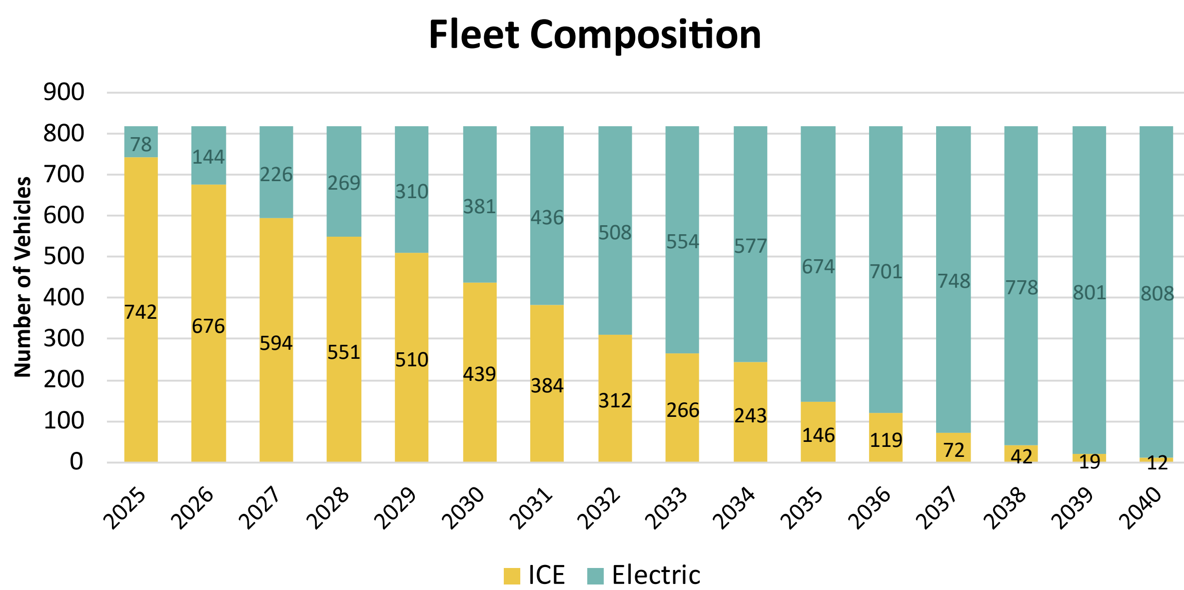

Figure E4. Glendale Fleet Composition by Year, 2040 Scenario

The annual capital investment is shown below in Figure E5.

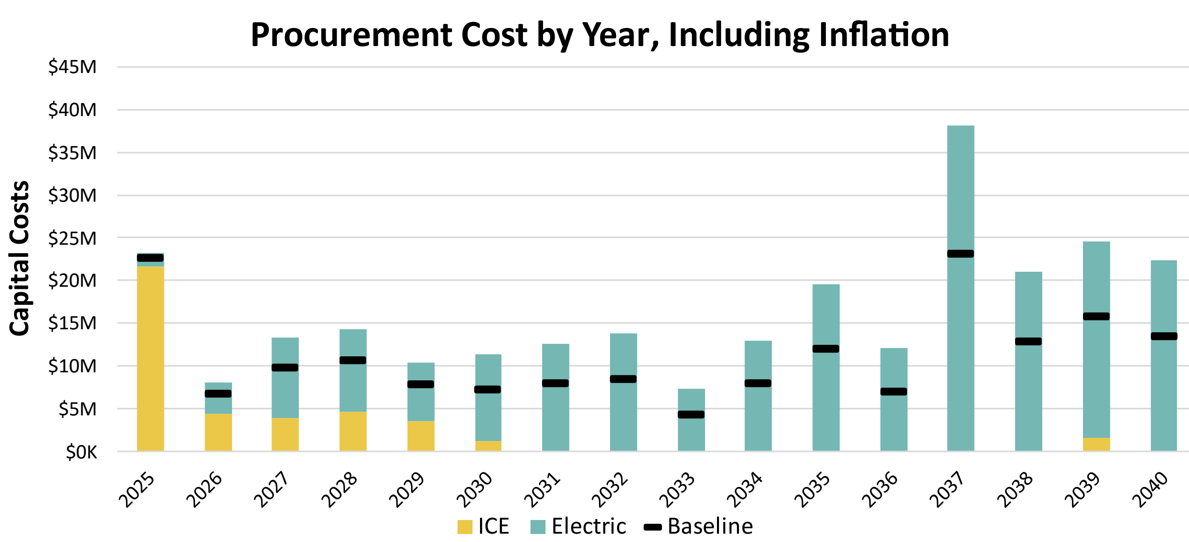

Figure E5. Glendale Annual Fleet Costs by Year, 2040 Scenario

CTE estimates that the cumulative fleet replacements will cost $264.6 million, an $87.8 million increase over the Baseline scenario.

Fuel Assessment

CTE estimated the annual fuel and energy consumption over the transition compared to the baseline scenario, the corresponding fuel costs, the number of chargers needed for the fleet, and the peak demand at each site.

First, CTE provided recommendations for the ratio of EVs to chargers and charger powers to Glendale to provide adequate charging while also minimizing additional electrical infrastructure. Glendale reviewed and modified the recommendations to their preferences. Using the final charging parameters, CTE projects 351 Level 2 and Level 3 chargers with 484 plugs across all sites in 2040 and 65 Level 1 proprietary chargers. Excluding Level 1 chargers, which have a low impact on space and demand, and the corresponding 65 vehicles, the vehicle to charger ratio is 2.11 (1.54 vehicles to plug).

For police patrol vehicles, some operational modifications will be needed with the planned charging infrastructure. Using a 150-kW fast charger, a patrol SUV could fully charge in approximately 30 minutes. Thus, CTE planned for 22 fast chargers for use on patrol vehicles, causing high demand at the Police Parking site, though less than the previous assessment. **Glendale will need to investigate operational changes such as switching patrol vehicles on the shift change rather than driving the same vehicle** if the time available is not enough to adequately charge.

CTE estimated the fuel and energy consumption for each year of the transition by type of fuel. The total amount of energy consumed decreases with electrification because EVs are much more efficient than ICEs. Glendale will decrease its total energy consumption by about 2/3 by 2040 and eliminate gasoline consumption by 2040. The only diesel consumption in 2040 is due to the remaining ladder trucks and fire engines.

Despite reducing the total energy consumption, the fuel costs increase significantly (Figure E6). CTE estimated costs based on current Glendale fuel costs and the appropriate GWP utility schedules. Electricity costs are much higher than the previous assessment due to rate increases at GWP while fossil fuel costs have declined. Additionally, the previous assessment planned for a charger for every vehicle; however, it estimated demand costs on the assumption that only 50% of chargers would be used at any one time. In this assessment, CTE has optimized the vehicle to charger ratio to approximately 2:1 across sites; however, CTE modeled that 100% of the chargers will be used at once[2]. Thus, the peak demand estimate across all sites is like the previous assessment, though some sites such as GPD are

[2] Because demand is charged based on the maximum demand over the previous 12 months, a single instance of all chargers being used at once will cause the peak demand to be charged.

less. The cumulative fuel costs are $100.6 million in the transition scenario, $71.2 million more than the baseline scenario including inflation (Figure E7).

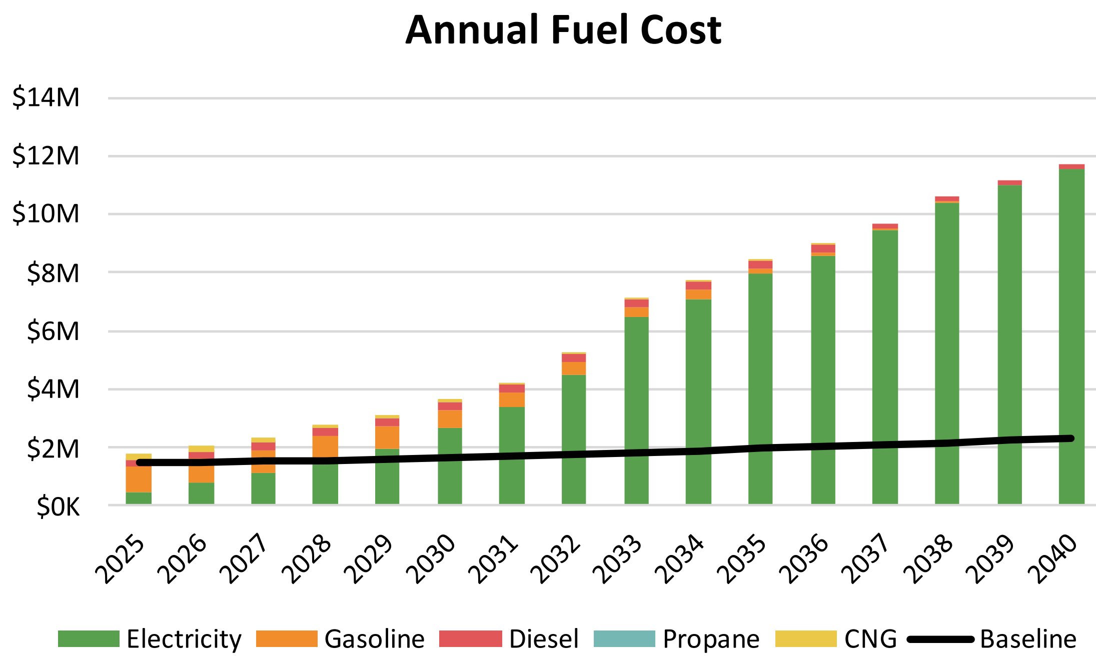

Figure E6. Annual Fuel Cost vs. Baseline

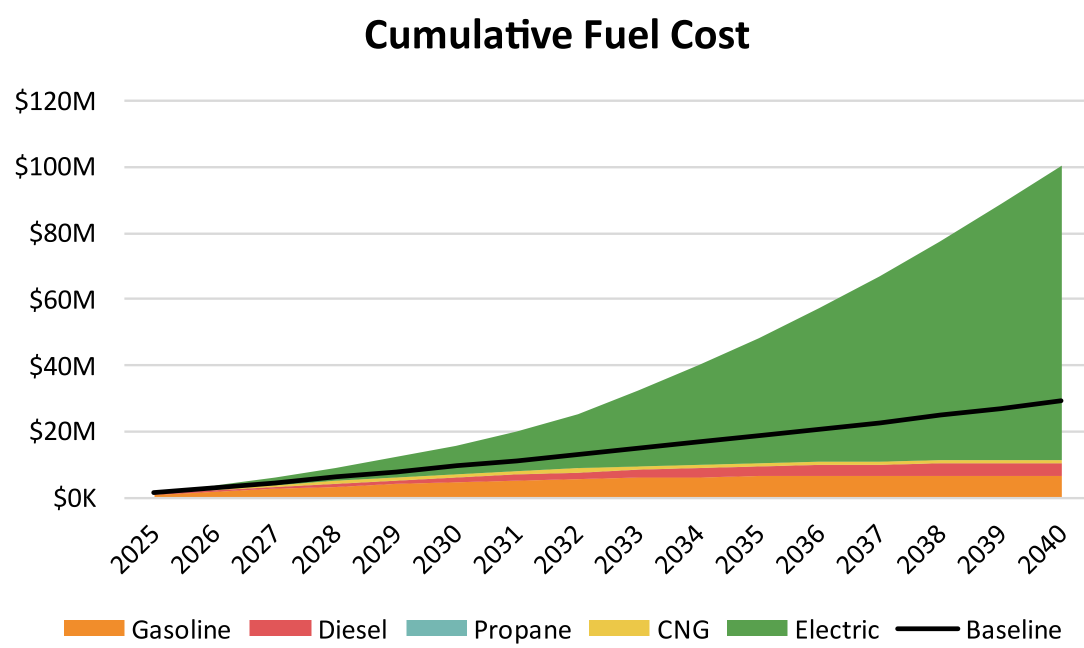

Figure E7. Cumulative Fuel Cost vs. Baseline

The estimated costs are a significant increase from current annual fuel costs and the previous analysis estimates. Additional steps to mitigate higher electricity costs include:

1. **Discuss potential EV charging rates** or demand time-of-use rates with GWP.
2. **Manage peak demand** manually or via a charge management system.
3. Consider other **infrastructure to reduce the peak demand** from the grid such as on-site battery storage or solar.

Infrastructure Transition Assessment

Scaling the City's fleet to 100% EVs requires significant investment in charging infrastructure. In the previous study, CTE used a 1:1 charger to vehicle ratio. This would represent a worst-case scenario and provide an upper boundary to cost. Glendale reports that many of its sites have space constraints that will limit the ability to install that number of chargers. CTE updated its estimate of the charging infrastructure costs based on updated assumptions for projected use of each vehicle, optimized charger numbers, and results from the fuel assessment. GWP provided the estimated utility upgrade costs to meet the required power and energy demand to all Glendale facilities, including distribution, transmission, and the Acacia substation. The overall cost to upgrade the utility infrastructure is $32.5 million. This is higher than the estimated cost from the previous study which was estimated at $21.9 million. This increase was due to several factors including long lead times and price increases for power transformers and other power components. Several design changes to the Acacia substation also increased the cost estimate. The new design includes the option of a third transmission line entry (the original estimate had 2 transmission lines) and improved reliability of the power grid. GWP also added the cost of building a new transmission system from the Grayson Power Plant to the Acacia substation.

Figure E8 shows the annual capital cost over time of the charging infrastructure including the GWP utility upgrades. The first year of the transition is assumed to include costs for the initial design for all six primary sites. The higher costs in 2032 and 2033 align with the phase 2 construction at multiple sites. The total capital cost of charging infrastructure and utility upgrades is estimated at $57.5 million This cost is a significant savings over the 1:1 charger to vehicle ratio used in the previous study, which estimated a cost of $49.2 million for construction and infrastructure plus $21.875 million for utility upgrades totaling $71 million.

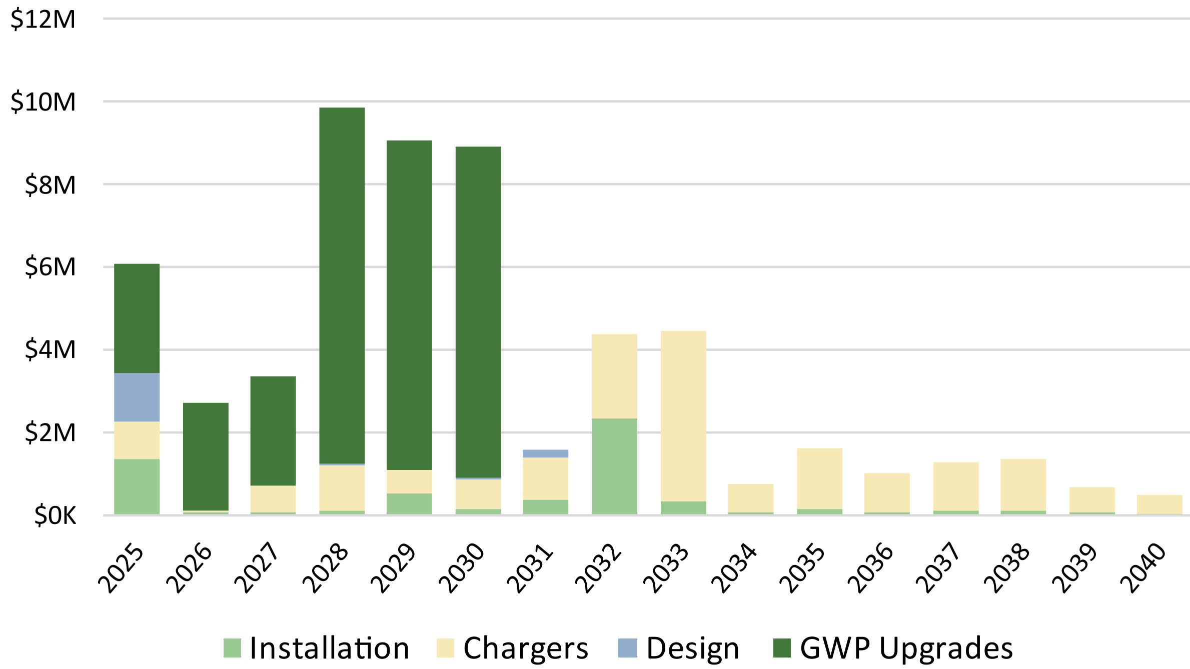

Figure E8. Glendale Infrastructure Cost

Note: these cost estimates are considered a "rough order of magnitude" estimate and not an engineering cost estimate. Also, we've excluded infrastructure upgrade and infrastructure design/build cost at "Other" facilities under the assumption that these costs would be minimal as compared to the six primary facilities because comparatively few vehicles park at these locations. Charger and installation costs for "Other" facilities are included in the estimates.

Maintenance Assessment

EVs have an advantage over ICE with respect to maintenance due to fewer moving parts, no fluids to replace, and less frequent brake changes due to regenerative braking. CTE applied a percent reduction to the maintenance costs based on the vehicle type based on a study of EV total cost of ownership[3]: 40% reduction for Light, 30% for Medium, and 25% for Heavy vehicles. Because there is limited commercialization and thus limited data for other vehicle classes, CTE conservatively applied a 25% reduction to non-road vehicles and emergency vehicles. CTE applied a 40% reduction to the Pursuit vehicles to match the Light category. The estimated annual maintenance cost compared to baseline vehicles is provided below in Figure E9. Cumulative costs are shown in in Figure E10; the

[3] Argonne National Labs, Vehicle TCO Analysis (2021)

cumulative cost of maintenance is approximately $30 million less in the transition scenario.

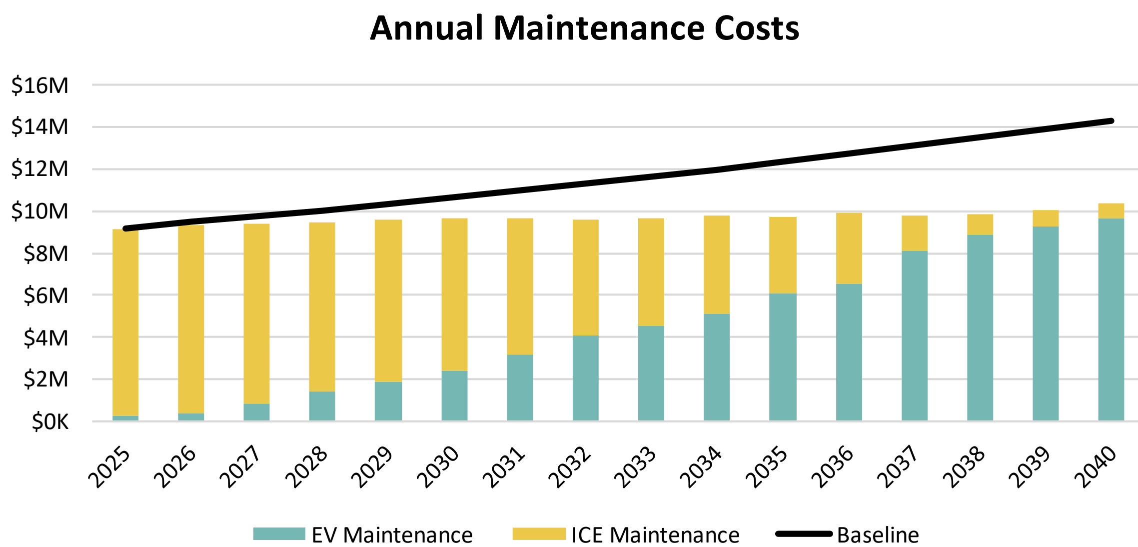

Figure E9. Estimated Annual EV Maintenance Costs Compared to Baseline, 2040

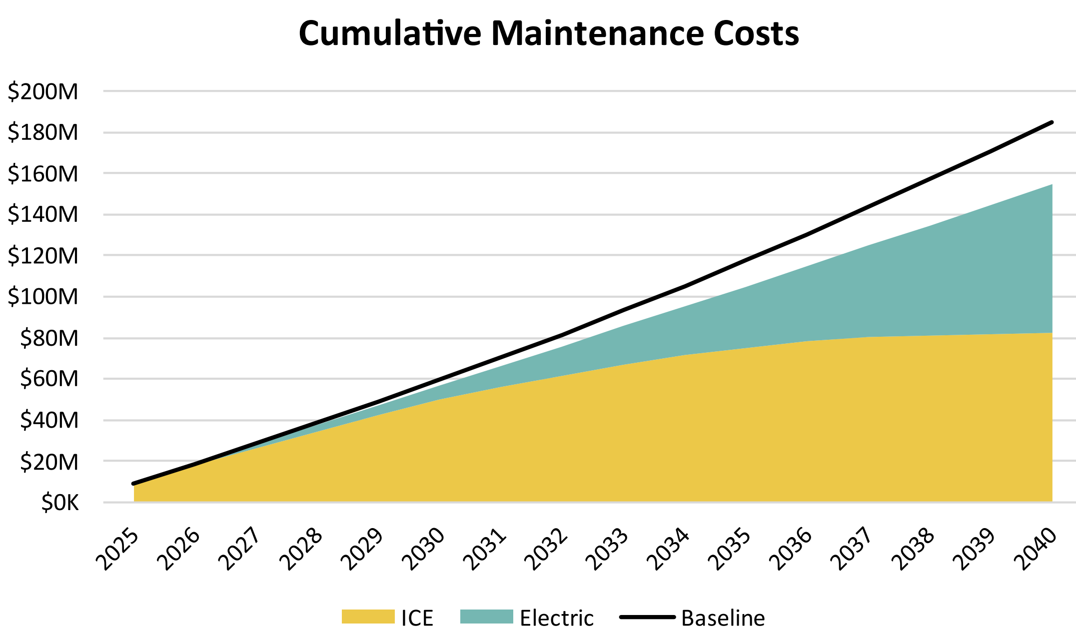

Figure E10. Cumulative EV Maintenance Costs Compared to Baseline, 2040

Emissions Assessment

The primary goal of transitioning the fleet to EVs is to reduce tailpipe pollutant emissions to improve local air quality and reduce the effect that greenhouse gases (GHGs) have on the environment. CTE compared the upstream and tailpipe emissions of the current fleet to emissions related to generation of the electricity required to charge the EVs. The estimated emissions reduction of the City's EV transition is shown below in Figure E11. Glendale may avoid approximately 53 million pounds of GHGs cumulatively, resulting in 62% lower annual GHG emissions in 2040. If fossil fuels are used to generate electricity, Glendale will not be able to achieve a fully zero-emission operation when considering upstream and in-use emissions; however, when considering only tailpipe emissions, Glendale will nearly achieve zero emission operation in 2040. The exception to this is the continued operation of 12 diesel fire engines and ladder trucks. Table 32 shows the expected 2040 annual emissions including criteria pollutants, which are greatly reduced via electrification except for SO_x. SO_x emissions increase due to electricity partially generated from coal combustion, but they will decrease if electricity generation moves toward non-fossil fuel sources such as nuclear, solar, wind, or hydropower.

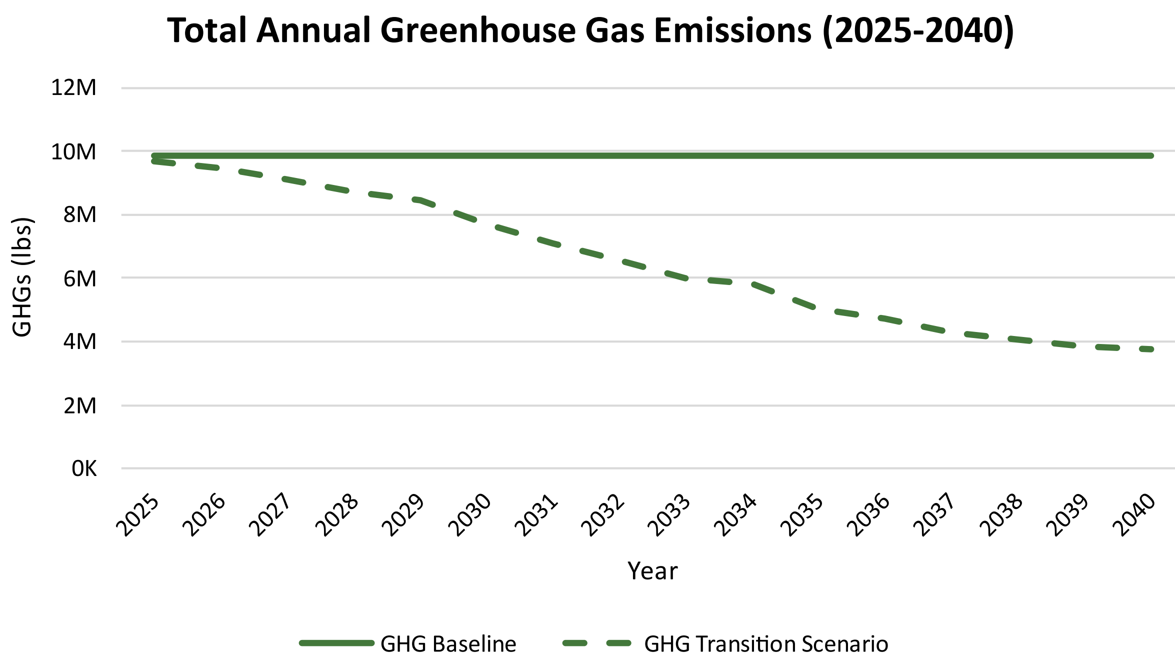

Figure E11. Estimated Emissions of Greenhouse Gases

Table E4: 2040 Annual Emissions, Baseline vs. Transition

Pollutant	2040 Annual Baseline Emissions (lbs)	2040 Annual Transition Emissions (lbs)	Difference (lbs)	Percent Difference
GHGs	9,844,000	3,771,000	-6,073,000	-62%
CO	51,000	2,000	-49,000	-96%
NO_x	7,000	3,000	-4,000	-57%
SO_x	900	1,900	1,000	+111%
PM_{10}	380	330	-50	-13%

Incremental Transition Costs

Incremental Transition Cost is the total incremental cost of first-time EV replacements (number of first-time purchases shown in Figure E13) plus total EV infrastructure costs. It represents the incremental capital funding required to transition to an all-electric fleet. Figure E12 provides the cumulative transition cost for the 2040 scenario which is estimated at $67.6 million.

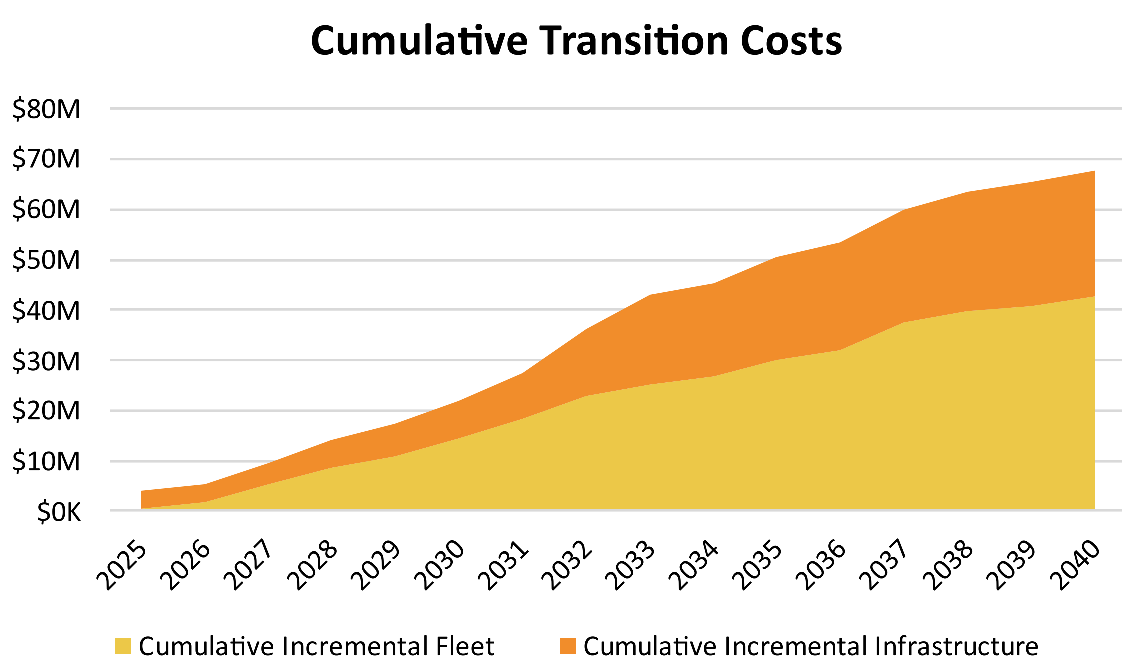

Figure E12. Cumulative Transition Costs

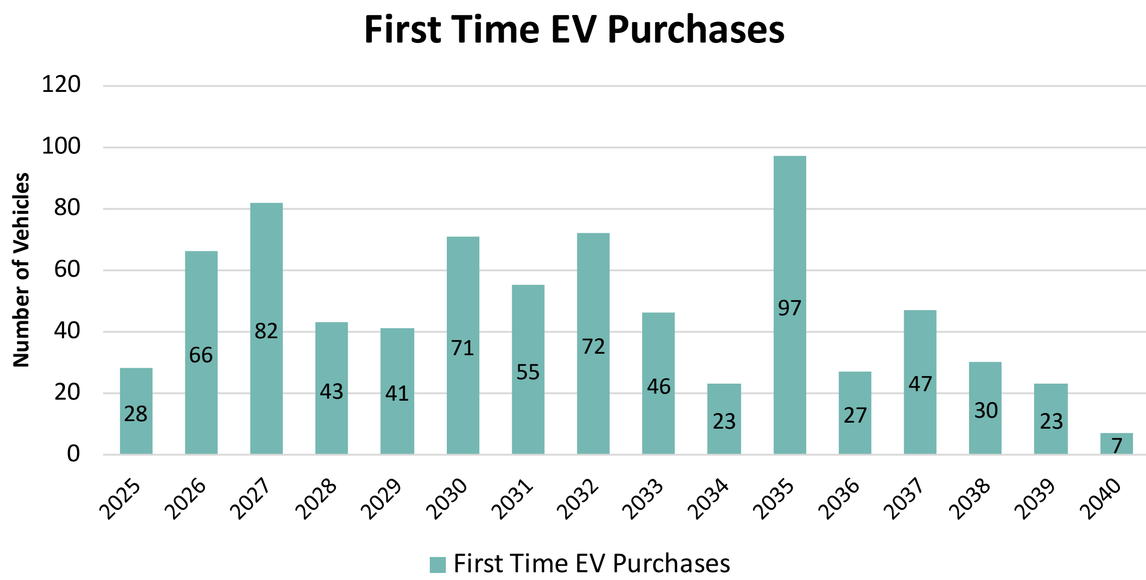

Figure E13. First Time EV Procurements

Total Cost of Ownership

The Total Cost of Ownership Assessment (TCO) provides a comprehensive view of costs to Glendale for the transition and baseline scenarios over the transition period by compiling the results from the Fleet, Fuel, Facilities, and Maintenance Assessments. The TCO estimate allows Glendale to make informed decisions based on the best information currently available about costs of each technology and the magnitude of costs of each facet of the transition in relation to others. This study assumes no cost escalation or any cost reduction due to economies of scale for ZEV technology because there is no historical basis for these assumptions and future market pressures, technology capabilities, and regulations may change significantly over the next 15 years. The assessments provide the best estimates using the information currently available and the assumptions detailed throughout this report.

Figure E14 provides the TCO across the entire fleet color coded by the element: Fleet Procurement, Facilities Projects, Annual Fuel, or Annual Maintenance costs, along with a reference line for the baseline total cost. Fleet and Maintenance costs are the largest costs, although maintenance is more consistent from year to year while fleet varies depending on the vehicles being replaced that year.

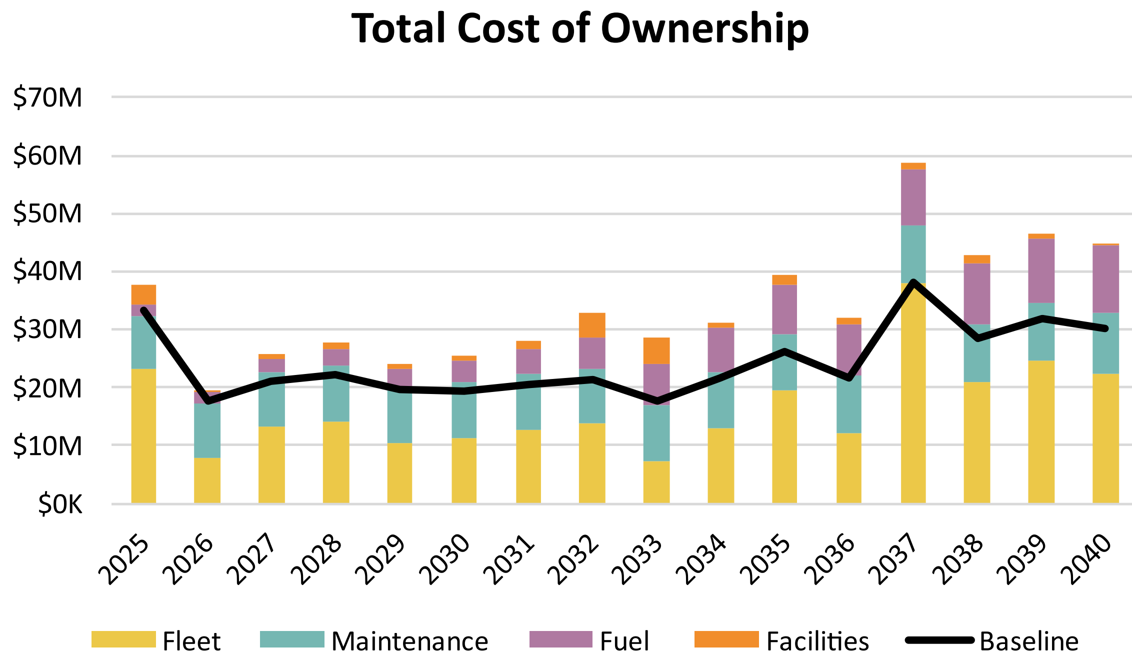

Figure E14. Annual Total Cost of Ownership

The total cost of the transition is approximately $154 million dollars (39%) more than the baseline scenario over the next 15 years as shown in Figure E15.

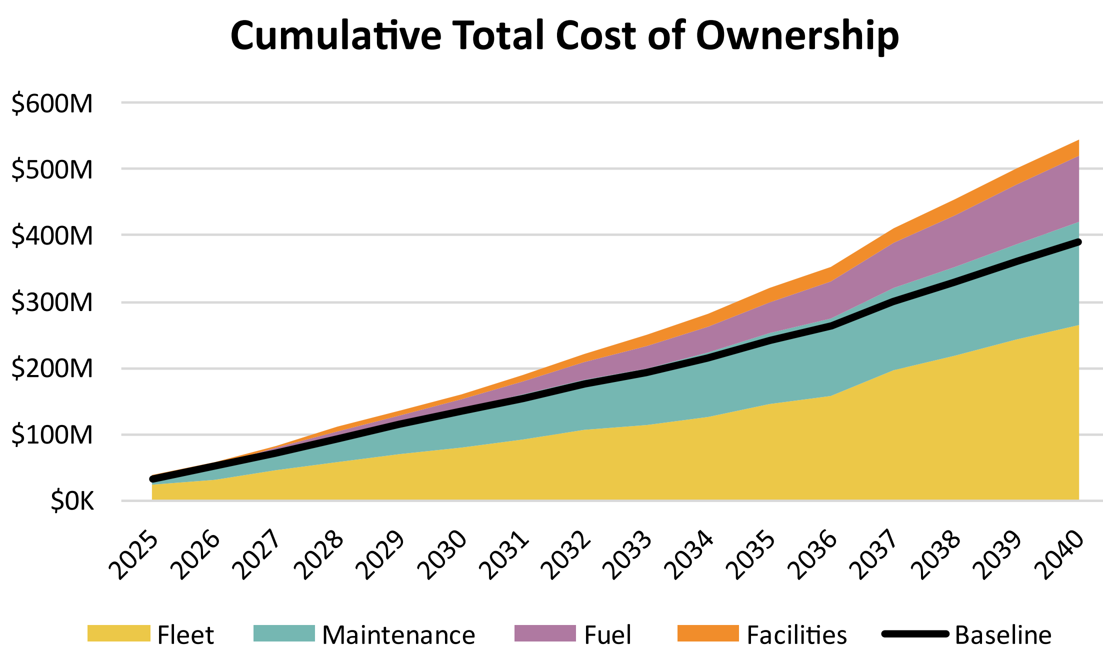

Figure E15. Cumulative Total Cost of Ownership by Scenario

Funding Opportunities

The City of Glendale has several zero-emission vehicle and infrastructure funding opportunities they can pursue to help fund the transition, including:

- HVIP
- VW Environmental Mitigation Trust Funding
- LCFS ZEV Infrastructure Crediting
- Electric Vehicle (EV) Rebate Program:
- National Electric Vehicle Infrastructure Formula Program
- Discretionary Grant Program for Charging and Fueling Infrastructure ($2.5 billion):
- The EPA's DERA Program funds grants and rebates
- Clean Vehicle Rebate Project (CVRP)
- Southern California Incentive Project (SCIP)
- CEC Clean Transportation Program: Government Fleet Electric Vehicle Charger Station Grants

Potential for Hydrogen in the City's Fleet

While many applications and use cases for municipal fleet vehicles are well suited to electric vehicles, some applications cannot easily be met with battery electric vehicles (BEVs). Use cases where vehicles have longer range and shorter downtimes may prove a challenge for current and future BEVs. These applications could be addressed by adopting fuel cell electric vehicles (FCEVs). FCEVs have a longer range than most BEVs and can be fueled in minutes vs. hours required by BEVs.

Light-duty FCEVs are now being sold by several automakers in areas with access to hydrogen fueling stations. However, today there are not any readily available medium-duty or heavy-duty FCEVs in the market suitable for municipal fleets. Development and demonstration projects are underway but won't field market-ready vehicles for several years. In the near term, the City could transition its light-duty sedans and SUVs to FCEV models. However, the City's duty cycle for most of their light-duty sedans and SUVs are better suited to BEVs. As a result, the City should elect to transition to BEVs because they are lower cost and can be charged on-site once charging stations are installed. Once FCEVs are available in all classes, several of the City's applications could potentially be met with this technology.

Hydrogen fueling stations can be broken down into heavy-duty, and light-duty categories. Light-duty facilities use a fueling protocol that is internationally recognized and approved by all vehicle original equipment manufacturers (OEM's). A typical light-duty station installation will include two independent fueling dispensers capable of simultaneous use. Fuel is delivered via gaseous delivery trailers and is stored at the facility in high-pressure gaseous storage vessels. Fuel is then compressed and cooled prior to dispensing into the vehicle. The cost to construct the station would be around 5.5 million.

Heavy-duty hydrogen fueling stations are predominantly used in the transit industry today. Aside from most facilities using liquid hydrogen, they differ from light-duty by dispensing H35 grade fuel (350 bar settled pressure onboard vehicle). Typical process description for a heavy-duty HRS using LH2 as a feedstock is as follows: hydrogen stored as a liquid on-site in a cryogenic bulk storage vessel. Liquid is drawn from the tank where it is pumped to high pressure prior to being vaporized through large ambient heat exchanger (vaporizer). Hydrogen is then stored at one or multiple pressures in gaseous form prior to being routed through a dispenser and into customer vehicles. The cost to construct a heavy-duty vehicle station would be around 7 million.

Interim solutions for hydrogen fueling during a transition include temporary mobile fuelers and using existing stations in the area. There are five existing stations that provide hydrogen within 14 miles of the main location for the city. The City could use these interim solutions until the fleet was of sufficient size to justify construction of a full-size station.

Conclusions and Recommendations

Since the last assessment, the EV market has progressed leading to a more feasible transition for Glendale's fleet. CTE has also improved upon the previous analysis, providing higher confidence in the feasibility for EVs in Glendale's duty cycles and optimizing the recommended charging infrastructure, leading to lower infrastructure capital costs. Developments such as the implementation of the ACF regulation and increasing demand costs have introduced aspects that need further attention from Glendale.

As discussed in the Fleet Assessment, there is a mismatch in the vehicles that the ACF regulation considers suitable for an EV replacement and those that Glendale considers suitable for heavy pickups (greater than ¾ ton, or class 2b-3). To meet ACF purchase percentage requirements while continuing to replace vehicles as needed, Glendale will need to consider the assets up for replacement and determine whether to **delay purchase, replace with a different EV, or pursue an ACF exemption**.

As discussed in the Fuel Assessment, CTE projects much higher electricity costs than the last assessment in large part due to rate increases at GWP. Most electricity costs are due to high demand rates. Therefore, CTE recommends that the City may be able to lower utility costs by **limiting maximum demand, collaborating with GWP for an EV rate or time-of-use demand rate, or investing in infrastructure to reduce peak demand** from the grid.

Finally, CTE recommends that Glendale continues its transition process with the following strategies:

1. **Remain proactive with grant funding** to reduce the capital costs of vehicles early in the transition.

2. **Continue to revisit the transition plan** every 2-3 years as ZE technologies and regulations evolve and the City becomes more experienced with EVs.
3. **Begin resilience planning for the EV fleet** as resilience practices and procedures will change for an EV fleet and the City will be able to depend less and less on ICE vehicles as they are phased out.
4. **Remain engaged with the Police and Fire Departments** to pilot ZEVs and find models that meet their needs. Support of the vehicle operators in every department will be critical for successful deployment.

The transition to EV technology represents a fundamental shift in vehicle procurement, operation, maintenance, and infrastructure. Achieving a sustainable, zero-emission transportation sector requires continuous deployment with clear advancement goals. Widespread adoption of zero-emission vehicles has the potential to greatly reduce GHG emissions and improve public health and the environment.

Introduction

City of Glendale, CA Municipal Fleet Service Overview

According to the city's website, the City of Glendale was incorporated on February 16, 1906, and spans approximately 30.6 square miles with a current population of approximately 203,054 people (US Census 2017 Population Estimates). Glendale is the fourth largest city in Los Angeles County and is surrounded by Southern California's leading commercial districts.

As one of its core functions, Glendale provides well-maintained streets and a variety of transportation services. The City's historic success at attracting employers is partially attributed to the result of its location at the center of four major freeways including

- the I-5 Golden State Freeway
- SR-2 Glendale Freeway
- ST-134 Ventura Freeway
- and the 210 Foothill Freeway

All these provide easy access for residents, workers, and customers from around the region. Glendale also offers its own bus services, the Beeline, with 13 routes connecting customers to Jet Propulsion Laboratory (JPL), the City of Burbank, and the Metrolink Stations in both Burbank and Glendale.

The Bob Hope Airport in Burbank serves the Los Angeles area including Glendale, Pasadena and the San Fernando Valley. It is the only airport in the greater Los Angeles area with a direct rail connection to downtown Los Angeles. The City of Glendale is located about 30 minutes from Los Angeles International Airport (LAX). LAX is a commerce leader and designated as a world-class airport for its convenient location, modern facilities, and superior sea/air/land connections.

Glendale prides itself on the quality of services it provides to the community. It is a full-service City which includes a water and electric utility. The City operates its own power plant, although the majority of power is currently imported from other areas. Water comes primarily from the Metropolitan Water District, along with a small portion from local wells.[4]

City Fleet Overview

As of November 2024, The City owns and operates a fleet of 820 active vehicles, which is the basis for the analysis. This list eliminates trailers, non-vehicular equipment, and parade antiques from the full asset list provided by the City. City vehicles are categorized as light-, medium-, and heavy-duty (based on gross vehicle

[4] City of Glendale overview taken from https://www.glendaleca.gov/government/about-us

weight rating [GVWR] classification), pursuit, emergency, and non-road vehicles. Figure 1 shows a breakdown of Glendale's fleet by category. Light-duty vehicles make up the largest portion of the fleet (47%) followed by pursuit vehicles at 16%, non-road vehicles at 12%, heavy duty vehicles at 10%, medium duty vehicles at 8%, and emergency vehicles at 7%.

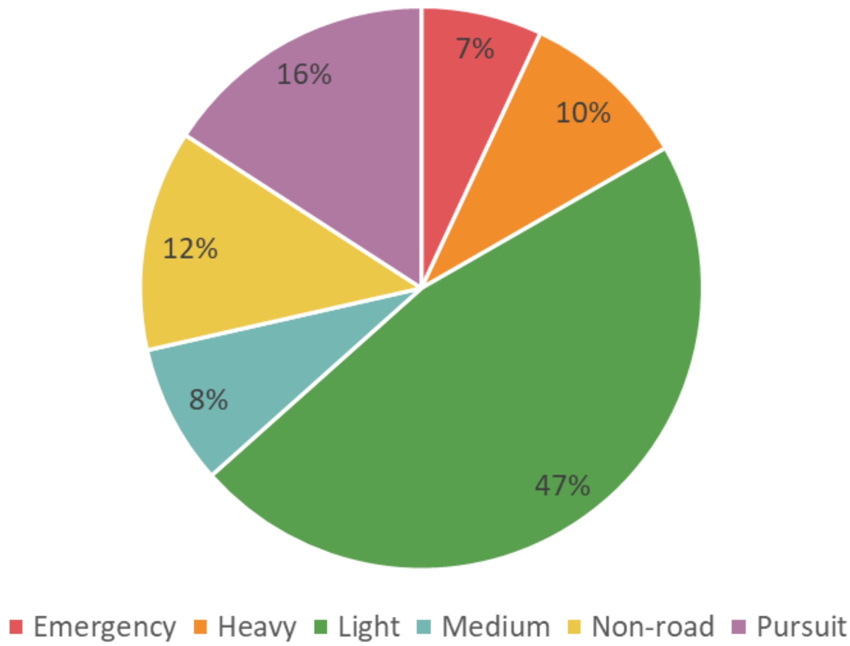

Figure 1. Glendale Fleet by Vehicle Type

City Facility Overview

This analysis focused on the vehicles parked at select primary facilities. The remainder of vehicles not captured at these facilities are generally parked at libraries or other City facilities, where typically only one or two vehicles are parked. For the purposes of this analysis, CTE assumed that the installation of charging infrastructure for those facilities will not require utility upgrades and can be done with little or no disruption to current operations.

Table *1* summarizes the number of vehicles at each of the facilities under consideration.

Table 1. Fleet Profile at Primary Facilities

Facility Name	Total Vehicles
Public Works Yard	110
City Hall Complex[5]	114
GWP Utility Operations Center[6]	148
Integrated Waste Yard	55
Fire Station 21	34
Police Parking Lot	200
Other Vehicles	159
Total Fleet	**820**

Public Works Yard

The Public Works Yard houses vehicles from multiple departments and includes vehicles from all types except pursuit. The number of vehicles at the Public Works Yard are summarized by vehicle class in Table 2. An aerial view of the facility is shown in Figure 2, with the property boundaries outlined in red.

Note that most departments that park vehicles at the Public Works Yard do not have assigned parking spots. When planning for fleet electrification, some vehicle assignments may need to be made to ensure that the vehicles are parked at the appropriate charger (i.e., Level 2 AC charger, DC fast charger).

Table 2. Fleet Profile at the Public Works Yard

Light Duty	Medium Duty	Heavy Duty	Non-Road	Emergency	Pursuit	Total
45	27	20	18	-	-	110

[5] City Hall includes CCG, CVC, and Perkins sites.

[6] Glendale Water and Power includes GWP, and Plant sites.

Figure 2. Public Works Yard aerial view

City Hall Complex

The City Hall Complex houses vehicles from multiple departments that are primarily light-duty. The number of vehicles at the City Hall Complex are summarized by vehicle class in Table 3. An aerial view of the facility is shown in Figure 3, with the property boundaries outlined in red. The City Hall Complex encompasses multiple parking areas, including a garage that has both public parking and parking for City vehicles.

Table 3. Fleet Profile at City Hall Complex

Light Duty	Medium Duty	Heavy Duty	Non-Road	Emergency	Pursuit	Total
107	4	-	3	-	-	114

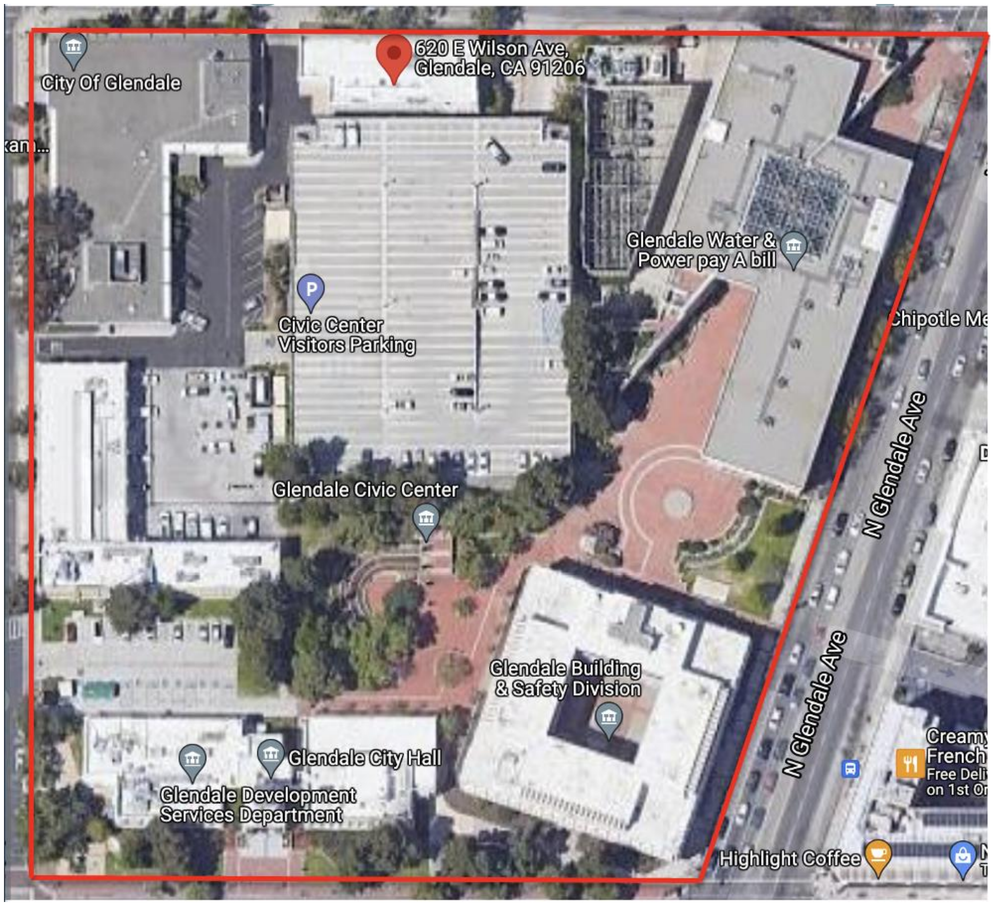

Figure 3. City Hall Complex aerial view

Glendale Water and Power Utility Operations Center

GWP Utility Operations Center houses GWP vehicles. The number of vehicles at the GWP Utility Operations Center are summarized by vehicle class in Table 4. An aerial view of the facility is shown in Figure 4, with the property boundaries outlined in red.

Table 4. Fleet Profile at GWP Utility Operations Center

Light Duty	Medium Duty	Heavy Duty	Non-Road	Emergency	Pursuit	Total
75	28	19	26	-	-	148

Figure 4. GWP Utility Operations Center aerial view

Integrated Waste Yard

The Integrated Waste Yard houses vehicles from multiple departments with the majority being heavy-duty vehicles. The number of vehicles at the Integrated Waste Yard are summarized by vehicle class in Table 5. An aerial view of the facility is shown in Figure 5, with the property boundaries outlined in red.

Table 5. Fleet Profile at Integrated Waste Yard

Light Duty	Medium Duty	Heavy Duty	Non-Road	Emergency	Pursuit	Total
13	1	41	-	-	-	55

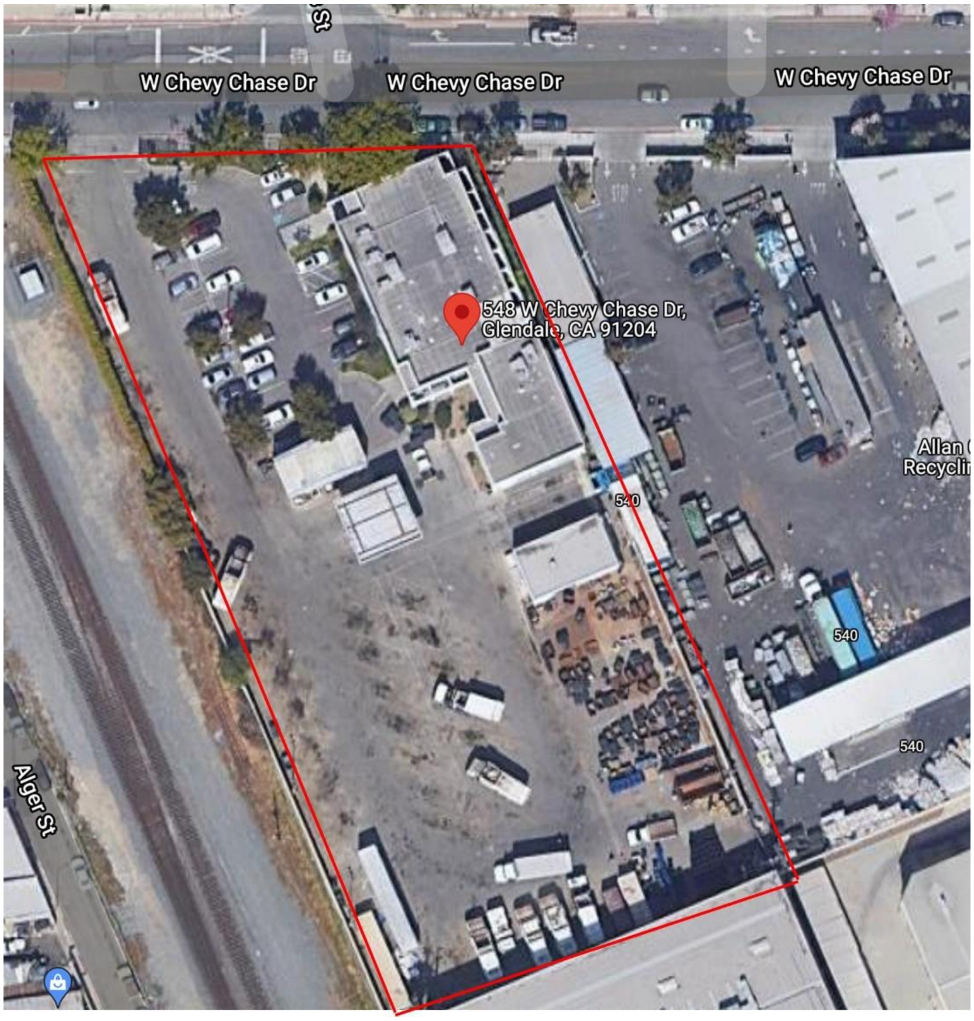

Figure 5. Integrated Waste Yard Aerial View

Fire Station 21

Fire Station 21 houses emergency response vehicles from the fire department, including the City's fire engines. The number of vehicles at Fire Station 21 are summarized by vehicle class in Table 6. An aerial view of the facility is shown in Figure 6, with the property boundaries outlined in red.

Table 6. Fleet Profile at Fire Station 21

Light Duty	Medium Duty	Heavy Duty	Non-Road	Emergency	Pursuit	Total
7	-	-	-	27	-	34

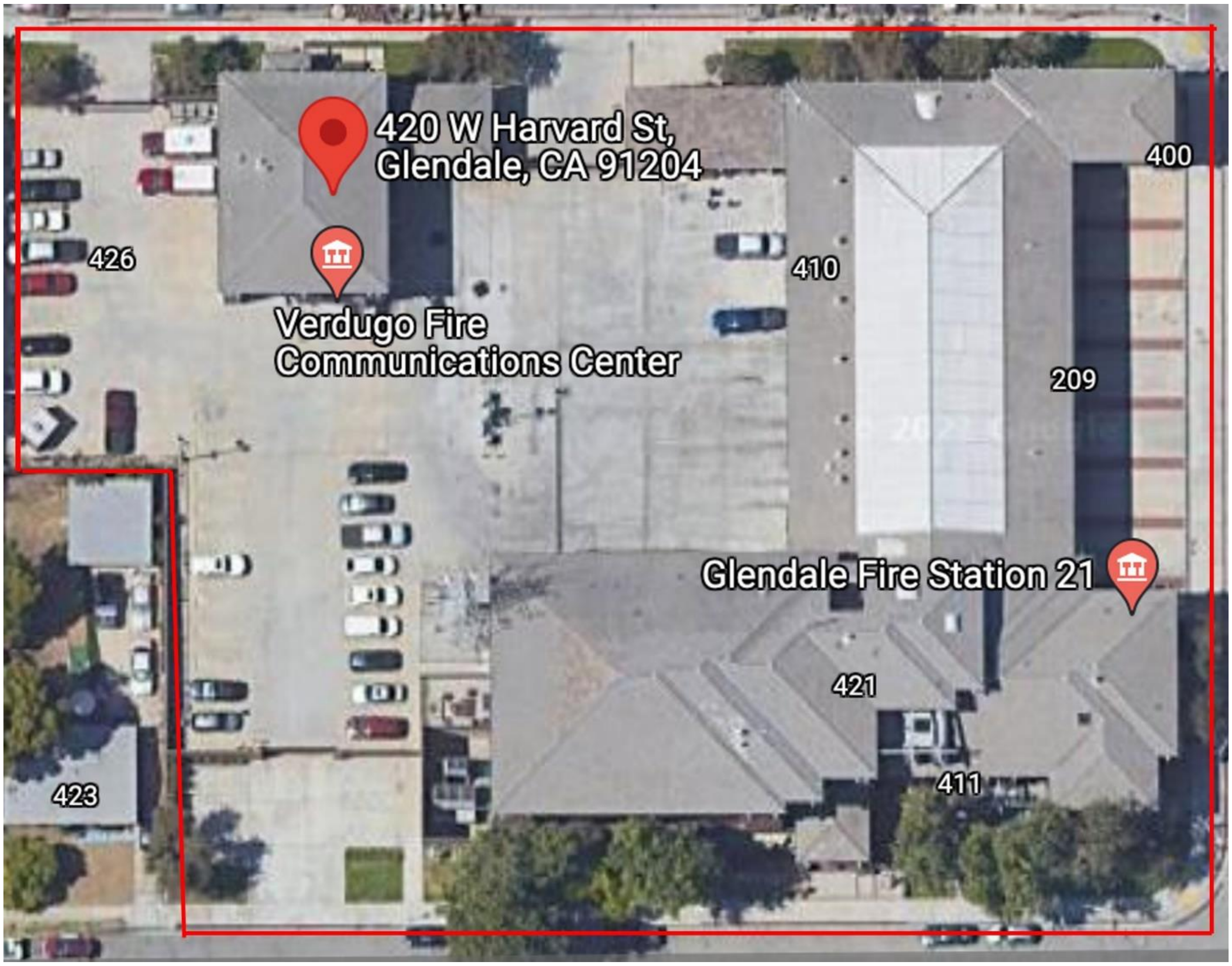

Figure 6. Fire Station 21 Aerial View

Police Department Parking Lot

Police Department Parking Lot houses pursuit and emergency response vehicles from the police department. The number of vehicles at the Police Parking by vehicle class are summarized in Table 7. An aerial view of the facility is shown in Figure 7 with the property boundaries outlined in red.

Table 7. Fleet Profile at Police Parking Lot

Light Duty	Medium Duty	Heavy Duty	Non-Road	Emergency	Pursuit	Total
65	-	-	2	3	130	200

Figure 7. Police Parking Lot Aerial View

Fleet Electrification Study

In 2021, the City of Glendale, California (the City) engaged the Center for Transportation and the Environment (CTE) to perform a fleet electrification study to evaluate the requirements, operational considerations, and costs to transition all vehicles in the municipal fleet to 100% electric vehicles by either 2035 or 2040. The results of the study were intended to inform the City of the estimated costs, benefits, constraints, and risks of the transition to an EV fleet and will guide future planning and decision-making. CTE presented the results of the study to the City Council in September 2022. Based on the methodology and assumptions used, the city fleet would have been 97% EV in 2040. The remaining ICE vehicles were emergency equipment (primarily fire engines and ladder trucks) due to the estimated time to market and long-life of these assets. The Council requested additional analysis to review scenarios to reach 100% EV by 2040 and to explore the potential for hydrogen fuel cell vehicles. CTE completed the additional analyses in August 2023.

The City initiated a new contract with CTE in February 2024 to update the study including the market analysis, refine the duty-cycle analysis to optimize the number of chargers required, reassess the infrastructure needs based on the real-world duty-cycle analysis, address the requirements of the state of California's Advanced Clean Fleet regulations, and update the results in a final report. This report includes the full study and all updated results.

California Regulations

CARB is responsible for establishing regulation in the state of California focused in addressing all major sources of smog-forming air pollution.[7] Several regulations affect the City of Glendale's fleet as follows:

Advanced Clean Fleet (ACF): This regulation covers fleets including those of state and local governments. Vehicles subject to the regulation have a GVWR greater than 8,500 lbs. Beginning on January 1, 2024, fleets must ensure that 50 percent of their annual vehicle purchases are ZEVs. Beginning on January 1, 2027, 100 percent of annual vehicle purchases must be ZEV. The ruling includes a list of vehicles currently exempt from the regulation.

Advance Clean Cars II (ACC): This regulation, which combined several previous regulations into one, requires an increased number of light-duty passenger cars, sport utility vehicles (SUV), and pickup trucks produced as ZEVs. This applies to manufacturers.

In-Use Off-Road Diesel-Fueled Fleets: Passed in 2023, this regulation is focused on reducing emissions from off-road vehicles and applies to fleets. The regulation imposes limits on idling and requires fleets to retire, replace, or repower older engines or install emissions control devices. Fleets are also required to report their compliance through an online tool.

Small Off-Road Engines (SORE): This regulation covers spark-ignited engines rated at or below 19 kW— primarily lawn, garden, utility vehicles, and other off-road equipment. This regulation applies to manufacturers.

Market Review

Vehicle availability is one of the most important factors for transition feasibility. The market for electric vehicles varies greatly depending on the type of vehicle, and the City's fleet is diverse. The EV market has expanded since the previous assessment, and CTE anticipates that electric vehicle offerings will continue to develop. CTE updated its ZEV market assessment to account for new EVs available for the City's fleet by vehicle type. Table 8 provides the list of vehicle categories and types included in the City's current asset list.

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[7] CARB web site: https://ww2.arb.ca.gov/about

Table 8. List of Fleet Vehicles by Type

Light		Medium		Heavy		Emergency		Pursuit		Non-road	
1 ton Pickup	57	Truck	16	Heavy Truck	10	Command Vehicles	13	Motorcycle	27	Bunker Rake	6
1/2 ton Pickup	39	Dump Truck	12	Refuse Truck	38	Emergency Specialty	12	SUV	103	Mowers	10
3/4 ton Pickup	46	Flatbed Truck	11	Street Sweeper	6	Fire Engine	16			Forklifts	11
Compact Pickup	53	Manlift Truck	12	Crane Truck	7	Ladder Truck	4			Lifts	4
Minivan	41	Cargo Van	15	Dump Truck	11	Rescue	12			Construction Equipment	25
Motorcycle	2			Manlift Truck	6					Roller	2
Refuse Truck	6			Roll-off Truck	2					Misc Equipment	7
Sedan	76									Utility Sweeper	6
SUV	36									Utility Vehicle	33
Van, Cargo	24										
Van, Passenger	3										
	383		**66**		**80**		**57**		**130**		**104**

The City's vehicles have been categorized into light-duty, medium-duty, heavy-duty, emergency, pursuit, and non-road vehicles. Appendix A provides tables of current EV models by type that could be suitable for the City fleet. The specific vehicle and equipment types that make up each of these six categories are described below.

Light-Duty

The light-duty category—including sedans, SUVs, vans, pickups, and motorcycles—is well suited for EV adoption with many OEMs producing commercial models that are readily available for purchase. Most vehicles in this segment can be transitioned as soon as an asset reaches its planned service life. The exception to this is the pickup category. Although there are many models of half-ton pickups currently available on the market, compact and heavier models (three-quarter-ton, 1-ton, 1.5-ton) have yet to be introduced. Ford has announced it plans to offer the heavier models by 2027 or 2028, however no OEM has indicated it will produce the smaller size pickup. The lack of compact and heavier pickups is a challenge for the City. The City currently uses the compact pickups for specific duties that could not be handled by the larger half-ton pickup. Similarly, the City has uses for the heavier pickups that would not be well suited for the half-ton pickup. Depending on the specific use of these pickups, the City may need to delay replacement until a suitable model is available.

Sedans: The fleet consist of 76 sedans in total. There are various electric vehicle options available to replace the City's current passenger vehicle fleet. There should be no limitation to transitioning the City's passenger cars to electric vehicles in the near term.

Pickup Trucks: Light-duty pickups are classified according to their payloads; the current categories in North America include compact, half-ton, three-quarter-ton, 1-ton, and 1-and-a-half-ton. The City fleet consists of 195 pickup trucks, making it the largest category that makes up the light-duty vehicles. The City can transition its half-ton pickups to EV models in the short term but will have to delay replacement of heavier and compact models until the market matures. Depending on use, the City may elect to replace some of its compact or heavier pickups with a half-ton pickup.

Sport Utility Vehicles (SUVs): The City operates 36 SUVs in its fleet. There are multiple OEMs currently offering SUVs in both smaller and larger sizes. The City should be able to transition its SUVs with no limitations.

Vans: There are 68 light-duty vans in the fleet including minivans, cargo vans, and passenger vans. The current market for light-duty vans is healthy, with 20 models available on the market. These models are primarily outfitted for cargo, which fits well with how the City operates its vans. Chrysler has announced a minivan will be available in 2025. The City should be able to transition its van fleet in the near term.

Medium-Duty

There are multiple medium duty electric chassis available on the market, though their current price point is 2 - 4 times that of their diesel equivalents. The City uses its medium duty vehicles for applications such as pickup and delivery trucks, small utility bodies, service bodies, small dump trucks, vans, and lighter garbage truck applications (needing a tight turning radius). Medium-duty trucks are ideal for almost any industry due to customizable features such as cab configurations, bodies, and chassis-mounted equipment. The City could transition these vehicles in the near term; however, the capital costs are high, and lead times are long. Fleets can apply for rebates through CARB's HVIP program. These funds are limited and available on a first-come-first-served basis. The City should prioritize HVIP requests when planning procurements to off-set the costs, but award of these funds is not guaranteed.

Medium-Duty Trucks: The City has 66 medium-duty trucks outfitted for various uses such as dump, flatbed, and manlift.

Medium-Duty Vans/Buses: Medium-duty vans are on-road vehicles whose GVWR ranges from 14,001 lbs. to 26,000 lbs. Medium-duty vans can be used in passenger and cargo applications. Glendale has 15 medium-duty cargo vans.

Heavy-Duty

Heavy-Duty Trucks: Heavy-duty trucks are motor vehicles that refer to truck Class 7 - 8, which have a gross vehicle weight rating of 26,001+ lbs. Applications include 18-wheelers, sleeper cabs, dump trucks, refuse trucks, and tractor trailers. There are 80 heavy-duty trucks in the Glendale fleet including 11 dump trucks, 6 manlift trucks, 7 crane trucks, 10 heavy trucks, 38 refuse trucks, 2 roll-off trucks, and 6 street sweepers. There are 10 OEMs offering heavy-duty ZE models for sale in the

United States that can be outfitted for specific applications. As with medium-duty EVs, the primary challenge is the high capital cost.

Emergency Vehicles

Emergency vehicles include light-, medium- and heavy-duty vehicles outfitted for emergency response duties including fire engines, rescue, and command support. The Coty's emergency fleet includes 13 command vehicles, 12 heavy-duty specialty vehicles, 4 ladder trucks, 16 fire engines, and 12 rescue vehicles. The ZEV market for these vehicles is currently limited to fire engines (some with ICE support engine) and standard light-duty EVs that could be used for command support.

Pursuit Vehicles

Standard vehicles of any type must be outfitted to handle high-speed pursuits for police interceptor applications. Current police pursuit-rated vehicles are sold by the OEM for that specific purpose. There are also companies that produce kits specific to a vehicle model that can be used to outfit a vehicle in the aftermarket. Most of the City's pursuit rated vehicles are SUVs (103) and motorcycles (27). The current market for pursuit rated ZEVs is limited. Chevrolet provides its EV Blazer outfitted for police pursuit. Other EV models (Tesla, Ford Mach E) have been outfitted in the aftermarket for several police departments for pilots.

Non-Road Vehicles

Non-road vehicles are used for a variety of reasons including park maintenance, construction, public works projects, electric and water services, traffic safety, etc. The City's non-road fleet is comprised of 6 bunker rakes, 10 mowers, 11 forklifts, 4 miscellaneous lifts, 25 construction vehicles (loaders, excavators, backhoes, pavers), 2 rollers, 6 utility sweepers, 33 utility vehicles, and 7 miscellaneous engines. Many of these vehicle types have been available in an EV version for years, such as utility vehicles and forklifts. OEMs are continually adding EV models of all types. While there are many EV models for construction applications, most are smaller compact sizes. The City can begin transition for most of its non-road fleet in the near-term.

Operational Challenges for Transition to EVs

Most vehicles in the City's fleet stay within the city limits, have duty cycles that are feasible for a 1:1 EV transition, are only used during business hours, and can charge overnight. However, some use cases will require additional planning and consideration before transitioning to an EV to ensure that the required duty cycles can be met without affecting operations or public safety.

The biggest challenge for the City in transitioning to full ZEV is with the Police and Fire Department vehicles. CTE held meetings with both departments to discuss the current models available and the concerns about how the specific needs could be met with EVs.

Emergency Fire Equipment Vehicles: As support vehicles to an actual emergency, the City's command vehicles could be transitioned to EV in the near term. The only type of emergency response vehicle currently available in EV are fire engines. Three OEMs currently produce a model that can be considered zero-emission. Two of those include an optional ICE for situations where the distance traveled is further than normal or for a long-duration event. The City has standardized its fleet with Pierce for its emergency response vehicles. The Pierce Volterra EV fire engine has an ICE for emergency backup that is fully integrated into the propulsion system. The OEM designed the system and battery storage for the needs of a typical fire department that will have at most 20 calls a day within a smaller radius distance from the station. The vehicle is considered zero-emission because when it is used within those parameters, the ICE never engages. Glendale FD operates its service differently and typically travels longer distances during each call. The department requests a delay for implementation to wait for the market to more fully mature and the operations costs to be understood. The department concerns with a transition to ZEVs include the following:

- Capital costs: current models are two times the cost of conventional vehicles
- Service life: The manufacturer lists the EV apparatus with a service life of 10 – 15 years—the City's current fleet has a 20-year life
- Incompatible with current operations: to extend the life of its assets, the City typically moves vehicles as they age from busy stations to stations with lower call volume. For EVs, this will limit transfers to stations that have the charging infrastructure already installed. The oldest apparatus are kept as reserve and need to be flexible to operate out of any station or to be deployed in neighboring jurisdictions as situations arise. Also, EV apparatus could not be deployed as part of Glendale's participation in California's Master Mutual Aid Agreement because it would require extended time away from any charging equipment (up to 21 days).
- Limited range: The City's Paramedic Engine EMS model covers more distance than that of a typical apparatus. This would result in greater battery consumption which reduces charging time and could result in greater reliance on the auxiliary ICE.
- Limited performance of auxiliary ICE: the current ICE used (6.7L) in the EV model is much smaller than a traditional engine. This could result in performance much lower than required when the batteries are depleted and extend emergency response times.
- Unknown long-tern maintenance costs and downtime: very little information is available on the maintenance costs for these apparatus. Electric drive components that need to be serviced by the OEM may cause extended downtime that is out of the control of the FD maintenance staff.

Ladder trucks are not likely to be available in an EV model for many years without a large improvement in battery technology. The excess weight of the ladder equipment would require a battery with double the capacity within the same size. CTE's analysis assumes a 5% increase in battery capacity every two years. At this rate, batteries will not be capable of handling the weight of a ladder truck for at least 28 years.

Police Pursuit Vehicles: The City typically has 32 vehicles assigned to patrol with 12 – 18 vehicles deployed each day. These vehicles are exchanged immediately between shifts, often referred to as a "hot swap". The vehicle can be stopped for as little as 5 minutes during this switch. This can occur continuously over a 2 – 3-day period depending on the availability of vehicles. Occasionally, officers can be held over their 12-hour shift if they are on a call late in the shift. On any given day, 10 vehicles are out of service for maintenance. This operational use results in limited time for charging an EV. Also, the department rotates its vehicles assigned to patrol to even out the mileage, meaning the entire fleet needs to be pursuit capable. The City prefers to use a larger size SUV (Ford Explorer) for its patrol vehicles because that model is durable, has more room for equipment, and has the largest custody area. The only current EV sold outfitted for pursuit is the Chevrolet Blazer. Glendale PD disfavors this vehicle because of its smaller size. Several other EV sedans have been outfitted to serve in a pursuit application; however, these have been upfit in the aftermarket. Glendale PD provided a list of concerns about the challenge of transitioning to EVs. These include the following:

- Rigorous use: the duty-cycle for a patrol car is demanding and dynamic and requires vehicles specifically built to handle this.
- Shift-Change: the 12-hour shift change with minimal time between does not allow for charging the vehicles. A transition to EVs would require operational changes or an increase in fleet size.
- Detective functions: vehicles used for surveillance need to blend into many environments. Current features of EVs—daytime running lights, large interior screens—are conspicuous and cannot be turned off or disabled.
- High-level charging: PD is concerned that continual high-level DC charging will prematurely deteriorate the battery and result in a shorter lifespan.
- Uncertain performance and cost for current models: actual data on the performance and maintenance costs are not readily available.

Pursuit Motorcycles: Glendale PD also has concerns over the transition of its motorcycle fleet. Like other pursuit rated vehicles, pursuit rated motorcycles are purpose built to handle dynamic operation. While there are many EV motorcycles on the market, none are currently built for police pursuit. Many models are lightweight, and the added weight after outfitted for police applications could greatly lower the range. Another challenge is that officers that are assigned motorcycles are allowed to take them home at the end of their shift, with many officers driving long distances to get home. The City will have to evaluate either a possible change in the policy to not permit officers to take the motorcycles home, or to install chargers at officer's homes to ensure the vehicles can charge overnight. Officers may also need to charge again before starting their shift, if driving long distances from their homes.

Because of these challenges, the Glendale PD prefers to delay the EV transition until the market matures and more information are available to understand performance and operational costs.

In addition to Police and Fire, some GWP vehicles may be called upon to provide interstate mutual aid and may be staged at a site for multiple days to support a disaster response. The City will need to ensure that there are methods for charging these vehicles to travel long distances, and to maintain a charge on vehicles that are staged at disaster or job sites for prolonged periods of time.

On-call GWP staff and GWP supervisors also take vehicles home with them. The City will have to evaluate either a possible change in the policy to not permit staff to take the vehicles home, or to install chargers at GWP staff members' homes to ensure the vehicles can charge overnight.

Analysis Overview

CTE conducted multiple assessments to evaluate the optimal approach for transitioning the City of Glendale's fleet to 100% EV.

The **Feasibility Assessment** evaluates the feasibility of replacing each vehicle in the City's fleet with an EV model in a 1:1 ratio, considering the current capabilities of EVs on the market. The Feasibility Assessment estimated an average duty cycle based on average daily miles and an estimated energy efficiency by vehicle type. CTE evaluates which duty cycles of any vehicles cannot be replaced in a 1:1 ratio with an EV and identifies operational strategies that could be implemented to achieve a feasible duty cycle. The electrification of a specific vehicle may be delayed if operational changes are not sufficient to achieve a suitable duty cycle.

The **Fleet Assessment** develops a projected timeline for replacement of current vehicles with EVs consistent with the City's plan to transition its fleet by 2040. This assessment considers a "suitability score" for each vehicle type that indicates the commercial viability of currently available EVs of that vehicle type each year. For the transition, the analysis prioritizes vehicles with a higher suitability score over vehicles with a lower suitability score. The Fleet Assessment also includes a projection of fleet capital costs over the entire transition timeline.

The **Fuel Assessment** estimates the amounts and costs of fuel consumed each year as well as the necessary charging equipment and resulting power and energy demands.

The **Facilities Assessment** determines the necessary infrastructure at each facility to support the EV fleet based on the results of the Fleet Assessment and Fuel Assessment. The Facilities Assessment shows the estimated power and energy loads throughout the fleet transition, which will inform any required utility upgrades to meet the infrastructure needs. The Facilities Assessment also includes a projection of the costs of charging equipment, installation, and utility upgrades.

The **Funding Assessment** compiles results from the previous assessments to provide a comprehensive view of the vehicle and infrastructure costs for the transition over the transition period. The assessment includes guidance on operations and maintenance (O&M) cost planning and a summary of available funding opportunities that can be used to fund vehicle or infrastructure purchases.

The **Benefits Assessment** summarizes the total GHG emissions and pollution reductions realized from transitioning the fleet to 100% EVs throughout the transition timeline to quantify the environmental, public health, and local air quality benefits from the fleet transition. It also covers the potential maintenance cost savings by transitioning to EVs.

Feasibility & Fleet Assessment

Purpose

For fleet transition planning, the goals of the fleet assessment component are:

1. Establish existing fleet inventory and operating requirements.
2. Determine the feasibility and suitability of an EV replacement for each asset type based on the operating requirements and available EV market options.
3. Create a procurement schedule over the transition period to determine fleet composition vs. a baseline (no transition) scenario.

Because Glendale's transition needs to comply with the ACF regulation, one constraint of the transition plan is to meet the requirements of Option 1[8], which are:

1. Starting January 1, 2024, 50% of annual purchases are zero emission (ZE).
2. Starting January 1, 2027, 100% of annual vehicle purchases are ZE.

Fleet Transition Approach

Figure 8 summarizes the approach used to develop a plan to transition the City's fleet by 2040. The EV procurement schedule and suitability scores are described in further detail later in the report.

[8] CARB ACF Regulation for State and Local Government Agency Fleets

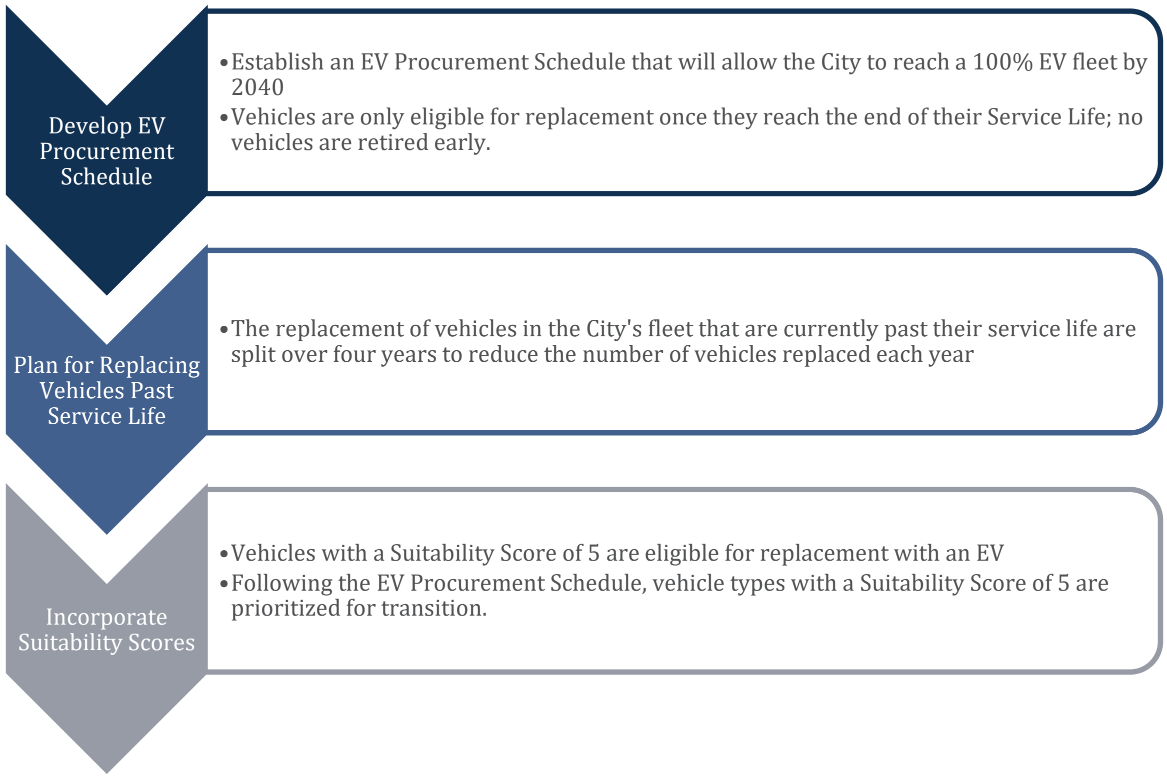

Figure 8. Fleet Transition Methodology

Methodology Overview

The fleet assessment methodology can be broken into three components: Service Assessment, Suitability Assessment, and Feasibility Assessment (Figure 9).

Service:

Inputs: CTE used Glendale's fleet inventory data including asset numbers, vehicle types, vehicle fuel economies, and annual use data such as mileage or operating hours.

Outputs: CTE determined the "operating requirements" for each type of vehicle, including average fuel economy, nominal daily use, days in use per year, and strenuous daily use. Nominal daily use represents a typical day of use, and strenuous daily use represents a day of heavy use. Nominal daily use determines the typical fuel consumption, while strenuous daily use determines whether an equivalent EV can feasibly perform the same maximum daily work without operational modifications.

Suitability:

Inputs: CTE analyzed the available EV market for all vehicle types in Glendale's fleet to determine how suitable the available options are for replacement and to manage the risk of new ZE technologies.

Outputs: CTE assigned a "suitability score" to each vehicle type to indicate whether a vehicle type is a) available and b) commercially viable and ready for purchase or is still a relatively unproven technology that should not be purchased.

Feasibility:

Inputs: CTE created a purchase schedule based on Glendale's fleet asset ages, average service lives, and purchase costs. Then, CTE used the operating requirements for each vehicle type defined in the Service Assessment and the available EV options, combined with the suitability scores, to determine whether each purchase was feasible for a switch to EV. Feasibility defines whether the purchased EV can perform under Glendale's operating conditions.

Outputs: CTE created a purchase schedule ICE vehicles and EVs, a fleet composition by year, and the procurement costs for the EV transition scenario vs. the baseline scenario. The baseline scenario assumes no additional ZE vehicles are purchased.

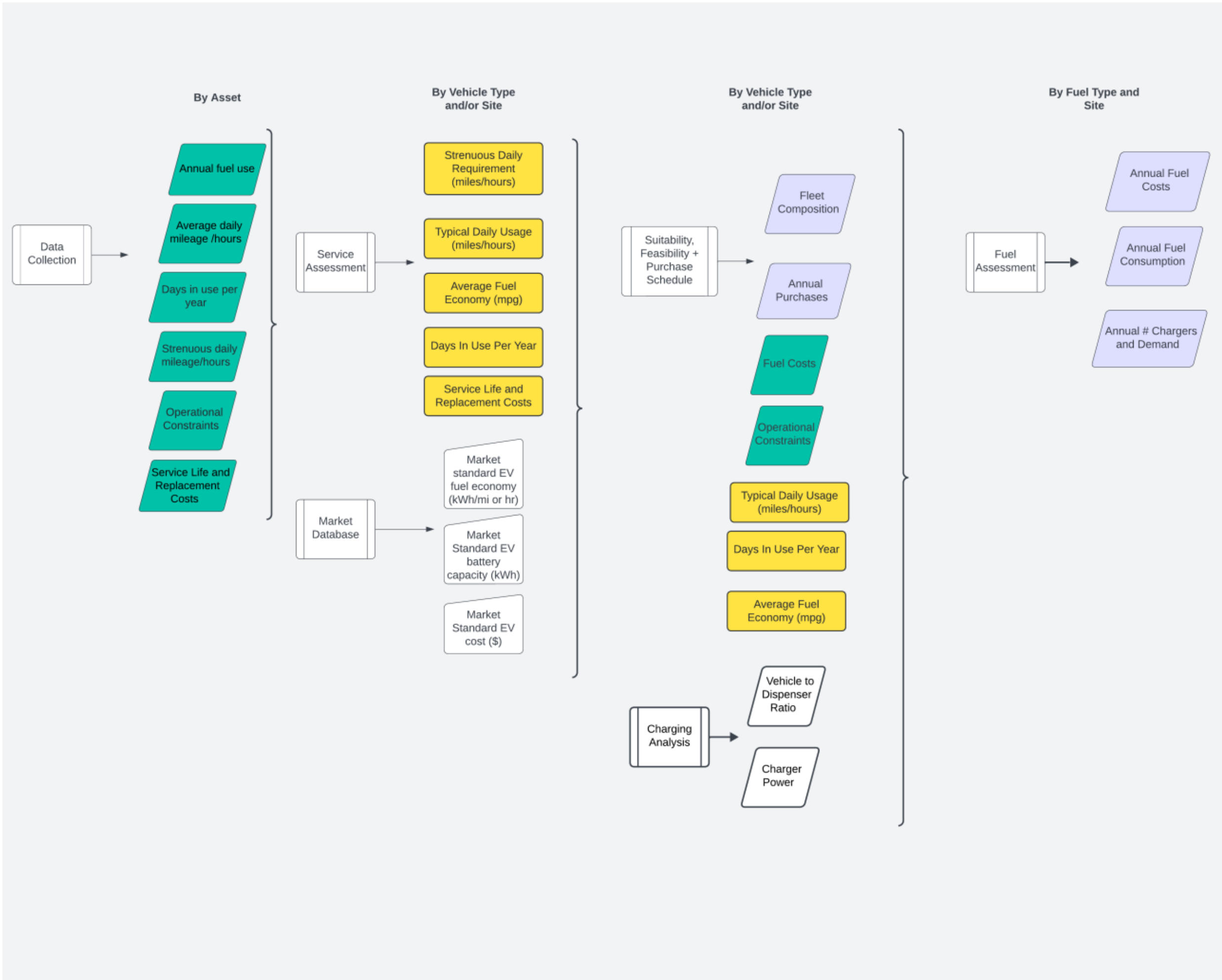

Figure 9. The Fleet Assessment major inputs, outputs, and processes.

Scope

The scope of the assessment included 820 vehicles across 6 primary sites (

Table 9), with the remaining vehicles combined into an ‘other sites’ category. Only self-propelled, city-owned assets were included. No expansions or retirements are planned, so the fleet size of 820 remains constant throughout the plan.

Table 9. Sites included in transition plan and number of assets at each site

Facility Name	Number of Assets
Public Works Yard	110
City Hall Complex	114
Glendale Water & Power	142
Integrated Works Yard	55
Fire Station 21	34
Police Parking	202
Other Sites	163
Total Fleet	**820**

Detailed Methodology and Assumptions

Operating Requirements Assumptions and Methodology:

1. Glendale provided CTE with two years of operating data (May 2022-May 2024). The annual mileage data were used to estimate daily operating requirements for each vehicle type.
2. To estimate the daily use, CTE assumed the number of "active days" per year for each vehicle type based on the total mileage, discussions with Glendale fleet managers, and the vehicle type.
3. Thus, the average daily use for the vehicle type was calculated using the Total Use in miles or hours for all vehicles in the type over two years divided by the number of vehicles in the type with data, the years of data, and the assumed active days per year:

   *Average Daily Use = Total Use (miles or hours) / (Years of Data * Assumed Active Days per Year per Vehicle * Number of Vehicles with Use Data)*
4. The strenuous daily use was calculated as 50% more than the average daily use:

   *Strenuous Daily Use = Average Daily Use * 150%*

5. The average fuel economy across all vehicles within the vehicle type was determined as:

   Average Fuel Economy (mpg) = Total Use (miles) / Total Fuel Consumption (gallons)

   For vehicles measured in hours, the calculation was:

   Average Fuel Economy (gallons per hour) = Total Fuel Consumption (gallons) / Total Use (hours)

   If a vehicle did not have both fuel consumption data and use data, it was excluded from the totals.

6. For vehicle types with incomplete data, CTE estimated missing values based on valid data from similar vehicles or published sources, such as Environmental Protection Agency (EPA) fuel economy ratings for EVs. These assumptions were provided to Glendale for approval prior to analysis.

All operating requirements and assumptions for each vehicle type are shown in Appendix B. CTE assumed the operating requirements remained constant throughout the transition.

Suitability Methodology and Assumptions:

Not all types of vehicles operated by Glendale are available in an EV model in 2024. When vehicles do become initially available, early adopters face a higher level of risk in introducing new technologies that are not yet proven. To manage this risk, CTE assigned a "suitability score" based on 2024 market research to each vehicle type or chassis in the fleet each year. The suitability scores consider criteria that indicates whether a vehicle is "commercially viable" for purchase, and the number of deployments. Table 10 outlines the criteria used to determine the suitability scores.

Table 10. Commercially Viability Criteria

Criteria	Definition
> 1 Make Available	Vehicle options from more than one OEM available
Readily Available	Light Duty Vehicles: Ready for purchase, can drive off the lot. Medium and Heavy-Duty Vehicles: Can immediately go into production schedule when purchase order is awarded.
Available for CA Municipality purchase	Available to be procured by CA Municipality.

Criteria	Definition
No additional customizations	Delivered to Glendale meeting technical specifications, does not require additional non-standard upfitting by Glendale to be put into service.
Cost Effective	Less than twice the cost of current vehicle type in conventional fuel equivalent.

The definitions of each suitability score are shown in Table 11. In the 2022 study, CTE considered a score of 4 or 5 as suitable for purchase. Newer data for medium- and heavy-duty vehicles indicate capital costs of 2 to 3 times higher than conventional models—much higher than the 1.5x assumption used in the previous study. Because of this, CTE changed the analysis to consider a vehicle suitable for purchase once the score is 5 to allow for stabilized costs that come with higher commercialization.

Table 11: Suitability Score Definitions

	Score	Definition
Eligible for transition	**5**	**Very High Suitability – (Widespread Adopters)** Meets all commercial availability criteria, can likely be a 1:1 replacement with proper charging infrastructure, vehicle options from more than 5 OEMs available. Costs estimated at 1.6x that of baseline vehicles.
Not eligible for transition	**4**	**High Suitability – (Limited Adopters)** Meets all commercial availability criteria, can likely be a 1:1 replacement with proper charging infrastructure. Costs ~2x that of baseline.
	3	**Medium Suitability – (Early Adopter)** Meets all commercial availability criteria except for "cost effective." Costs between 2x to 3x that of baseline vehicle. Available for purchase, few commercial deployments, but past the prototyping stage. May not be a 1:1 replacement.
	2	**Low Suitability – (First Customer)** – Can be ordered but may not be able to be immediately entered into production. In pilot/prototyping stage of development.
	1	**Not yet available for purchase**

Feasibility Methodology and Assumptions

1. Based on market research, CTE established a "market standard" usable battery capacity for each vehicle type. If no models were available, CTE based the capacity on a similar vehicle type.
2. To account for technology improvements, CTE models a 5% improvement in the market standard EV capacity every two years[9].
3. CTE estimated the equivalent EV fuel consumption (kWh per mile or kWh per hour) for each vehicle type based on Glendale's operations.
4. To determine feasibility, CTE compared the energy consumption for the strenuous and nominal daily usage with the market standard battery capacity over each year of the transition (i.e., if the EV could complete the nominal and strenuous daily usage on a single battery charge with no operational modifications). If the energy consumption was less than the usable battery capacity in the projected year of purchase, the asset is feasible for transition.

Purchase Schedule Methodology and Assumptions

1. CTE used a standard service life for each vehicle type based on the average projected replacement age for assets in the class (Appendix B).
2. All overdue replacements are spread over the first four years of the transition plan.
3. Costs for the incumbent ICE vehicles were based on an average of Glendale's reported replacement costs.
4. Costs for EV vehicles were estimated using a percent increase from Glendale's baseline (ICE) cost based on the known costs of ZE replacements in each class. Percent increases were used instead of published base vehicle costs because most vehicles have special equipment and upfits that are not reflected in the base EV cost. CTE modeled most classes as 1.6 times the ICE cost, and light-duty vehicles were modeled as 1.2 times the ICE cost. These multipliers were based on several factors: comparison of known costs for ICE and EVs in certain vehicle types from Glendale and other municipal projects. For vehicles that Glendale has already electrified, the baseline cost is the same as the EV cost.
5. Inflation was included at 3% for all capital costs.

ACF Exempt Vehicles

1. Not all vehicles in the fleet are subject to the ACF regulation[10]. Vehicles under 8,500 lbs. (light duty automobiles, pickups and vans, etc.) are subject to the

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[9] Bloomberg NEF, "Hitting the EV Inflection Point" (2021)

[10] CARB, Final Regulation Order, Advanced Clean Fleets Regulation, Appendix A-1

Advanced Clean Cars regulation which is only applicable to original OEMs. Larger off-road assets such as excavators are subject to the Off Road Diesel Fleets regulation[11]. Small off-road assets are subject to Small Off Road Engines regulation which is only applicable to manufacturers[12]. Nevertheless, these vehicles are included in the transition plan.

2. Some vehicles categories are covered by ACF but are explicitly exempt such as emergency vehicles. Because Glendale's goal is complete electrification, emergency and pursuit vehicles are included in the plan; however, the transition is delayed due to the suitability of EV models and concerns from the Glendale Fire Department and Police Department. Therefore, CTE modeled the transition start date for all emergency and pursuit vehicles as 2030, even if the vehicle was considered suitable before 2030. This date may need to be modified depending on technology development and regulations; exemption from ACF may affect technology development.
3. Vehicles subject to ACF may be exempt in the short term due to availability of ZE configurations. For the Fleet Assessment, the replacement schedule and feasibility of the base chassis determined the transition speed for all specialized configurations. The lack of available EV models in the heavier pickup sizes may pose a challenge for Glendale. The CARB web site for ACF provides a list of available and certified ZEV models. This list currently has 38 models in the Class 2b – Class 3 size. This includes half-ton pickups (Class 2a) which may not be suitable for the heavier applications. The remaining vehicles in the list are van-based chassis, which may not be suitable for replacement of pickup based vehicles. Until there is a suitable pickup-based model for the heavier applications, Glendale will have to either select a model off the list or adjust the schedule for replacing the heavier pickups (delay replacement).
4. ACF also has exemptions for vehicles where there is no new ZEV model capable of meeting the daily mileage or energy needs or there is no ZEV in the necessary configuration available to purchase. CARB will publish a short-term exemption list in January 2025, and Glendale can apply for additional exemptions. Because of concerns about the capacity of refuse trucks and the limited space at the Integrated Waste facility, CTE delayed the transition of all refuse vehicles until 2027, at which point all new purchases will be subject to the 100% ACF EV purchase rule.

[11] CARB, Guide to Off-Road Vehicle and Equipment Regulations

[12] CARB, Small Off-Road Engines

Results and Discussion

Suitability

The vehicle types in the fleet were rated for suitability in

Table 12. Most vehicles are suitable for purchase in 2027. Glendale should note:

- The medium- and heavy-duty chassis can be outfit for any use, so CTE used it as the basis for specialty medium- and heavy-duty vehicle types.
- Similarly, CTE used pickup trucks of the appropriate class as the basis for any specialty pickup configurations. Ford announced a medium sized pickup model for late in 2027 which is the basis for a score of 4 in 2028.
- CTE assumed that the current EV fire engine designs would enable other emergency specialty vehicles by 2029.
- CTE assumed the available EV cargo vans could be outfitted for passenger use.
- Though there are no minivans currently available, there are two EV models slated for 2025.
- Based on conversations with OEMs, CTE does not expect any EV ladder truck models to be available during the term of the transition plan without significant technology improvement.
- The available EV models for fire engines are fully electric drive but have a backup diesel engine that engages during longer duration events. For two of the OEMs, the backup engine is optional. For Pierce (Glendale's standardization OEM), the ICE engine is fully integrated into the system. This engine is about half the size of the typical engine in a conventional model.

Because the market for EVs is developing quickly, the availability of each vehicle type is only an estimation and should be re-evaluated throughout the transition.

Table 12: Suitability Rankings by Year

Category	Vehicle Type	Commercially Available?	2025	2026	2027	2028	2029	2030	2031
Construction	Backhoe Loader**	Yes	3	3	4	4	4	5	5
Construction	Excavator**	Yes	3	3	4	4	4	5	5
Construction	Excavator, Compact	Yes	5	5	5	5	5	5	5
Construction	Wheel Loader**	Yes	3	3	4	4	4	5	5
Construction	Wheel Loader, Compact	Yes	3	3	4	4	4	5	5

Category	Vehicle Type	Commercially Available?	2025	2026	2027	2028	2029	2030	2031
Construction	Loader, Skid-steer**	Yes	3	3	4	4	4	5	5
Construction	Loader, Skid-steer, Compact	Yes	4	4	4	5	5	5	5
Construction	Loader, Track Steer**	No	2	3	3	3	4	4	5
Construction	Loader, Track Steer, Compact	Yes	3	3	4	4	4	5	5
Construction	Roller	Yes	5	5	5	5	5	5	5
Emergency	Fire Engine*	Yes	4	4	5	5	5	5	5
Emergency	Ladder Truck	No	1	1	1	1	1	1	1
Emergency	Specialty Vehicle	No	2	3	3	3	4	4	5
Emergency	Rescue	No	2	3	3	3	4	4	5
Heavy-Duty	Chassis (Class 7)	Yes	4	4	5	5	5	5	5
Heavy-Duty	Refuse	Yes	4	4	5	5	5	5	5
Heavy-Duty	Street Sweeper	Yes	4	4	5	5	5	5	5
Heavy-Duty	Semi (Class 8)	Yes	4	4	5	5	5	5	5
Light-Duty	1 ton Pickup (Class 3)	No	2	3	3	4	4	5	5
Light-Duty	1/2 ton Pickup (Class 2a)	Yes	5	5	5	5	5	5	5
Light-Duty	3/4 ton Pickup (Class 2b)	No	2	3	3	4	4	5	5
Light-Duty	Compact Pickup (Class 1)	No	2	3	3	4	4	5	5
Light-Duty	Minivan	No	4	4	5	5	5	5	5
Light-Duty	Motorcycle	Yes	5	5	5	5	5	5	5
Light-Duty	Sedan/Wagon	Yes	5	5	5	5	5	5	5
Light-Duty	SUV	Yes	5	5	5	5	5	5	5
Light-Duty	Van, Cargo	Yes	5	5	5	5	5	5	5
Light-Duty	Van, Passenger	Yes	5	5	5	5	5	5	5
Medium-Duty	Chassis (Class 4-6)	Yes	4	4	5	5	5	5	5
Non-Road	ATV	Yes	5	5	5	5	5	5	5
Non-Road	Boom lift	Yes	5	5	5	5	5	5	5
Non-Road	Bunker Rake	Yes	4	4	4	5	5	5	5
Non-Road	Concrete Cutter	No	2	3	3	4	4	5	5
Non-Road	Digger Derrick	No	2	3	3	4	4	5	5
Non-Road	Forklift, Light	Yes	5	5	5	5	5	5	5
Non-Road	Forklift, Medium	Yes	5	5	5	5	5	5	5
Non-Road	Forklift, Heavy	Yes	5	5	5	5	5	5	5
Non-Road	Hammer	No	2	3	3	4	4	5	5
Non-Road	Low Speed Vehicle	Yes	5	5	5	5	5	5	5
Non-Road	Mower	Yes	5	5	5	5	5	5	5
Non-Road	Order Picker	Yes	5	5	5	5	5	5	5
Non-Road	Root Cutter	No	2	3	3	4	4	5	5

Category	Vehicle Type	Commercially Available?	2025	2026	2027	2028	2029	2030	2031
Non-Road	Scissor Lift	Yes	5	5	5	5	5	5	5
Non-Road	Stump Grinder	No	2	3	3	4	4	5	5
Non-Road	Tractor, Compact	Yes	5	5	5	5	5	5	5
Non-Road	Tractor, Medium	Yes	4	4	5	5	5	5	5
Non-Road	Tractor, Large	Yes	2	3	3	4	4	5	5
Non-Road	Utility Sweeper	Yes	4	4	4	4	5	5	5
Non-Road	Utility Vehicle	Yes	5	5	5	5	5	5	5
Non-Road	Utility Vehicle, Transport	Yes	5	5	5	5	5	5	5
Pursuit	Motorcycle	No	2	3	3	4	4	5	5
Pursuit	Sedan	Yes	4	4	4	4	5	5	5
Pursuit	SUV	Yes	2	3	3	4	4	5	5

** Existing fire truck models have a diesel backup engine.*

*** Multiple sizes are encompassed in these classes; however, not all sizes are immediately available in an EV version. Please refer to the Market Assessment for details on available models.*

Feasibility

The vehicle types in the fleet were rated for feasibility, as shown in Table 13. The table shows which vehicle types currently have, or are projected to have, sufficient capacity to perform at either Glendale's strenuous or nominal daily use. As technology progresses, a vehicle type may transition from infeasible to feasible, or from only nominal use feasible to strenuous use feasible. The feasibility table is blank for years where an EV model is not yet commercially available, or the transition is delayed due to the City's preferences (as in the case of some emergency vehicles). There may be two rows for the same vehicle type for different fuel types if the aggregate fuel economy was significantly different between the two.

Glendale should note that the feasibility projections are primarily based on estimated daily use and estimated EV vehicle energy consumption. Glendale provided detailed route information on its refuse service. CTE used these data to estimate energy use requirements for refuse trucks. CTE did not have detailed daily data for most of Glendale's operations, and some assets lacked any data at all; therefore, the estimated nominal requirements hours may or may not reflect the true feasibility for an electric replacement. For EVs that are not deployed widely, or no model is available, the energy consumption estimations should be used with caution. Many factors—including heating, ventilation, and air conditioning (HVAC) use, driving style, idling behavior, and variations in daily operations—can affect actual energy consumption and therefore vehicle range and feasibility.

There are some vehicles that, as modeled, do not meet the nominal requirement throughout the transition: mowers, bunker rakes, boom lifts, and heavy manlift trucks. CTE modified the purchase schedule as discussed in the next section to plan for full electrification.

Table 13: Feasibility of each Vehicle Type

Key:	
Grey	Not Yet Suitable
Light blue	Purchase Delayed
Pink	Nominal Use Infeasible Without Modifications
Yellow	Nominal Usage Feasible, Strenuous Usage Infeasible
Green	Strenuous Usage Feasible

Vehicle Type	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**
Pursuit SUV	Grey	Grey	Grey	Grey	Grey	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Pursuit Motorcycle	Grey	Grey	Grey	Grey	Grey	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Non-Road Wheel Loader	Grey	Grey	Grey	Grey	Grey	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Non-Road Utility Vehicle	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Non-Road Utility Sweeper	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Non-Road Tractor, Compact	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Non-Road Stump Grinder	Grey	Grey	Grey	Grey	Grey	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green
Non-Road Scissor lift	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Non-Road Root cutter	Grey	Grey	Grey	Grey	Grey	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Green	Green	Green	Green	Green
Non-Road Roller	Yellow	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Non-Road Order picker	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Non-Road Mower	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink
Non-Road Loader, Track Steer, Compact	Grey	Grey	Grey	Grey	Grey	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Non-Road Loader, Skid Steer	Grey	Grey	Grey	Grey	Grey	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Non-Road Loader, Skid Steer, Compact	Grey	Grey	Grey	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Non-Road Hammer	Grey	Grey	Grey	Grey	Grey	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Non-Road Forklift, Light	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Non-Road Forklift, Heavy	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Non-Road Excavator, Compact	Pink	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Non-Road Digger Derrick	Grey	Grey	Grey	Grey	Grey	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Non-Road Concrete Cutter	Grey	Grey	Grey	Grey	Grey	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Non-Road Bunker Rake	Grey	Grey	Grey	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink
Non-Road Boom lift	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink	Pink
Non-Road Backhoe Loader	Grey	Grey	Grey	Grey	Grey	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Non-Road Asphalt Paver	Grey	Grey	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Medium Van, Cargo	Grey	Grey	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green

Vehicle Type	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Medium Truck, Manlift (Gasoline)																
Medium Truck, Manlift (Diesel)																
Medium Truck, Flatbed																
Medium Truck, Dump																
Medium Truck																
Light Van, Passenger																
Light Van, Cargo																
Light SUV																
Light Sedan																
Light Motorcycle																
Light Minivan																
Light Compact Pickup																
Light 3/4 ton Pickup																
Light 1 ton Pickup, Manlift																
Light 1 ton Pickup, Flatbed																
Light 1 ton Pickup, Dump																
Light 1 ton Pickup																
Light 1/2 ton Pickup, Refuse Bin																
Light 1/2 ton Pickup																
Heavy Truck, Rolloff																
Heavy Truck, Manlift (Diesel)																
Heavy Truck, Manlift (CNG)																
Heavy Truck, Dump																
Heavy Truck, Crane																
Heavy Street Sweeper																
Heavy Refuse Truck																
Heavy Truck (Diesel, Gasoline)																
Heavy Truck (CNG)																
Emergency Rescue 1.5 ton Pickup																
Emergency Ladder Truck																
Emergency Fire Engine																
Emergency Specialty Medium																
Emergency Specialty Light																

Vehicle Type	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040
Emergency Specialty Heavy																
Emergency Command SUV																
Emergency Command Sedan																
Emergency Command Pickup																

Purchase Schedule

Because Glendale's goal for the transition plan is full electrification by 2040 and to ensure compliance with ACF purchase requirements, CTE considered a vehicle feasible for EV purchase if the nominal operating requirement was feasible. There are several reasons why this is appropriate:

1. Because the fleet is transitioning as vehicles retire, ICE vehicles will be available in the fleet to perform the most strenuous operations for several years into the transition.
2. CTE does not have visibility into the details of vehicle operation. For example, a strenuous requirement of 200 miles per day may not be continuous driving; it may be 100 miles each way which may allow for charging at the destination. As another example, an 8-hour requirement does not account for potential charging over a lunch break, which would increase feasibility.

To provide Glendale with a complete electrification plan, CTE also planned for the purchase of the mowers, boom lifts, and bunker rakes despite not meeting the nominal feasibility requirement. These vehicles will still be able to operate on a job site but may require some operational modifications such as midday charging.

CTE made the following edits to the original purchase schedule that was based only on feasibility, suitability, and natural replacement timelines:

- CTE delayed the purchase of a concrete cutter and a digger derrick to 2030 so that there would be feasible EV replacements; otherwise, an on-time replacement with an ICE vehicle would delay electrification past 2040.
- Heavy manlift trucks are estimated to become feasible in the later 2030s; in the purchase schedule, these assets are purchased in 2025 as ICE vehicles due to suitability but are replaced in 2037 as EV on the normal replacement schedule and are then feasible.

- The purchase schedules for diesel mowers and boom lifts were edited to transition to EVs starting in 2027 regardless of the modeled feasibility to achieve full electrification.
- CTE set the purchase schedule for gasoline mowers and bunker rakes to transition starting in 2025 due to the SORE regulation that prohibits the sale of new gasoline lawn equipment under 25 hp starting in 2024 in California[13], though Glendale may choose to delay the transition.

Figure 10 shows the total projected annual procurements based on the purchase schedule and feasibility. Based on the replacement schedule determined by service life and purchasing feasible and suitable EV replacements, Glendale will purchase 20% EVs in 2025. Due to the replacement of the pursuit SUVs with ICE or hybrid vehicles, in 2028 only 26% EVs are purchased. By 2031, 100% of purchases will be EV, except for 2039 where an ICE ladder truck is purchased due to the projected lack of suitable EV models. The total purchase percentage by year is shown in

[13] CARB Approves Updated Regulations Requiring Most New Small Off-Road Engines Be Zero Emission by 2024

Table 14.

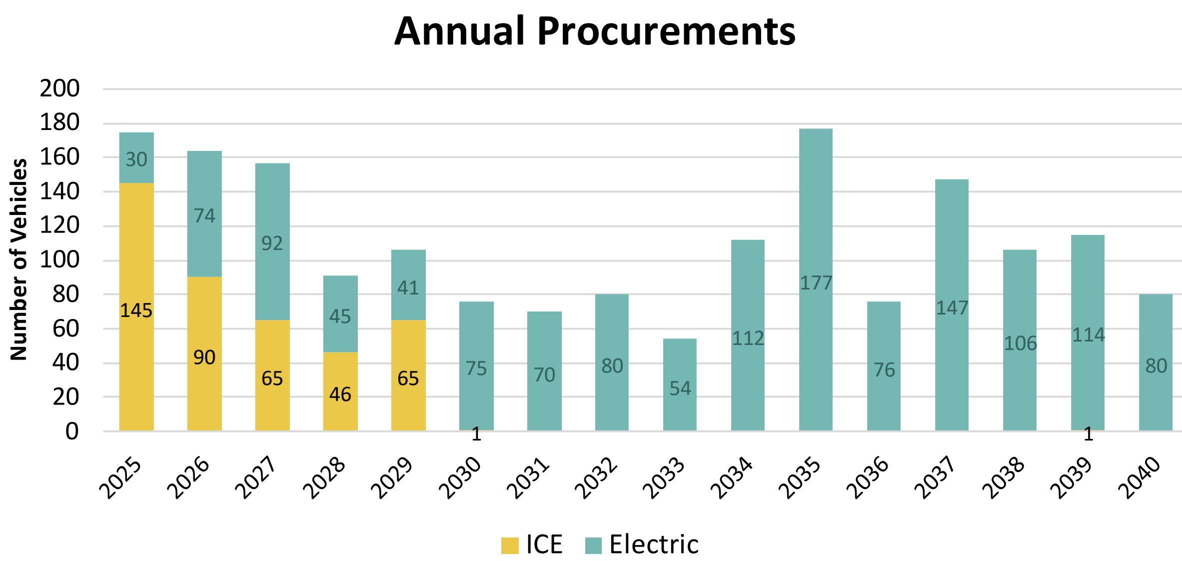

Figure 10: Annual procurements by Propulsion Type

The ACF regulation requires 50% ZE purchase in 2025 and 2026, and 100% ZE purchase starting in 2027. Currently, the exact list of exempt vehicles and configurations is unknown; CARB will release a final list by January 1, 2025. The guidance released in October 2024 and in the regulation text states that some configurations will certainly be exempt such as dump trucks and refuse trucks, but some types of vehicles will not be exempt such as pickups. CARB has provided a list of medium and heavy duty ZE vehicle options.[14] On this list in the class 2b-3 category are ½ ton pickup options such as the Ford Lightning and some cab and chassis models such as the Ford T350 that are van style. There are no heavier pickups; however, heavier pickups are not exempt due to the options provided on the list. Glendale has expressed that upfitting van-style chassis has not worked in the past; therefore, CTE did not include those as viable options for EV heavy pickups and did not change the suitability for heavy pickups from the rating of 5 in the year 2030.

To evaluate the ACF compliance of the recommended purchase schedule, CTE divided Glendale's vehicle categories into exempt and non-exempt categories. Emergency and light duty (less than 8,500 lbs.) are exempt, and off-road vehicles fall under other CARB regulations. For on-road vehicles heavier than 8,500 lbs., all pickups, semis, and basic chassis were considered included and non-exempt.

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[14] CARB List of Certified Medium and Heavy-Duty ZEVs

Configurations such as dumps, cranes, manlifts, and refuse trucks were considered exempt.[15] The full list of vehicles in each category is in the Appendix,

Table B2.

Based on this categorization, the purchase schedule is shown in

[15] "The (*exemption)* list will **not** include the following configurations: pickups, any buses, box trucks, vans, or any tractors… The (*exemption*) list will include the following vehicle configurations: Bucket truck, boom truck, dump truck, flatbed truck, stake bed truck, front-loader refuse compactor truck, side- loader refuse compactor truck, rear-loader refuse compactor truck, refuse roll-off truck, service body truck, street sweeper, tank truck, tow truck, water truck, car carrier truck, concrete mixer truck, concrete pump truck, crane, drill rig, vacuum truck." CARB ACF Regulation

Table 14. **The current purchase schedule does not meet ACF purchase requirements until 2030 without additional exemptions or purchase delays due to the lack of ZE ¾, 1, and 1.5 ton pickups until approximately 2028-2030.** As shown in the table below and highlighted in red, there are 45 ICE vehicles scheduled for purchase in 2025 that CARB does not consider exempt. These are all 1 Ton Pickups, Heavy Trucks, ¾ Ton Pickups, and Medium Trucks. To comply with the 50% EV purchase requirement, Glendale needs to find an alternative for at least 24 of those vehicles to match the planned 21 EVs planned for purchase in 2025. Glendale may consider these options for compliance in the short term:

1. Delay purchase of vehicles to decrease the percentage of ICE vehicles purchased each year.
2. Replace some Class 2b-3 pickups with available EV models such as a ½ ton pickup, a van-type cab and chassis, or a heavier Class 4 trucks.
3. Explore other avenues for exemptions.[16]

This may change as CARB releases its official exemption list.

[16] October 2024 ACF Exemption Guidance

Table 14: Purchases by ACF Status

		2025	2026	2027	2028	2029	2030	2031
Exempt, Emergency	ICE	60	30	47	32	34	1	0
ACF, non-exempt	ICE	**45**	**19**	**3**	0	**19**	0	0
ACF, configuration exempt short term	ICE	32	6	0	1	0	0	0
Exempt, <8500 lb.	ICE	3	35	0	12	12	0	0
Different regulation	ICE	5	0	15	1	0	0	0
Exempt, Emergency	Electric	0	0	0	0	0	25	23
ACF, non-exempt	Electric	21	11	22	14	10	21	3
ACF, configuration exempt short term	Electric	0	0	19	16	10	7	16
Exempt, <8500 lb.	Electric	8	54	17	8	19	12	25
Different regulation	Electric	1	9	34	7	2	10	3
Total Percent EV Purchase		17%	45%	59%	49%	39%	99%	100%
ACF, excluding exempt vehicles		**32%**	**37%**	**88%**	100%	**34%**	100%	100%
ACF, including exempt vehicles		21%	31%	93%	97%	51%	100%	100%

Figure 11 shows the fleet composition over the transition period. Glendale does not achieve 100% electrification by 2040 due to the delayed transition of emergency vehicles and the lack of suitable EV models for the heaviest fire equipment. The 12 ICE vehicles that remain in 2040 are all fire engines and ladder trucks.

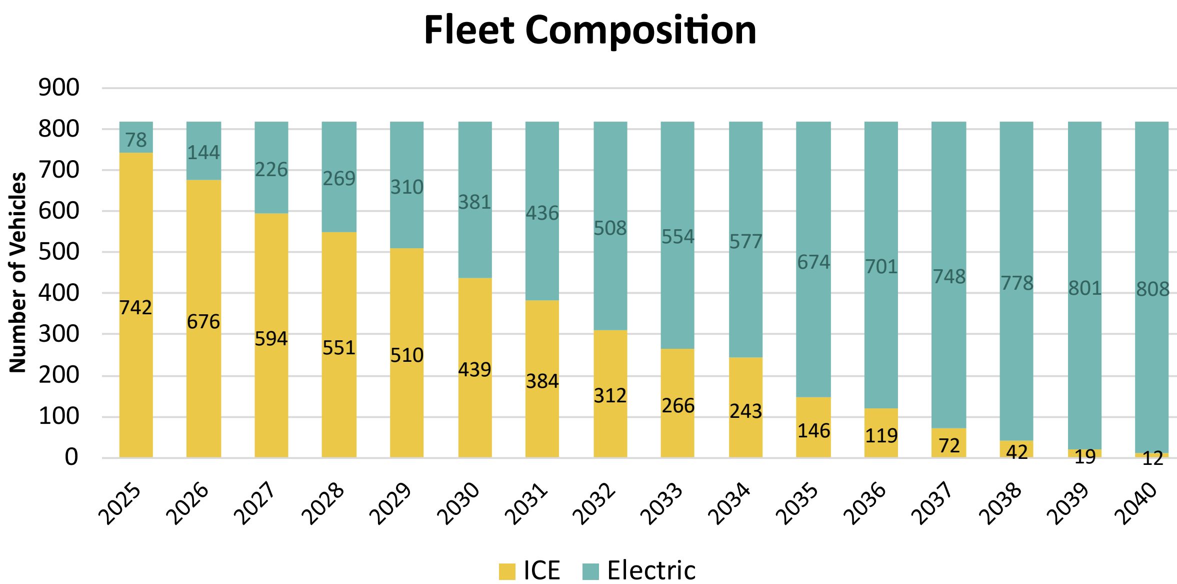

Figure 11: Fleet composition throughout the transition.

Figure 12 shows the *total* projected procurement costs for vehicles over the transition period compared to the baseline scenario. The baseline scenario follows the same purchase schedule as the transition scenario, but each asset is replaced with the same fuel type as it is in 2024; existing EVs are replaced with EVs, but no further vehicles are electrified. Due to the lower service life for specific vehicles, some are replaced twice within the period.

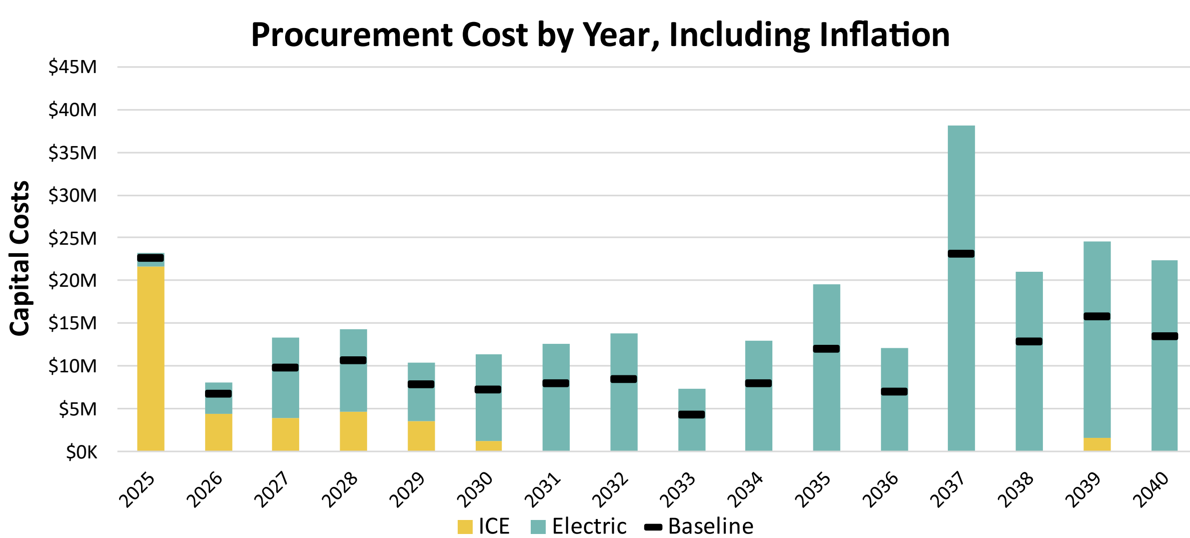

Figure 12: Total procurement costs throughout the transition compared to the baseline (no further electrification) scenario.

The cumulative cost of all vehicle procurements is approximately $87.8 million more for the transition scenario from 2025-2040 compared to the baseline scenario (Table 15, Figure 12).

Table 15: Baseline vs. Transition Cumulative Procurement Costs, 2025-2040

Cumulative Transition Procurements	Cumulative Baseline Procurements	Cumulative Difference
$264,568,000	$176,706,000	$ 87,862,000

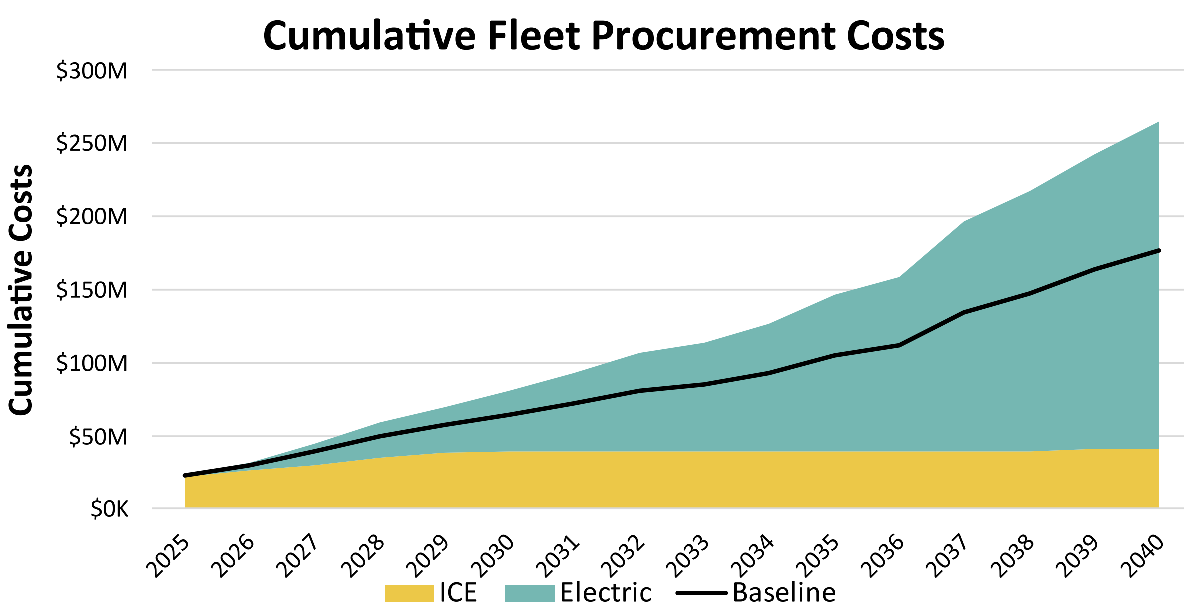

Figure 13: Cumulative procurement costs throughout the transition compared to the baseline (no further electrification) scenario.

Fuel Assessment

Purpose

For fleet transition planning, the goals of the fuel assessment component are:

1. Establish the annual fuel and energy consumption over the transition compared to the baseline scenario.
2. Estimate the annual cost of fuel and energy in the transition and baseline scenario.
3. Estimate the number of chargers in the transition scenario and the peak demand at each location.

Methodology Overview

The fuel assessment methodology can be broken into two components, the Charging Analysis and Fuel Assessment, which build on the results of the Fleet Assessment (Figure 14).

Charging Analysis:

Inputs: CTE used the service requirements established in the Fleet Assessment and the average battery capacity of the electric model of each vehicle type to determine the amount of battery capacity, or state of charge (SOC), that each vehicle type is expected to use on a typical operational day. CTE also estimated the time to charge each vehicle fully from 0% to 100% SOC at various charging powers to ensure that vehicles could be fully charged overnight in case of a day of strenuous usage where the entire battery capacity is used.

Outputs: CTE provided recommendations for the ratio of EVs to chargers and charger powers to Glendale to provide adequate charging while also minimizing additional electrical infrastructure. Glendale reviewed and modified the recommendations to their preferences. The final charger powers and ratios were used to project the number of chargers needed at each site annually to meet the vehicle transition and the resulting annual maximum demand. CTE also estimated the annual maintenance costs for chargers.

Fuel Assessment:

Inputs: CTE used the fuel economies (ICE and EV), the typical daily usage, and the active days per year from the Fleet Assessment to estimate the fuel use for each vehicle. Energy use is based on a nominal day, and electrical demand assumes all chargers are active concurrently at least once per year. Glendale provided the unit costs for fuel and utility schedules at major sites.

Outputs: CTE calculated the annual fuel consumption and fuel costs for each fuel type for each site over the transition scenario and the baseline scenario.

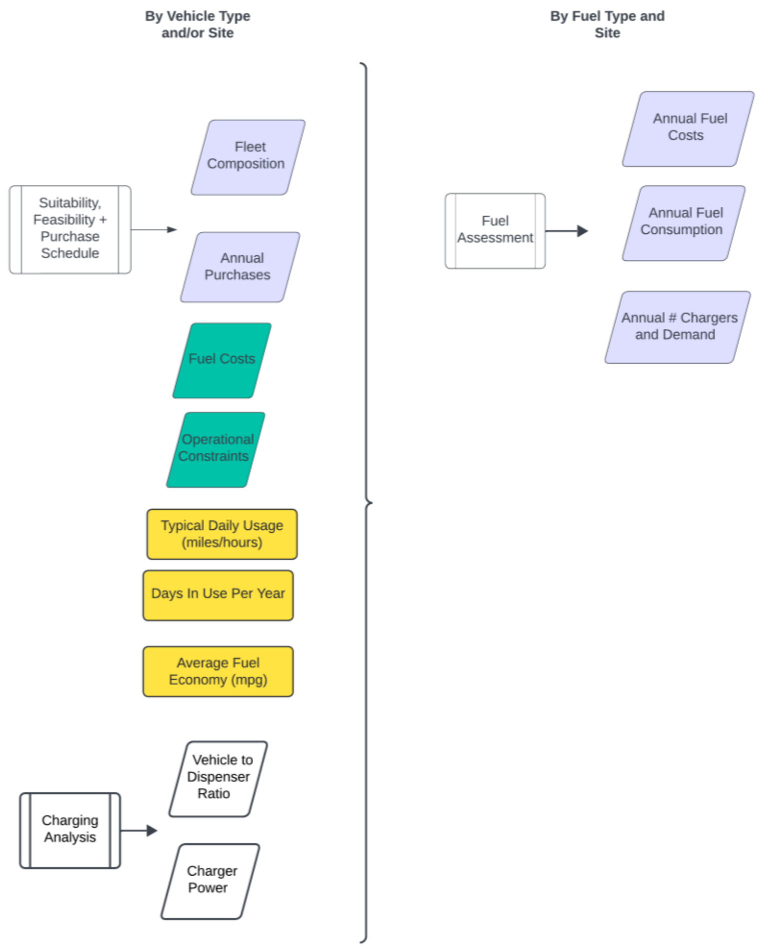

Figure 14: The Fuel Assessment builds on the results of the Fleet Assessment.

Scope

The scope of the assessment included 820 vehicles across 33 sites. Because only a small number of the fleet are take-home vehicles and employees may not have charging infrastructure at home, this analysis assumes that all vehicles will be charged on-site.

Detailed Methodology and Assumptions

Charger Analysis Assumptions and Methodology:

1. CTE used the outputs of the Fleet Assessment as inputs to the Fuel Assessment, namely the estimated EV battery size and EV fuel consumptions.
2. To determine charger needs, CTE considered two key factors:
    a. How quickly vehicles can fully charge (the charger power), and

b. How often vehicles need to charge (the EV to charger ratio).

3. CTE considered four types of chargers in the analysis Table 16:
    a. Level 1 Proprietary Charger: In the current smaller offroad equipment market, EVs are sold with level 1 chargers specific to the OEM and vehicle model (Table 17). These chargers plug directly into a wall outlet (120V AC) and can only achieve approximately 1 kW of charging power. These vehicles are not yet compatible with standard Level 2 or Level 3 chargers. Charging speeds are thus limited for these vehicles and are dependent on the OEM.
    b. Level 2 AC Charger (J1772) with One Dispenser: For EVs with smaller batteries that are compatible with standard chargers, a Level 2 charger is appropriate for overnight charging. Level 2 chargers can provide up to 19.2 kW of power to the vehicle depending on the utility service available on site and the hardware on the vehicle. CTE modeled all Level 2 chargers as 16.6 kW to reflect a 208 V three phase utility service at 80 A. Actual charging maximum power may also be limited by the onboard AC to DC converter rating for some light duty vehicles.
    c. Level 3 DC Charger with Two Dispensers: For EVs with larger batteries, higher power is needed to fully charge overnight. CTE modeled a 60 kW charger with two dispensers such that each dispenser can provide 30 kW at once. For some vehicles, the full 60 kW of power is needed which is accounted for in the number of chargers and dispensers.
    d. Level 3 DC Fast Charger with One Dispenser: For EVs with very large batteries or a need for fast charging, CTE modeled a 150 kW DC fast charger. Not all vehicles are compatible with this charging speed, but all vehicles compatible with DC charging can use this charger at the vehicle's maximum power.

Table 16: Charger types

Type	Modeled Maximum Power	Dispensers
Level 1	~1 kW	1
Level 2	16.6 kW	1
Level 3	30 kW (2 dispensers) 60 kW (1 dispenser)	2
Level 3 Fast Charger	150 kW	1

Table 17: Vehicle types that are only compatible with proprietary level 1 chargers

Vehicles with Proprietary Level 1 Chargers (2024)		
• Boom lift, Non-road • Bunker Rake, Non-road • Mowers, Non-road	• Order picker, Non-road • Roller, Non-road • Root cutter, Non-road	• Scissor lift, Non-road • Stump Grinder, Non-road • Utility Sweeper, Non-road • Utility Vehicle, Non-road

4. To determine the charger power, CTE used the projected battery size for each vehicle type in 2024 and estimated the time to fully charge from 0%-100% SOC. CTE used the minimum charging power that achieved full charging in 7 hours overnight with a one-hour buffer to account for slower charging due to temperature or battery preconditioning. For vehicles with large batteries, this is not feasible on a Level 2 charger. CTE evaluated the DC charging options and CTE chose the minimum charging power. CTE also considered the need to limit total demand, in which case approximately 8 hours to fully charge was considered acceptable for some vehicles. Emergency and some pursuit vehicles were adjusted to fast charge. Table 18 shows the charger power modeled for each vehicle type.

Table 18: Vehicle types by assigned charger power

Level 2 (16.6 kW)	Level 3 (30 kW – half of 60 kW)	Level 3 (60 kW)	Level 3 Fast Charge (150 kW)
• Backhoe Loader, Non-road • Excavator, Compact, Non-road • Concrete Cutter, Non-road • Digger Derrick, Non-road • Forklift, Light, Non-road • Hammer, Non-road	• Asphalt Paver, Non-road • Forklift, Heavy, Non-road • Wheel Loader, Non-road • 1 Ton Pickup, Light • 1/2 Ton Pickup, Light • 3/4 Ton Pickup, Light • Command, Pickup, Emergency	• Emergency Specialty, Light, Emergency • Emergency Specialty, Medium, Emergency • Heavy Truck, Heavy • Refuse Truck, Heavy • Rescue, 1.5 ton Pickup, Emergency	• Emergency Specialty, Heavy, Emergency • Fire Engine, Emergency • Ladder Truck, Emergency • SUV, Patrol, Pursuit*

• Tractor, Compact, Non-road • Loader, Skid Steer, Compact, Non-road • Loader, Skid Steer, Non-road • Loader, Track Steer, Compact, Non-road • Compact Pickup, Light • Minivan, Light • Motorcycle, Light • Sedan, Light • SUV, Light • SUV, Police, Pursuit • SUV, Patrol, Pursuit* • Van, Cargo, Light • Van, Passenger, Light	• Command, Sedan, Emergency • Command, SUV, Emergency • Motorcycle, Pursuit • Street Sweeper, Heavy • Truck, Crane, Heavy • Truck, Dump, Heavy • Truck, Dump, Medium • Truck, Flatbed, Medium • Truck, Manlift, Medium • Truck, Rolloff, Heavy • Truck, Medium • Van, Cargo, Medium • 1 ton Pickup, Dump, Light • 1 ton Pickup, Flatbed, Light • 1 ton Pickup, Manlift, Light • 1/2 ton Pickup, Refuse Bin, Light	• Truck, Manlift, Heavy	

* *SUV Patrol vehicles appear in both the Level 2 and Level 3 Fast Charge categories because of the desired charging scheme. For the approximately 20 vehicles on a 24-hour patrol duty, fast chargers are needed. All other vehicles can charge more slowly overnight. See the Results for further discussion.*

5. To determine the number of chargers needed, CTE estimated how frequently each vehicle needs charger access based on its typical daily usage. CTE estimated the percentage of the battery capacity that would be used on a typical day using the battery capacity (kWh) and EV fuel economy (kWh/mi or kWh/hour). CTE assumed 87% usable capacity for EV batteries. The daily SOC usage was calculated as:

$$\frac{Average\ Daily\ Usage\ [miles\ or\ hours] * EV\ fuel\ economy\ \left[\frac{kWh}{mi}\ or\ \frac{kWh}{hr}\right]}{EV\ Battery\ Capacity\ [kWh] * Usable\ Capacity\ [\%]} = Daily\ SOC\ Usage\ [\%]$$

6. Then, CTE assigned vehicle to charger ratios as follows:
    a. More than 40% SOC per day = 1:1 vehicle to dispenser (plugged in every night)
    b. 20-40% SOC per day = 2:1 vehicle to dispenser (plugged in every other night)
    c. Less than 20% SOC per day = 3:1 vehicle to dispenser (plugged in every 3 nights)
7. CTE worked with Glendale to assign each vehicle type to the appropriate vehicle category. The analysis assumes no violations of these categories; additional hardware will be required for any vehicles that are charged more frequently. With fewer chargers, Glendale will need to carefully monitor the SOC and planned vehicle use to ensure vehicles are adequately charged on time. Table 19 shows the planned charger ratios (excluding vehicles in Table 17 with proprietary level 1 chargers).

Table 19: Vehicle to Dispenser Ratios

Charging Every Night (1:1 Vehicle to Dispenser)	Charging Every Other Night (2:1 Vehicle to Dispenser)	Charging Every 3 Nights (3:1 Vehicle to Dispenser)
• Fire Engine, Emergency • Ladder Truck, Emergency • Motorcycle, Pursuit • Refuse Truck, Heavy • Rescue, 1.5 ton Pickup, Emergency • Street Sweeper, Heavy • SUV, Police, Pursuit • SUV, Patrol, Pursuit	• Asphalt Paver, Non-road • Backhoe Loader, Non-road • Excavator, Compact, Non-road • Concrete Cutter, Non-road • Digger Derrick, Non-road • Forklift, Light, Non-road • Hammer, Non-road • Loader, Skid Steer, Compact, Non-road • Loader, Skid Steer, Non-road • Loader, Track Steer, Compact, Non-road	• Forklift, Heavy, Non-road • Tractor, Compact, Non-road • Wheel Loader, Non-road • 1 Ton Pickup, Light • 1/2 Ton Pickup, Light • 3/4 Ton Pickup, Light • Compact Pickup, Light • Heavy Truck, Heavy • Minivan, Light • Sedan, Light • SUV, Light • Truck, Crane, Heavy • Truck, Dump, Heavy

	• Command, Pickup, Emergency • Command, Sedan, Emergency • Command, SUV, Emergency • Emergency Specialty, Heavy, Emergency • Emergency Specialty, Light, Emergency • Emergency Specialty, Medium, Emergency • Motorcycle, Light • Truck, Flatbed, Medium • 1 ton Pickup, Flatbed, Light	• Truck, Dump, Medium • Truck, Manlift, Heavy • Truck, Manlift, Medium • Truck, Rolloff, Heavy • Truck, Medium • Van, Cargo, Light • Van, Cargo, Medium • Van, Passenger, Light • 1 ton Pickup, Dump, Light • 1 ton Pickup, Manlift, Light • 1/2 ton Pickup, Refuse Bin, Light

Fuel Assessment Methodology and Assumptions:

1. To calculate the annual fuel consumption, CTE followed the Fleet Assessment results for each vehicle's fuel type by year. CTE used the established average daily use (miles or hours) per vehicle, the average ICE and EV fuel economy, and the active days per year per vehicle type established in the Fleet Assessment:

$$No.Vehicles\ per\ Type * Active\ Days\ per\ Year * Fuel\ Economy\ \left[\frac{fuel\ units}{mile}\ or\ \frac{fuel\ units}{hour}\right] * Average\ Daily\ Use\ [miles\ or\ hours] = Annual\ Fuel\ Consumption\ [fuel\ units]$$

2. The annual fuel consumption was aggregated by fuel type and by location.
3. The charging process is not 100% efficient which results in some losses between the grid and the vehicle battery. This means that some additional energy and power are purchased that does not reach the vehicle battery. To account for this and estimate the true capacity needed, **CTE assumes 85% charger efficiency** (85% of energy drawn from the grid reaches the

battery).[17] Thus, if a vehicle requires 100 kWh to fully charge, the estimated energy drawn from the grid is 100 kWh * (1/0.85) = 117.6 kWh. CTE applied this efficiency factor to the electric energy estimation.

4. To estimate the number of chargers needed each year at each location, CTE used the vehicle to dispenser ratios, types of chargers, and charger powers established in the Charging Analysis and the annual fleet composition defined in the Fleet Assessment. CTE estimated the number of chargers of each type needed at each location based on the number and type of EV at each location each year of the transition. CTE aggregated the chargers such that vehicles were sharing chargers to minimize the number of chargers needed (e.g., if a Flatbed Pickup and a Cargo Van at one location need a Level 2 charger at a 2:1 vehicle to dispenser ratio, then one Level 2 charger is added to the location). In the case of a non-whole number of chargers at a location, CTE rounded up to the nearest whole charger, which provides some spare capacity (e.g. three vehicles need a Level 2 charger at a 2:1 ratio, the number of chargers needed is technically 1.5 chargers, which would be rounded up to two chargers). The spare capacity is considered for future vehicle purchases and used first before adding chargers. No additional spare chargers were added for the purposes of the fuel assessment.
5. The number of chargers informs the maximum demand at each location. CTE calculated the maximum demand by multiplying the charger power by the number of chargers of each type and summing for each site. This method assumes no additional charge management system that would limit the maximum demand. CTE also applied the 85% charger efficiency assumption to all DC chargers (Level 3 and Level 3 Fast Charge) because the stated maximum charger power (e.g., 60 kW) is the maximum power reaching the vehicle. Due to inefficiencies in converting grid power to vehicle power, more power is drawn from the grid than reaches the vehicle. Thus, for a 60 kW charger, the demand on the grid is estimated as 60 kW * (1/0.85) = 70.5 kW.

Cost Assumptions

CTE estimated the annual fuel costs using the current costs of fuel provided by Glendale as shown in

[17] National Renewable Energy Laboratory, "Estimating the Breakeven Cost of Delivered Electricity to Charge Class 8 Electric Tractors" (2022)

1. Table 20 and the annual consumption amounts calculated previously.

Table 20: Fossil fuel costs per unit in 2024

Fuel	Cost per Unit in 2024
Diesel	$ 3.80 / gallon
Gasoline	$3.50 / gallon
CNG	$2.14 / gasoline gallon equivalent
Propane	$3.00 / gallon*

**Assumed by CTE*

2. For utility costs, GWP provides several options for utility rates depending on the maximum demand. These rates have changed since the previous assessment. The available rates are:
    a. For sites with demand over 20 kW: Rate LD2A[18]
    b. For sites with demand over 150 kW and less than 500 kW: Any PC1 rate (minimum demand charge is 150 kW)[19]
    c. For sites with demand over 500 kW: Rate PC1B
3. CTE used LD2A for sites that remained under 150 kW throughout the transition. For any sites over 150 kW by the end of the transition period, CTE used PC1B to estimate costs throughout the transition because the overall demand charges are lower than PC1A (see Table 21 for the utility rates used in the analysis). Because no sites in the baseline scenario cross 150 kW, CTE modeled all baseline sites on LD2A for any existing EVs.
4. PC1B includes a time of use (TOU) component for energy rates but not demand rates. Because most charging will occur in the off-peak hours (from 9 pm to 12 pm most of the year) and the energy component of the total bill is much lower than the demand component, CTE approximated all energy costs as the off-peak rate.
5. CTE used the Phase 5 (2027) rates from the planned rate increases because most electrification will occur during and after 2027, though costs in 2025 and 2026 will be slightly overestimated.

[18] GWP Rate LD2A

[19] GWP PC1 Rates

6. CTE assumed one meter per location and that all EVs will be charged on a meter separate from other loads at the site.
7. CTE did not include reactive power (kVAR) charges because chargers typically have a power factor rating over 95% which causes little reactive power to be fed back to the grid and the charge is low compared to the other components of the bill.

Table 21: Utility rates applied

Rate	Bill Component	High Season Cost (July to October)	Low Season Cost (November to June)	Annual Weighted Average including PBC (2.85%)
LD2A	**Energy**	\$0.1707 per kWh	\$0.1632 per kWh	**\$0.1704 per kWh**
	Demand (Maximum over previous 12 months)	\$1.15 per kW per day	\$0.80 per kW per day	**\$0.94 per kW per day**
	Flat Rate	\$1.70 per meter per day		**\$1.76 per meter per day**
PC1B	**Energy (Base)**	\$0.14630 per kWh	\$0.14630 per kWh	**\$0.1505 per kWh**
	Demand (Maximum over previous 12 months)	\$0.96 per kW per day	\$0.68 per kW per day	**\$0.80 per kW per day**
	Flat Rate	\$10.50 per meter per day		**\$10.88 per meter per day**

8. CTE included charger maintenance costs in the cost of electric fuel to account for the fact that fossil fuel prices include the cost of maintaining the fueling stations. CTE assumes **\$2,800 per charger per year for annual maintenance.** Inflation is included at 3% per year for charger maintenance costs.
9. Finally, to account for inflation and future changes in the cost of each fuel type, CTE used the Energy Information Administration's Annual Energy Outlook (EIA)[20] to provide an estimated change in price for each fuel type from 2025-2040. Using this analysis helps account for the fluctuating price of fossil fuels over time, as well as the potential electricity rate increases that

[20] Energy Information Administration 2023 Energy Outlook data

GWP indicated may occur beyond 2027. Because the Energy Outlook does not include inflation, CTE also added 3% inflation to the changes. The resulting percent change in price from current 2024 prices is shown in Figure 15. These price changes were applied to each year of fuel costs in the transition.

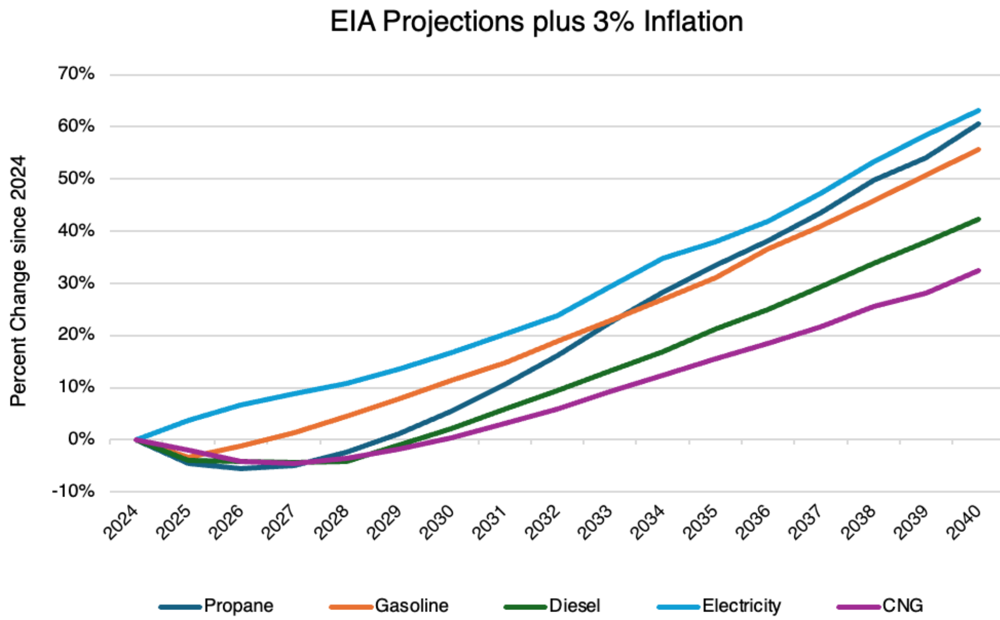

Figure 15: The estimated change in fuel prices until 2040 based on EIA projections and inflation.

Results and Discussion

Charging Analysis

CTE projects 351 Level 2 and Level 3 chargers with 484 plugs across all sites in 2040 and 65 Level 1 proprietary chargers. The overall vehicle to charger ratio is 1.94 including all charger types (1.47 vehicles to plug) and the 808 electrified vehicles by 2040. Excluding Level 1 chargers, which have a low impact on space and demand, and the corresponding 65 vehicles, the vehicle to charger ratio is 2.11 (1.54 vehicles to plug). The charging infrastructure for the 12 remaining ICE vehicles (fire engines and ladder trucks) in 2040 is excluded from the analysis as installation and use will occur outside the transition timeline.

For police patrol vehicles, some operational modifications will be needed with the planned charging infrastructure. Currently, approximately 20 police vehicles are on patrol for days at a time and would only be able to charge during the 15 minute "hot swaps" after the 12-hour shifts. Using a 150-kW fast charger, a patrol SUV could fully charge in approximately 30 minutes. Thus, CTE planned for 22 fast chargers for use on patrol vehicles. For the remaining approximately 50 patrol vehicles, CTE planned for a level 2 charger for each vehicle so they could be slow charged overnight. **Glendale will need to investigate operational changes such as switching patrol vehicles on the shift change rather than driving the same vehicle** if the time available is not enough to adequately charge.

The projected demand, energy, and applied utility rates at each location are shown in Appendix C. The projected demand at the 6 primary sites[21] over the transition is shown in Figure 16. The high projected demand at GPD is due to the number of DC fast chargers.

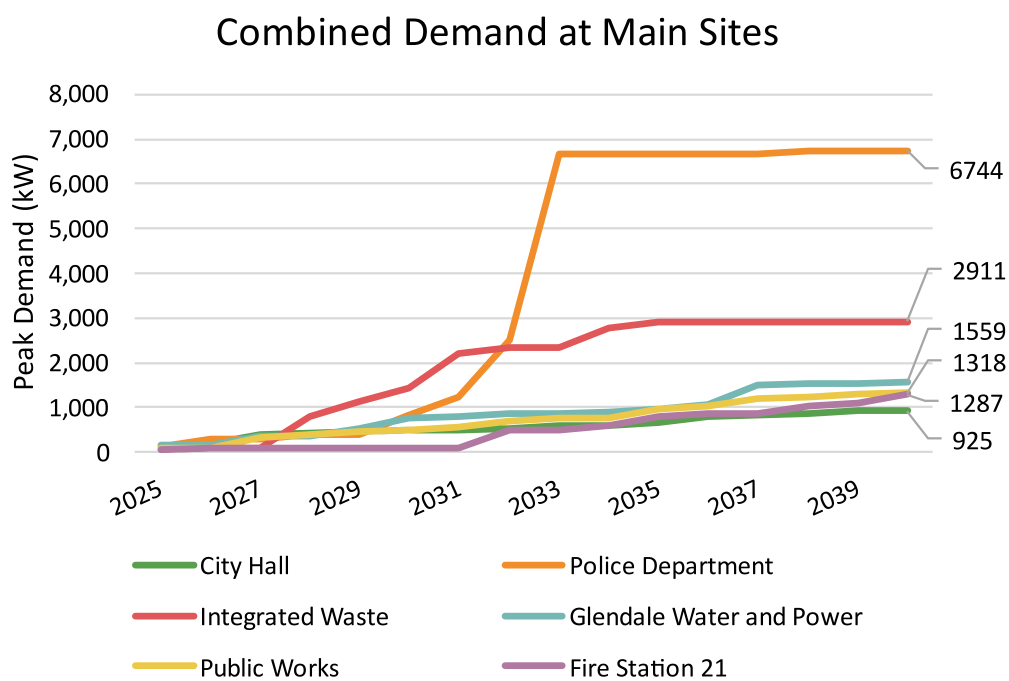

Figure 16: Demand over the transition period at the major sites

Fleet Energy Consumption

CTE estimated the fuel and energy consumption for each year of the transition by type of fuel. For direct comparison, CTE converted each fuel type based on its energy content into gasoline gallon equivalents (GGE). The total amount of energy consumed decreases with electrification because EVs are much more efficient than ICEs. Glendale will decrease its total energy consumption by about 2/3 by 2040 and eliminate gasoline consumption by 2040 based on the current purchase schedule (Figure 17). The only diesel consumption in 2040 is due to the remaining ladder

[21] Some distinct locations that are co-located are combined to encompass the major sites. City Hall includes CCG, CVC, and Perkins. Glendale Water and Power includes GWP and Plant.

trucks and fire engines that are not electrified as discussed in the purchase schedule. Appendix C provides figures showing the fuel consumption by site.

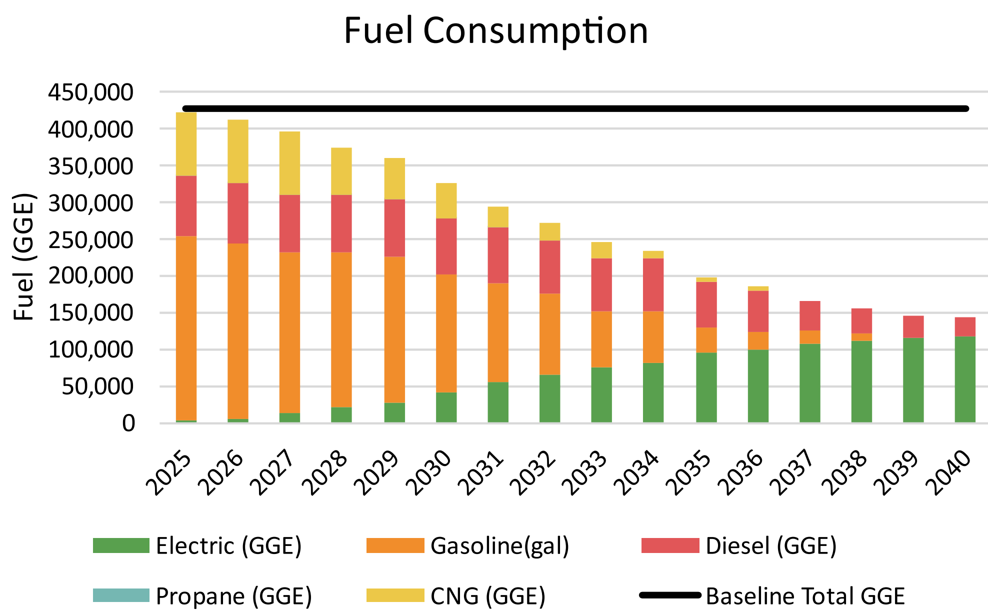

Figure 17: Fuel Consumption in Gasoline Gallon Equivalents (GGE) in the transition vs. the baseline scenario.

Fuel Costs

Based on the fuel consumption above, fuel costs, and charger maintenance costs, the estimated annual fuel cost is shown in Figure 18. (Appendix C provides figures showing the fuel cost by site.) The cost of electricity is much higher than other fuels and higher than the previous assessment. There are several factors influencing this:

1. The previous assessment planned for a charger for every vehicle; however, it estimated demand costs on the assumption that only 50% of chargers would be used at any one time. In this assessment, CTE has optimized the vehicle to charger ratio to approximately 2:1 across sites; however, CTE modeled that 100% of the chargers will be used at once[22]. Thus, the peak demand estimate across all sites is like the previous assessment, though some sites such as GPD are significantly less.
2. GWP rates have increased.

[22] Because demand is charged based on the maximum demand over the previous 12 months, a single instance of all chargers being used at once will cause the peak demand to be charged.

   a. The previous analysis used an energy cost of $0.0714 per kWh based on rate LD2B for all sites. The current analysis rate at PC1B sites is 111% more per kWh ($0.1505), and 138% more at LD2A sites ($0.1704).
   b. The previous analysis used a demand cost of $0.66 per kW **per month**. The current analysis rates are $0.94 per kW **per day** for LD2A sites and $0.80 per kW **per day** for PC1B sites. The rates per kW have increased by 42% and 20% respectively. Calculating demand per day rather than per month also increases the demand component of the bill significantly. The demand charges account for most of the utility costs in the current assessment.
3. The previous inflation applied a blanket 3% inflation to all fuel costs and did not include the EIA Energy Outlook predictions. Higher inflation costs were applied to the previous analysis, and different rates were applied to each fuel type.
4. Fossil fuel costs have decreased since the previous analysis. In 2022, the reported costs per unit were as follows:
   a. $6.04 per diesel gallon (Current analysis is 37% less)
   b. $4.98 per gasoline gallon (Current analysis is 30% less)
   c. $2.42 per CNG GGE (Current analysis is 12% less)

   Additionally, using the Energy Information Administration (EIA) Energy Outlook incorporates different changes in price for different types of fuel, and fossil fuel costs do not increase as much as electricity costs over the transition scenario. Thus, the baseline scenario in the current analysis costs less than the baseline scenario in the previous analysis.
5. Including the charging maintenance costs in fueling costs assumes that the price paid for baseline fuels includes costs of maintaining baseline fueling infrastructure; however, Glendale's fossil fuel infrastructure costs are captured in their vehicle maintenance chargeback system. Fossil fuel infrastructure—such as underground and aboveground tanks, fueling dispensers, and kiosks—are costly to maintain but must be maintained even if it is not in use. Removing the infrastructure, especially underground tanks, is costly; therefore, CTE has not modeled reductions in this cost. Glendale should consider the costs and benefits of maintaining fossil fuel infrastructure.

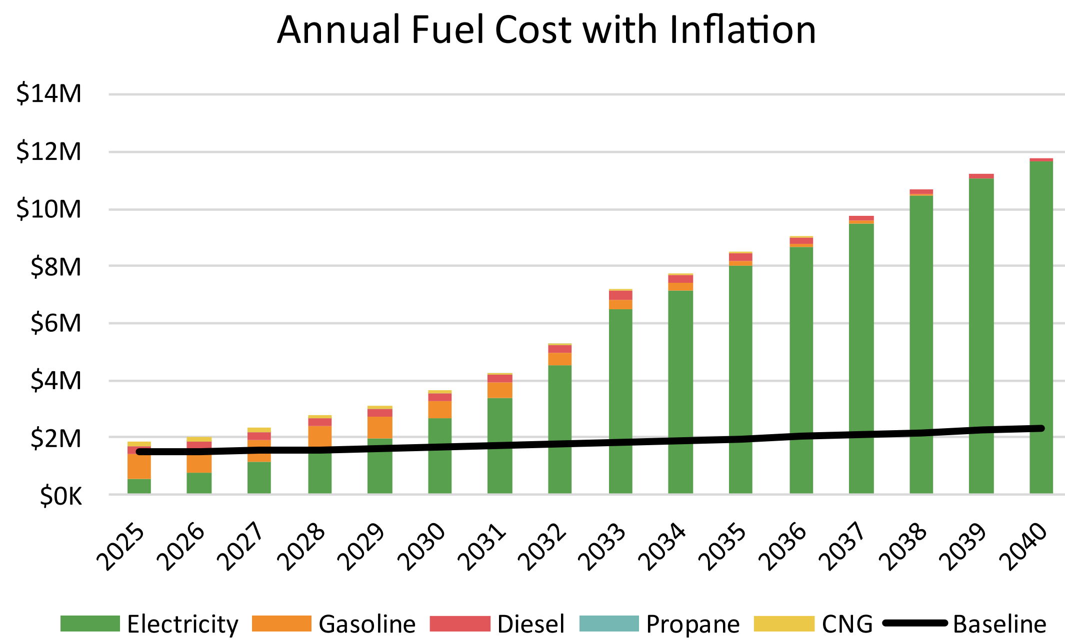

Figure 18: Estimated annual fuel cost at all sites.

Table 22 summarizes the cost differences between the baseline and transition scenario. The cumulative cost of fuel is approximately $71 million more for the transition scenario from 2025-2040 than the baseline scenario (Figure 19).

Table 22: Baseline vs. Transition Cumulative Fuel Costs, 2025-2040

Cumulative Transition Fuel Costs	Cumulative Baseline Fuel Costs	Cumulative Difference
$100,609,000	$29,428,000	$71,181,000

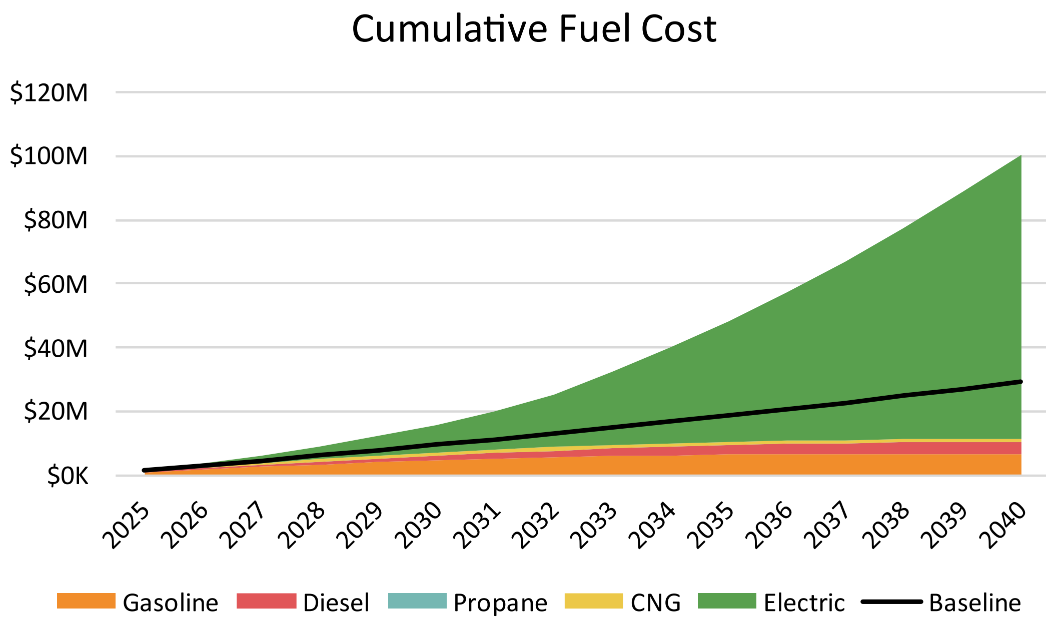

Figure 19: Cumulative fuel costs over the transition compared to baseline.

The estimated costs are a significant increase from current annual fuel costs and the previous analysis estimates. Additional steps to mitigate higher electricity costs include:

4. **Limit maximum demand:** Demand charges at GWP are based on the highest point of power usage during the previous 12 months. This means that a single instance of high demand, such as using all chargers at maximum charging rate at the same time, will be the amount of demand charged for an entire year. Thus, limiting the maximum demand is key for minimizing demand cost which is generally the most expensive component of the utility bill. Limiting demand can be accomplished in a few ways:
    a. Reduce the total number of chargers and/or the number of chargers used at once. Though this limits operational flexibility and potentially requires more logistics to share chargers between vehicles, it can result in savings. As Glendale adopts more EVs, the number of vehicles that can share a charger with minimal additional logistics may be able to be reduced from CTE's projections.
    b. Reduce charging speeds. Charging vehicles using slower, lower-powered chargers reduces the demand on the grid. If vehicles can be charged overnight rather than rapid charging, that will reduce demand.

c. Implement at charge management system (CMS). A CMS is software that can manage demand and energy use across all chargers at a site by automatically taking on the above tasks while still ensuring vehicles are charged by the start of shifts (e.g., slowing down charging to avoid maximum power or charging vehicles sequentially over night before the vehicles are required for use in the morning. While a CMS is not free, Glendale may investigate the utility savings and logistical needs versus the costs of the software.

5. **Discuss potential EV charging rates with GWP.** Many utilities such as Southern California Edison[23] offer different rates for EV-only meters to mitigate demand charges. The current PC1B rate does not have a TOU component to the demand charge; because Glendale will charge most vehicles at night, a TOU rate for demand may reduce costs. Additionally, the City should work with GWP every few years to determine the optimal rate schedule for each terminal as the demand and energy needs increase.
6. Consider **other infrastructure to reduce the peak demand** from the grid. Infrastructure such as on-site battery storage can be charged when electricity is cheaper during off-peak hours or from on-site solar generation and then discharged during peak hours to reduce the maximum demand on-peak. Depending on the charging scheme that the City finds works best, peak-shaving infrastructure may reduce costs and improve resilience.

Facilities Assessment

Purpose

For fleet transition planning, the goals of the facilities assessment components are:

1. Estimate the annual capital cost of infrastructure required to charge EVs
2. Estimate the annual cost of construction for EV charging infrastructure

Methodology Overview

The facilities assessment builds on the results of the Fuel Assessment (Figure 20)

Inputs: CTE used the outputs of the fuel assessment: recommended charger ratios, number of chargers, and expected demand. CTE received estimates for utility upgrades and costs from GWP.

[23] Southern California Edison Business EV Rates

Outputs: CTE calculated the annual capital costs for chargers and infrastructure construction based on industry average cost assumptions.

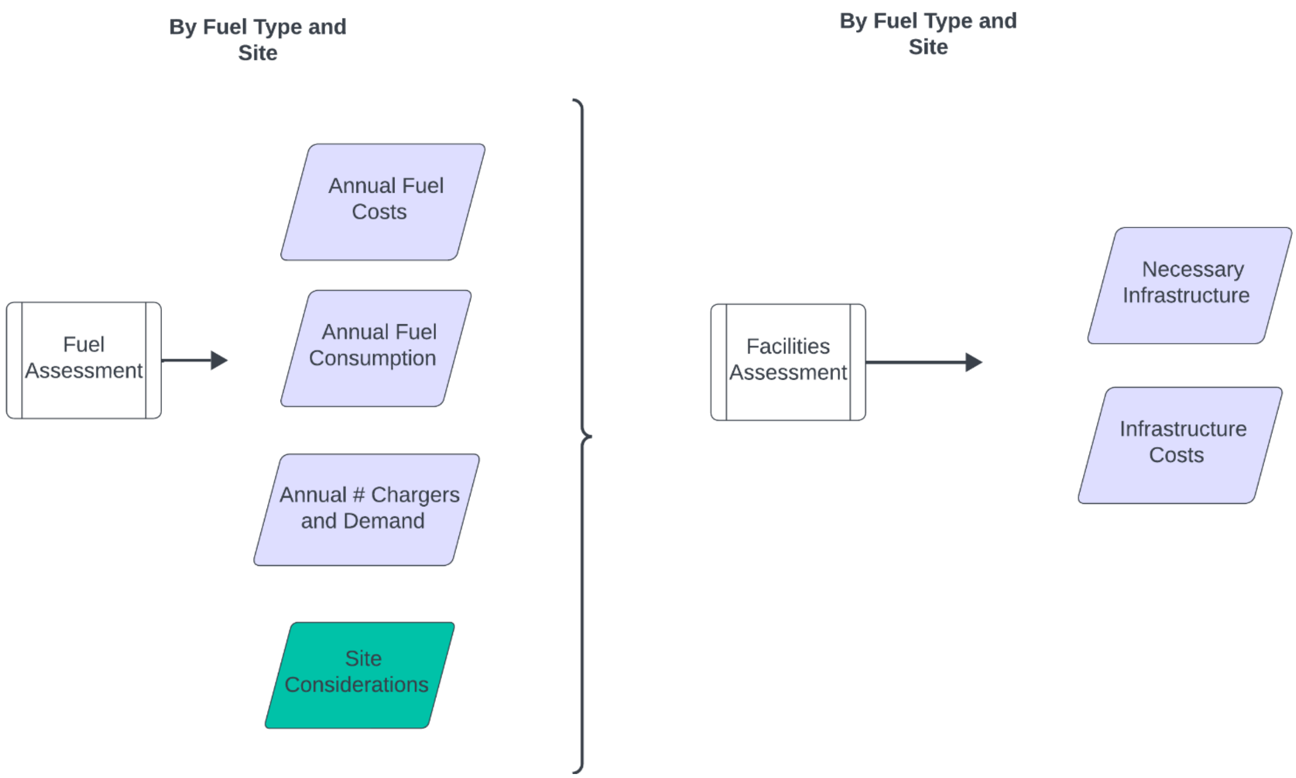

Figure 20. The Facilities Assessment builds on the results of the Fuel Assessment

Scope

The scope of the infrastructure assessment is focused on 661 vehicles domiciled at 6 primary City of Glendale facilities. The chargers for the remaining 159 vehicles are included without construction costs as these vehicles are expected to be distributed in small numbers among non-primary sites where installation costs will be minimal.

Detailed Methodology and Assumptions

Based on the duty-cycle analysis, CTE determined the quantity and power levels of chargers for each site and vehicle type at each primary facility. The costs are split into two categories: 1) utility upgrades and 2) equipment and installation.

Utility Upgrades

1. CTE coordinated with GWP on the infrastructure upgrades needed to provide the required power and demand. CTE provided a summary of power and energy demand by primary facility. Table 23 summarizes the expected peak demand at each of the primary sites.

Table 23. Summary of the Combined Peak Demand at the Primary Facilities

Facility	Peak Demand (kW)
Public Works Yard	1,318
City Hall Complex	925
GWP Utility Operations Center	1,559
Integrated Waste Yard	2,911
Fire Station 21	1,287
Police Parking Lot	6,744

2. GWP provided the estimated costs to meet the required power and energy demand to all Glendale Facilities – outlined in Table 24. Figure 21 shows the annual costs for utility upgrades—including distribution, transmission, and the Acacia substation—across all main sites. CTE divided the costs evenly by the number of years over the timeline provided by GWP. The overall cost to upgrade the utility infrastructure is $32.5 million. This is higher than the estimated cost from the previous study which was estimated at $21.9 million. This increase was due to several factors including long lead times and price increases for power transformers and other power components. Several design changes to the Acacia substation also increased the cost estimate. The new design includes the option of a third transmission line entry (the original estimate had 2 transmission lines) and improved reliability of the power grid. GWP also added the cost of building a new transmission system from the Grayson Power Plant to the Acacia substation.

Table 24. GWP Upgrade Cost Estimates and Timeline

Element	Estimated Cost	Timeline
Distribution	6,000,000	2025-2027
Transmission	2,500,000	2025-2028
Acacia Station	24,000,000	2028-2030
Total	**32,500,000**	

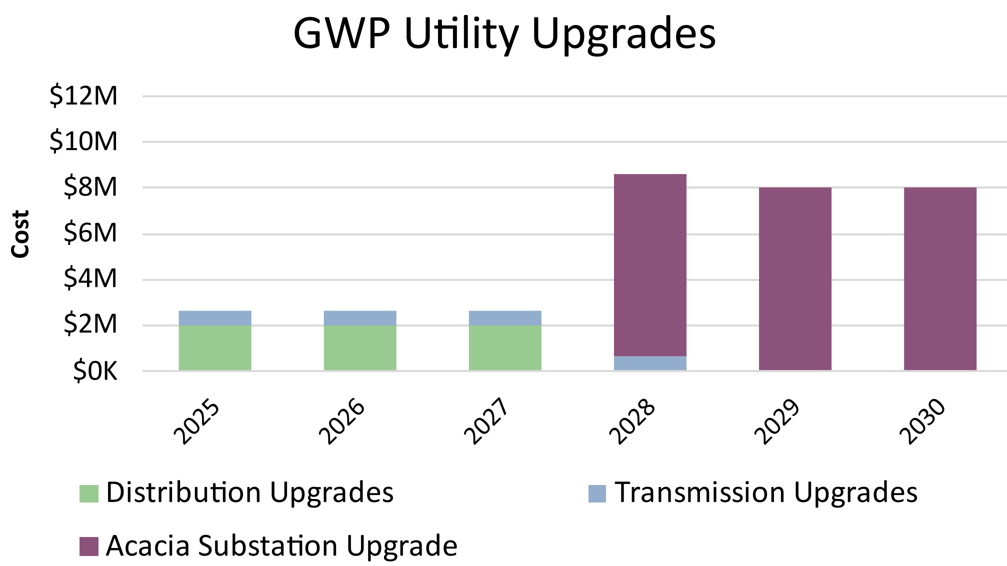

Figure 21. Annual Costs for Utility Upgrades across all sites

3. As outlined in the previous table, GWP has a major upgrade planned for the Acacia Substation. This substation serves the load of the Public Works Yard and Integrated Waste Yard, in addition to other City facilities, most notably the Beeline Maintenance Facility. GWP indicated that this is an old substation with 8 transformers that were manufactured in 1963 for a total capacity of 22.54 MW. Considering the additional load from the fleet transition project, the increased use of this substation would reach 98% of the total capacity. To provide reliable service, GWP will need to replace the older equipment and increase the capacity of the Acacia substation. Upgrading the Acacia substation will cost an estimated $24,000,000 (includes costs to upgrade Public Works Yard and Integrated Waste Yard). The City will need to coordinate with GWP throughout the implementation of the transition plan to understand the available power at the site over time, and when utility upgrades will be required.

Equipment and Installation Costs

1. The equipment and installation estimates are focused on the City's fleet using level 2 and level 3 chargers. Using the chargers outlined in the fuel assessment,

3. Table 25 outlines the number of chargers planned by charger type and site.

Table 25. Number of Chargers installed by type and site

Facility	Level 2 16.6 kW chargers	Level 3 DC 60 kW chargers	Level 3 DC high power 150 kW chargers
Public Works Yard	11	16	0
City Hall Complex	30	6	0
GWP Utility Operations Center	20	16	0
Integrated Waste Yard	1	41	0
Fire Station 21	1	8	4
Police Parking Lot	100	17	22
Other Locations	47	20	8
TOTAL	**183**	**133**	**35**

4. CTE estimated the costs of chargers and installation based on market research and data from existing projects.

5. Table 26 summarizes the estimated costs for the three types of chargers and installation. CTE added a 10.25% tax on the capital cost of the chargers. Construction and installation costs are assumed to include site preparation, conduit, transformers, switchgear, concrete pads, bollards, etc. These costs are highly variable depending on local conditions, number of chargers installed at any given time, distance from the transformer, local labor market, etc.

Table 26. Cost Assumption for Infrastructure Installation

Charger Type	Capital Cost	W/Tax (10.25%)	Construction/ Stub-outs, per Charger	Installation, per Charger
L2 16.6 kW	$2,000	$2,205	$5,000	$2,500
L3 60 kW	$60,000	$66,150	$20,000	$5,000
L3 150 kW	$125,000	$137,813	$30,000	$10,000

6. CTE used a 3% inflation each year through the transition on all chargers and installation costs.
7. CTE assumes chargers will be installed at the primary facilities in two phases. In the first phase, Glendale would install the conduit and stub-outs for approximately half the required chargers. The second phase would install conduit and stub-outs for the remaining chargers. The individual chargers would be purchased and installed on the stub-outs as the vehicles are delivered.
8. CTE assumes a cost of $200,000 for the initial Phase 1 construction design at each main facility. CTE estimates a $50,000 cost for any updates to the design for Phase 2 at each facility.
9. The analysis for the other locations includes the cost of chargers and installation needed for vehicles not located at one of the six selected facilities, however it does not include the initial cost of preparing the sites for adding chargers (design, stub outs, conduit, etc.) CTE assumes the construction and utility upgrades for these sites would be minimal, since the number of chargers at each of the other sites is small.

Results and Discussion

Scaling the City's fleet to 100% EVs requires significant investment in charging infrastructure. In the previous study, CTE used a 1:1 charger to vehicle ratio. This would represent a worst-case scenario and provide an upper boundary to cost. Glendale reports that many of its sites have space constraints that will limit the ability to install that number of chargers. One of the goals of this updated analysis was to develop a better understanding of the projected use of each vehicle and to optimize the number of chargers required to support the fleet. CTE updated its estimate of the charging infrastructure costs based on these updated assumptions and results from the fuel assessment.

Facility Infrastructure Costs

Table 27 summarizes costs by facility. CTE estimates the total cost of design, charging equipment, and construction and installation is approximately $25 million, excluding utility upgrades.

Table 27. Summary of Estimated Infrastructure Costs by Facility

Facility	Design	Charging Equipment	Installation	Total Costs by Facility
Public Works Yard	$250,000	$1,334,000	$544,000	$2,128,000
City Hall Complex	$250,000	$576,000	$398,000	$1,224,000
GWP Utility Operations Center	$250,000	$1,362,000	$597,000	$2,209,000
Integrated Waste Yard	$250,000	$3,197,000	$1,122,000	$4,569,000
Fire Station 21	$250,000	$1,450,000	$455,000	$2,155,000
PD3 Parking Lot	$250,000	$5,475,000	$2,431,000	$8,156,000
Other Locations	NA	$4,205,000	$367,000	$4,572,000
Total	**$1,500,000**	**$17,599,000**	**$5,914,000**	**$25,013,000**

The first year of the transition is assumed to include costs for the initial design for all six primary sites. Figure 22 provides the annual capital cost over time throughout the transition. The higher costs in 2032 and 2033 align with the phase 2 construction at multiple sites. The appendix includes the annual capital cost analysis for each of the six main sites.

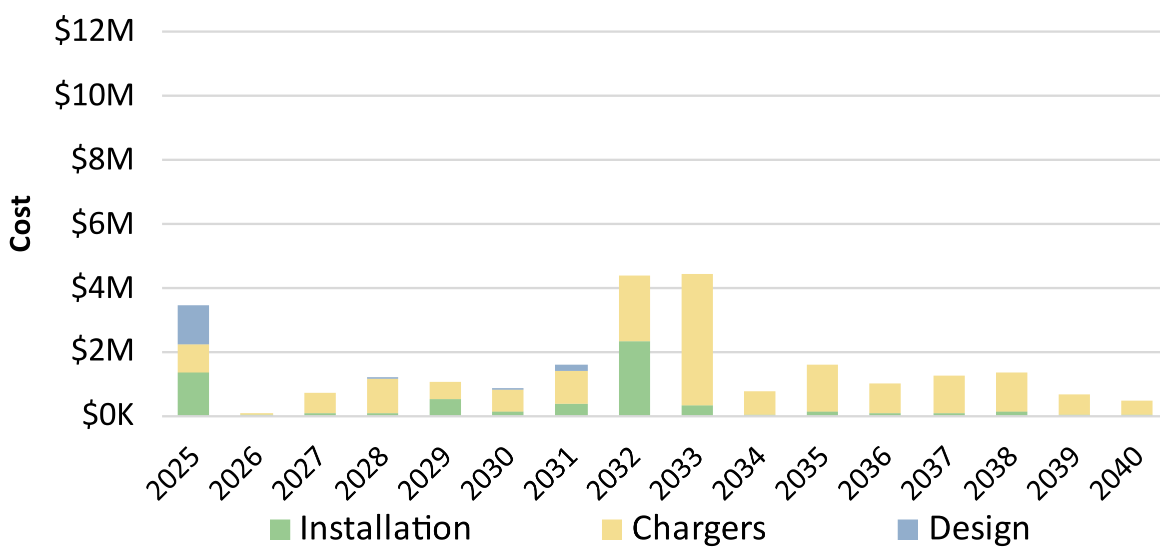

Figure 22. Annual Facility Costs through 2040

Total Charging Infrastructure and Utility Upgrade Costs

The total capital cost of charging infrastructure and utility upgrades is estimated at $57.5 million. This cost is a significant savings over the 1:1 charger to vehicle ratio used in the previous study, which estimated a cost of $49.2 million for construction and infrastructure plus $21.875 million for utility upgrades totaling $71 million. Figure 23 shows the total annualized capital costs including utility upgrades.

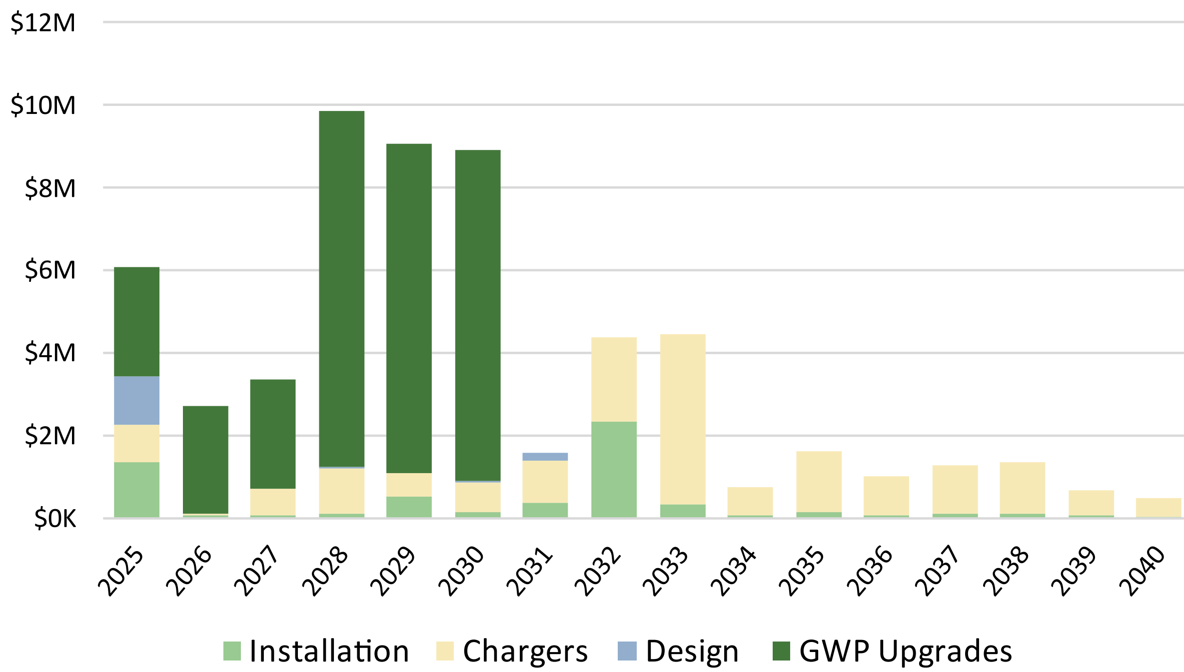

Figure 23. Annual Facility Costs through 2040 including Utility Upgrades

Benefits Assessment

Maintenance Cost Assessment

Industry sources and academic studies report that EVs should realize maintenance savings over that of their conventional baseline counterparts. In the early stages of deployment, CTE has not documented this savings in all vehicle categories but expects savings in the long term once the industry matures. Switching from conventionally fueled vehicles to EVs has other benefits that are less easy to quantify. Over time, the City should expect savings from the reduced need for engine oil and costs associated with used oil storage and disposal.

Purpose and Scope

For fleet transition planning, the goals of the maintenance assessment component are to estimate the annual costs of maintenance for the fleet in the transition and the baseline scenario. EVs have different maintenance needs that CTE expects will lead to savings as the fleet electrifies. Both ICE and EVs require maintenance on non-powertrain components such as cabin HVAC, tires, and lifting and hydraulic systems on construction equipment; however, EV vehicles do not require maintenance such as engine oil, drive belts, or alternators. Additionally, EVs require less frequent brake maintenance because of regenerative braking, but EVs may require more frequent tire replacements due to the additional weight of the battery. The maintenance assessment includes the costs of labor and materials for both preventive maintenance and repair.

Methodology and Assumptions

Electric vehicles have different maintenance needs than combustion engine vehicles. The Maintenance Assessment is based on Glendale's current costs for maintaining its ICE fleet and the expected reductions in EV maintenance for different vehicle classes.

1. CTE used Glendale's fleet maintenance costs in 2024 to establish the ICE maintenance cost per vehicle class as follows:
    a. CTE established the percentage of total maintenance costs for each vehicle class (Light, Medium, Heavy, Non-Road, Emergency, and Pursuit) based on the reported annual maintenance and repair costs from 2023-24 from Glendale's fleet tracking system.
    b. The annual fleet chargeback rates, which includes data from the fleet tracking system, captures the city's full cost of maintenance. These rates provided CTE with the basis for Glendale's expected maintenance costs in 2024.
    c. CTE scaled the costs for each vehicle class based on the proportions recorded in the fleet tracking system.
2. CTE applied a percent reduction to the maintenance costs based on the vehicle type based on a study of EV total cost of ownership[24]: 40% reduction for Light, 30% for Medium, and 25% for Heavy vehicles.
3. Because there is limited commercialization and thus limited data for other vehicle classes, CTE conservatively applied a 25% reduction to non-road vehicles and emergency vehicles. CTE applied a 40% reduction to the Pursuit vehicles to match the Light category.

[24] Argonne National Labs, Vehicle TCO Analysis (2021)

4. Table 28 summarizes the resulting annual maintenance costs for each vehicle class.
5. CTE applied these costs to the vehicle composition for each year of the transition determined in the Fleet Assessment.

Table 28: Annual Maintenance Cost Assumptions per Vehicle in 2024

Vehicle Class	ICE Annual Maintenance Costs Per Vehicle	EV Reduction	Modeled EV Annual Maintenance Costs Per Vehicle
Emergency	$34,166	25%	$25,624
Heavy	$41,174	25%	$30,881
Light	$3,454	40%	$2,072
Medium	$10,613	30%	$7,429
Non-road	$5,712	25%	$4,284
Pursuit	$8,699	40%	$5,219

Results and Discussion

The annual maintenance costs are shown in Figure 24. As the fleet electrifies, the projected maintenance costs are lower than baseline.

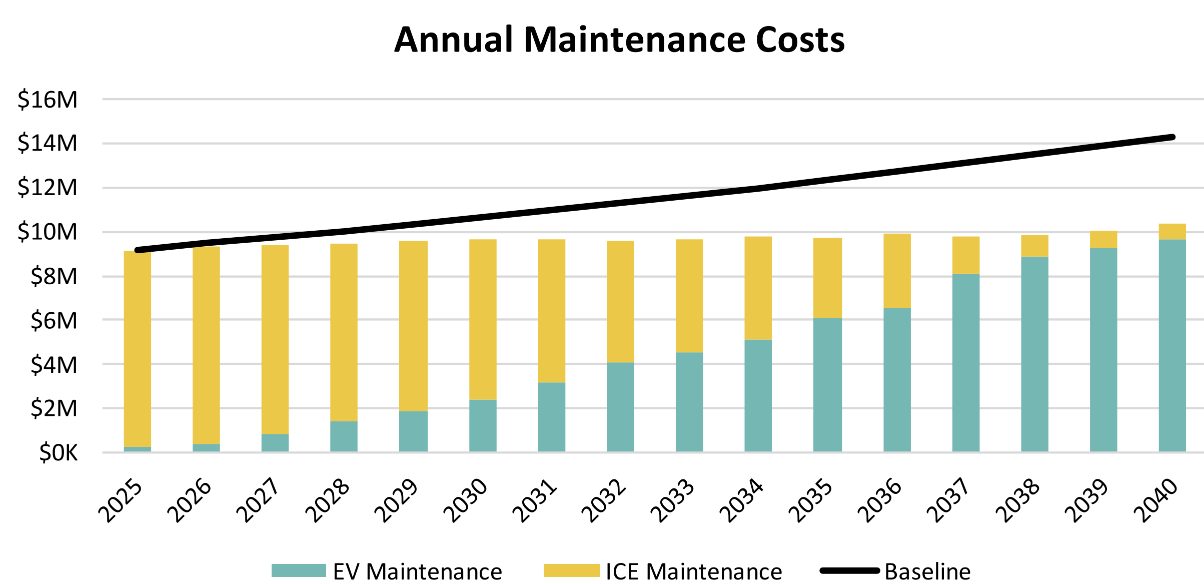

Figure 24: Annual Maintenance Costs in the transition vs. baseline scenarios.

The cumulative cost of maintenance is approximately $30 million less for the transition scenario from 2025-2040 than the baseline scenario (Figure 25, Table 29).

Table 29: Baseline vs. Transition Cumulative Maintenance Costs, 2025-2040

Cumulative Transition Fuel Costs	Cumulative Baseline Fuel Costs	Cumulative Difference
$155,013,000	$185,179,000	-$30,166,000

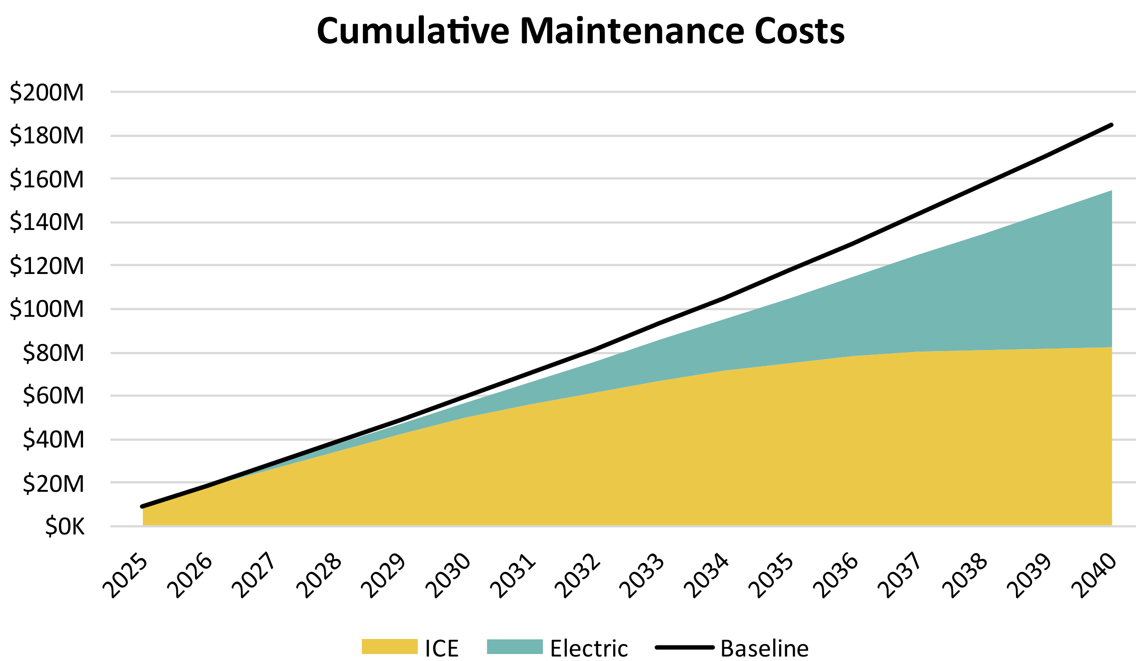

Figure 25: Cumulative Maintenance Costs in the transition vs. baseline scenarios.

Emissions Reductions

Purpose

Reduction of criteria pollutants and GHG emissions are one of the benefits of operating EVs. EVs have zero tailpipe emissions while in use, while fossil-fueled ICE vehicles produce emissions that are harmful to public health and the environment. Both EVs and ICE vehicles have emissions associated with the upstream production of fuel because electricity is produced from a mix of sources including fossil fuels.

The emissions assessment is well-to-wheel (WTW), including both upstream emissions from fuel production and in-use emissions. CTE uses the Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool [25] published by Argonne National Laboratory. Estimates are based on the annual fleet composition determined by the Fleet Assessment purchase schedule, as well as the annual fuel consumption calculated in the Fuel Assessment, and the annual use of each vehicle based on Glendale's data.

Scope

The pollutants considered are total GHGs and criteria pollutants Nitrogen Oxides (NO_x), Sulfur Oxides (SO_x), Carbon Monoxide (CO), and particulate matter under 10 micrometers (PM_{10}).

Future improvements to the grid and alternative fuel production methods were considered out-of-scope for this assessment; all years are based on 2023 emissions intensities. Future purchases of ICE vehicles with newer engines may result in decreased emissions intensity as compared to the values used in this study. Likewise, if the grid becomes cleaner, emissions associated with EV operation will decrease further.

Methodology and Assumptions

Utility Assumptions:

CTE used the electricity mix defined in AFLEET 2023 applicable to southern California as shown in Table 30.

Table 30: Grid electricity source mix

Western Electricity Coordinating Council (WECC) Grid Mix	
Residual oil	0.1%
Natural gas	32.3%
Coal	16.7%
Nuclear power	8.1%
Biomass	0.5%
Others (Wind, Solar, Hydropower, etc.)	42.2%

[25] AFLEET 2023

Greenhouse Gas Well to Wheel Calculations:

1. To calculate annual GHG emissions, CTE used the annual fuel consumption for each vehicle and multiplied it by the GHG emissions intensity associated with each fuel type from AFLEET.
2. The emissions intensity includes emissions associated with the production and consumption of the fuel.

Upstream Criteria Pollutant Calculations:

1. To calculate annual upstream criteria pollutant emissions, CTE used the annual fuel consumption for each vehicle and multiplied it by the criteria pollutant emissions intensity associated with each fuel type from AFLEET.
2. The emissions include those associated only with production of the specific fuel.

In-Use (Tailpipe) Criteria Pollutant Calculations:

1. To calculate annual in-use pollutant emissions, CTE used the vehicle class, fuel type, average model year, and approximate horsepower to determine the appropriate emissions intensity for in-use criteria pollutants from AFLEET.
2. CTE then multiplied the total annual mileage or operating hours from the Fleet Assessment by the emissions intensity for in-use criteria pollutants.
3. Electric vehicles do not have any in-use emissions.
4. CTE used emissions intensities associated with the current age distribution of the ICE fleet.

Total emissions are the sum of both in-use and upstream emissions.

Results and Discussion

Figure 24 - Figure 28 shows the annual emissions estimates for the baseline and transition scenarios.

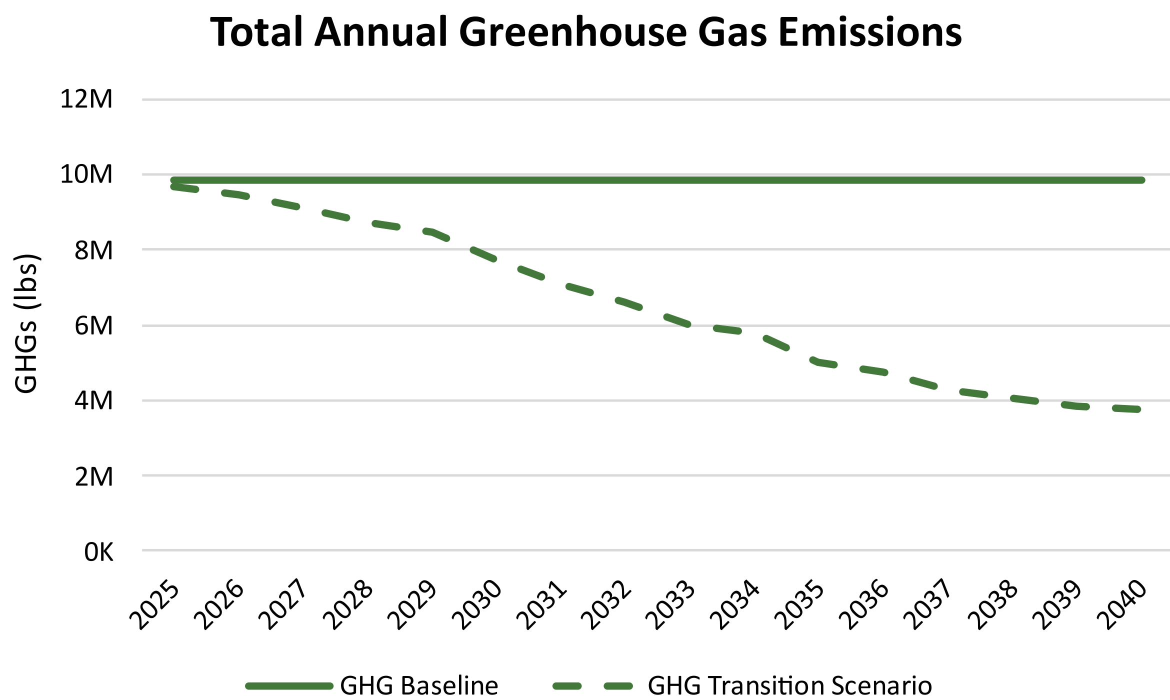

Figure 26: Greenhouse Gas emissions in the transition vs. baseline scenarios.

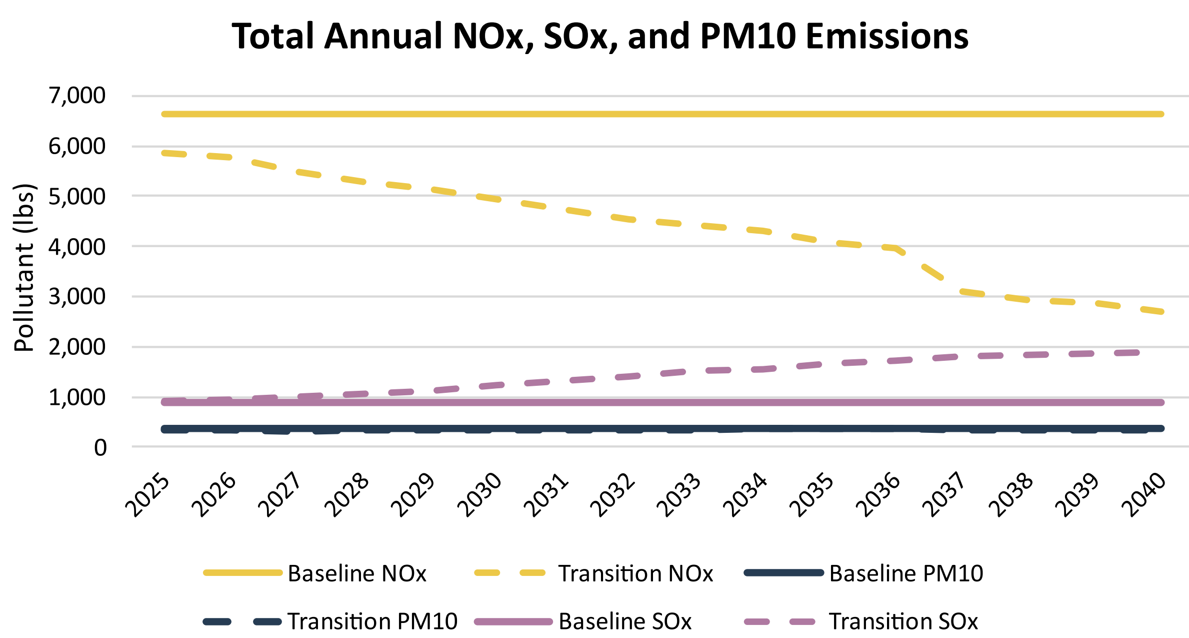

Figure 27: Criteria pollutant (NO_x, SO_x, PM_{10}) emissions in the transition vs. baseline scenarios.

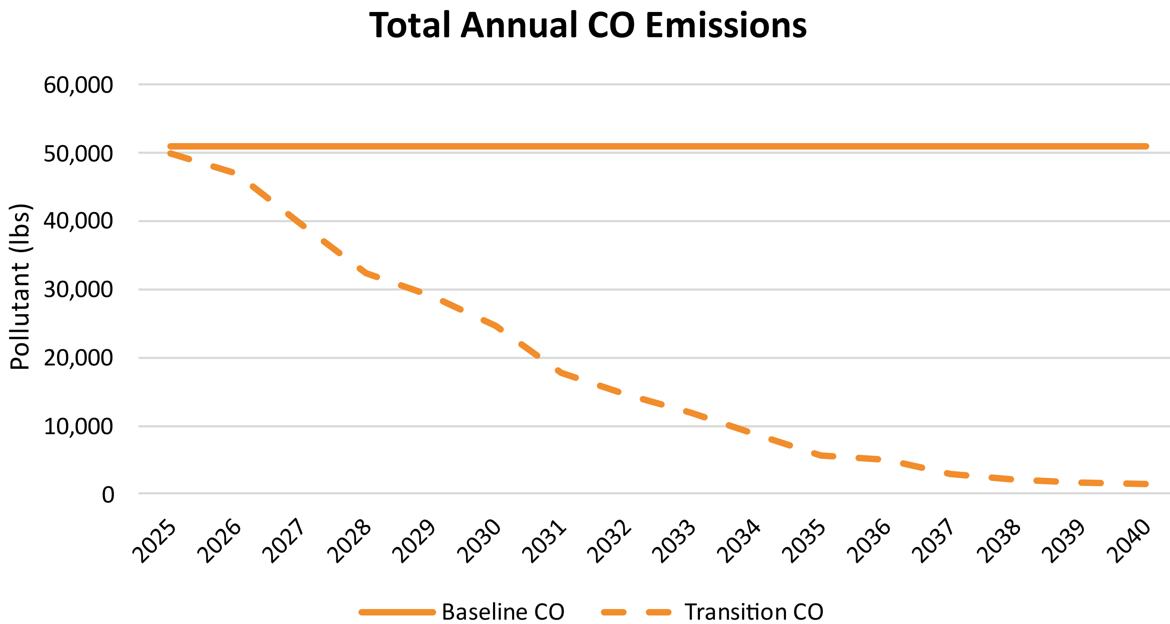

Figure 28: Criteria pollutant emissions (CO) in the transition vs. baseline scenarios.

Through the transition from 2025 – 2040, Glendale is estimated to avoid approximately 53 million pounds GHG emissions compared to the baseline (Table 31). Cumulative criteria pollutant emissions are also reduced in every category except for SO_x. SO_x emissions increase due to electricity partially generated from coal combustion. Sulfur emissions will decrease if electricity generation moves toward non-fossil fuel sources such as nuclear, solar, wind, or hydropower.

Table 31: Baseline vs. Transition Cumulative Emissions, 2025-2040

Pollutant	Cumulative Baseline Emissions (lbs)	Cumulative Transition Emissions (lbs)	Cumulative Difference (lbs)	Cumulative Percent Difference
GHGs	157,499,000	104,441,000	-53,058,000	-34%
CO	817,000	295,000	-522,000	-64%
NO_x	106,000	70,000	-36,000	-34%
SO_x	14,300	22,800	8,500	59%
PM_{10}	6,100	5,500	-600	-10%

Table 32 shows the estimated annual emissions in 2040. If fossil fuels are used to generate electricity, Glendale will not be able to achieve a fully zero-emission operation when considering upstream and in-use emissions; however, when considering only tailpipe emissions, Glendale will nearly achieve zero emission operation in 2040. The exception to this is the continued operation of 12 diesel fire engines and ladder trucks.

Table 32: 2040 Annual Emissions, Baseline vs. Transition

Pollutant	2040 Annual Baseline Emissions (lbs)	2040 Annual Transition Emissions (lbs)	Difference (lbs)	Percent Difference
GHGs	9,844,000	3,771,000	-6,073,000	-62%
CO	51,000	2,000	-49,000	-96%
NO_x	7,000	3,000	-4,000	-57%
SO_x	900	1,900	1,000	+111%
PM_{10}	380	330	-50	-13%

The major differences from the 2022 assessment are:

1. The mix of grid electricity generation has shifted slightly toward natural gas from coal which reduces SO_x, PM, NO_x, and GHG intensities.
2. Upstream emissions are included for all pollutants which increases the total quantities projected.
3. The delay in fleet electrification in the new transition plan increases the cumulative emissions projected.

Cost Assessment

Transition Costs

As a result of the City's asset replacement schedule, duty cycle feasibility, vehicle type suitability, and the City's transition goals, Figure 29 outlines the annual number of EVs purchased that represent first-time replacement of ICE with EVs for a given vehicle. Tracking the first-time cost of replacing conventional vehicles with EVs is important to understand the cost to transition. Note that these totals will change depending on the City's ACF compliance strategy and vehicle exemptions in the near term.

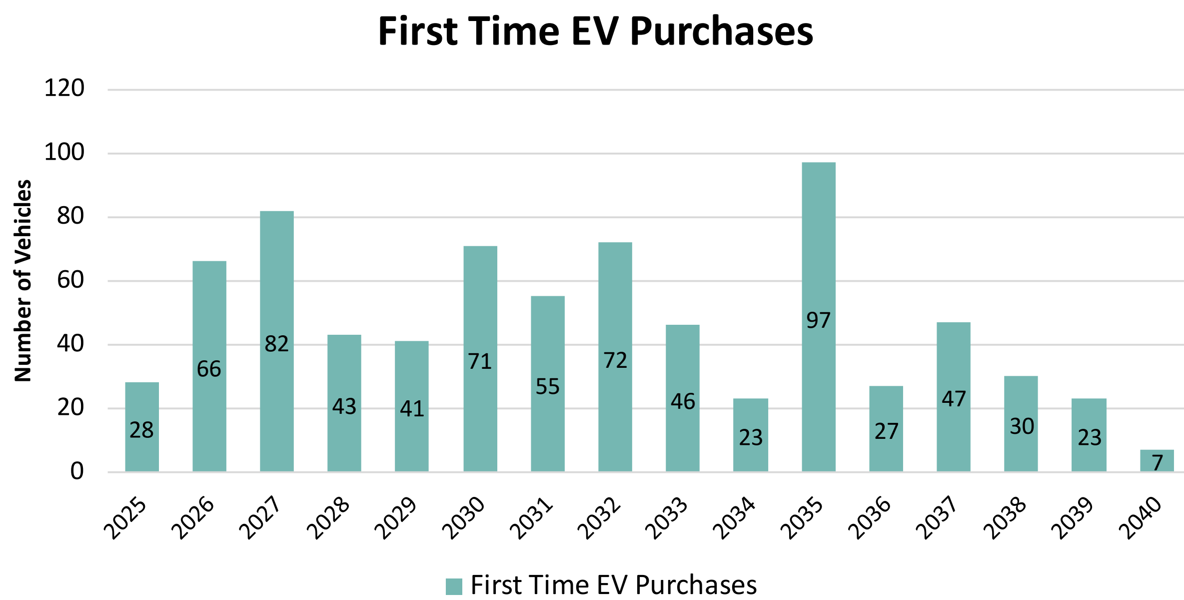

Figure 29: First time EV purchases throughout the transition period.

The incremental EV purchase cost is defined as the difference in cost between the EV and the baseline vehicle for the purchase where the vehicle transitions from ICE to EV (costs of replacing EVs with EVs are excluded, e.g., for second replacements within the timeline or vehicles that are already EV before 2025). Inflation is included. The cumulative incremental cost of the fleet transition is just under $42.6 million (Figure 30).

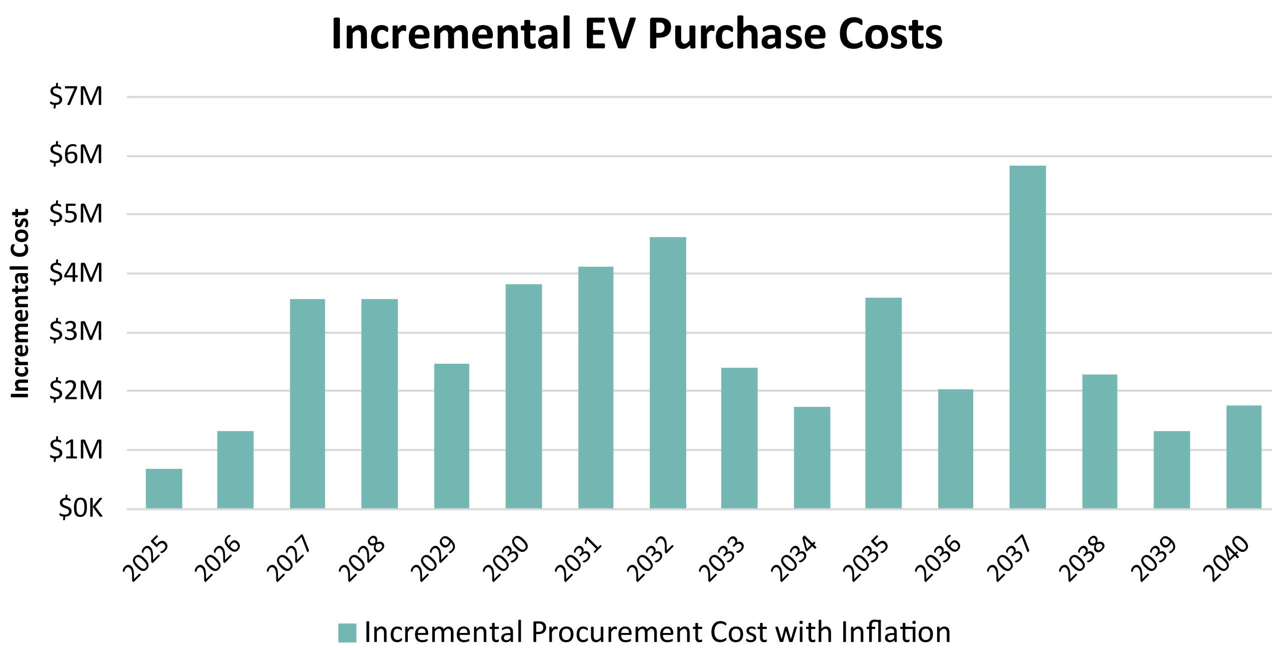

Figure 30: Incremental procurement costs throughout the transition compared to the baseline (no further electrification) scenario.

Total Transition Cost is the total incremental cost of first-time EV replacements plus total EV infrastructure costs. It represents the incremental capital funding required to transition to an all-electric fleet. Table 33 provides the total cumulative transition cost CTE estimates at $67.6 million (Figure 31).

Table 33. Summary of Transition Costs for 2040 Scenario

Glendale Site	Incremental Fleet Costs	Infrastructure Costs	Total Cost
Public Works Yard	$6,770,000	$2,127,000	$8,898,000
City Hall	$2,376,000	$1,225,000	$3,601,000
GWP	$7,179,000	$2,209,000	$9,388,000
Integrated Waste Yard	$8,104,000	$4,569,000	$12,673,000
Fire Station 21	$2,877,000	$2,155,000	$5,032,000
Police Parking Lot	$6,520,000	$8,156,000	$14,676,000
Other (infrastructure: chargers only)	$8,720,000	$4,572,000	$13,291,000
Total	$42,546,000	$25,013,000	**$67,559,000**

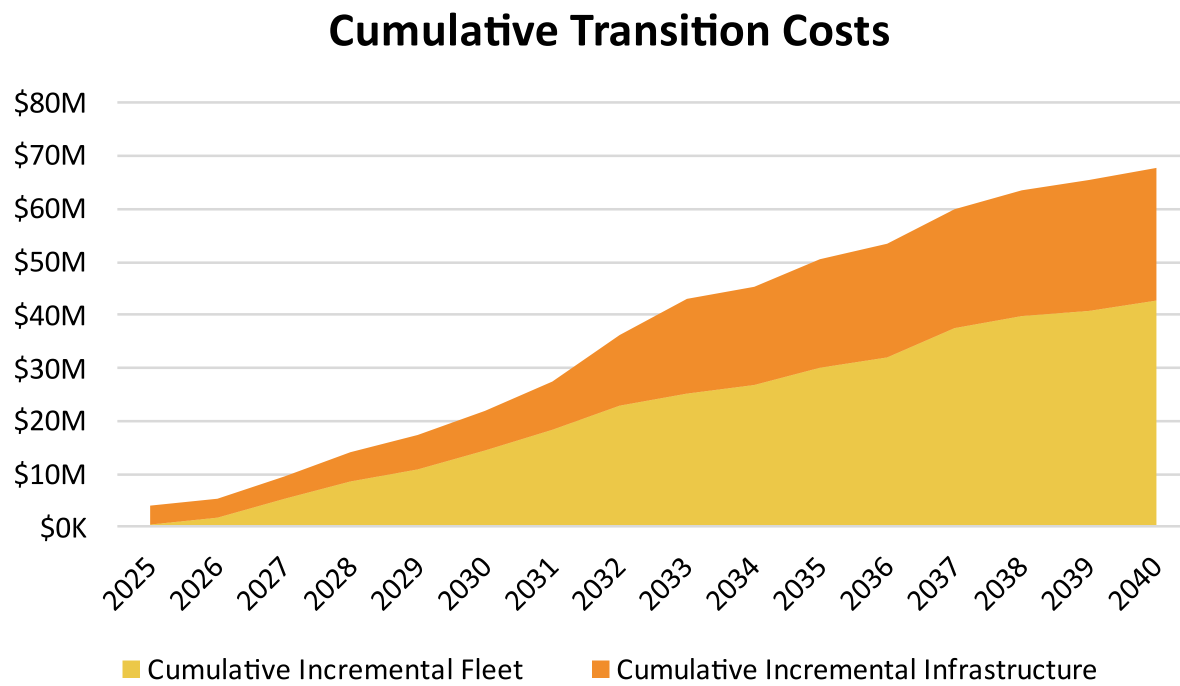

Figure 31: Cumulative Transition Costs

Total Cost of Ownership

The Total Cost of Ownership Assessment (TCO) provides a comprehensive view of costs to Glendale for the transition and baseline scenarios over the transition period by compiling the results from the Fleet, Fuel, Facilities, and Maintenance Assessments. The TCO estimate allows Glendale to make informed decisions based on the best information currently available about costs of each technology and the magnitude of costs of each facet of the transition in relation to others.

The City's TCO for EV Transition considers the total capital investment for the replacement vehicles over the transition period, including both ICEs and EVs, the upgrade of utility service to each facility, the design and construction of charging infrastructure, and the purchase and installation of chargers. The TCO also includes the total fuel and maintenance operating costs over the transition period. Fuel costs include all fuel types over the transition period including electricity, diesel, gasoline, and CNG. Maintenance cost includes maintenance of both ICE and EVs. Other costs may be incurred (e.g., incremental operator and maintenance training) during a fleet transition; however, these four assessment categories are the key drivers in ZEV transition decision-making. TCO includes inflation. Please see cost assumptions for the Fleet, Fuel, Maintenance and Facilities Assessments for details of each element.

This study assumes no cost escalation or any cost reduction due to economies of scale for ZEV technology because there is no historical basis for these assumptions and future market pressures, technology capabilities, and regulations may change significantly over the next 15 years. The assessments provide the best estimates using the information currently available and the assumptions detailed throughout this report.

Figure 32 provides the TCO across the entire fleet color coded by the element: Fleet Procurement, Facilities Projects, Annual Fuel, or Annual Maintenance costs, along with a reference line for the baseline total cost. Fleet and Maintenance costs are the largest costs, although maintenance is more consistent from year to year while fleet varies depending on the vehicles being replaced that year.

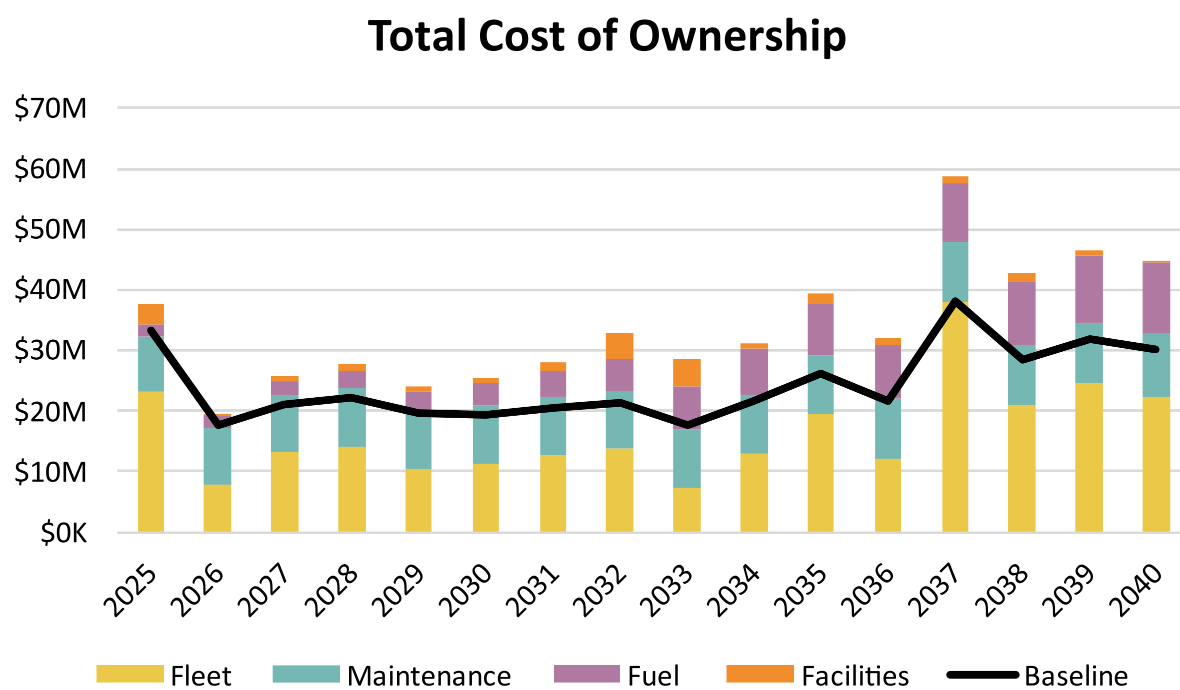

Figure 32. Annual Total Cost of Ownership

The cumulative totals are summarized in Table 34 and graphed in Figure 33. The total cost of the transition is approximately $154 million dollars (39%) more than the baseline scenario over the next 15 years.

Glendale may be able to further offset costs by applying for grants from federal or state agencies, especially for initial investments in ZEVs and infrastructure. The Funding Strategies outlines some funding opportunities.

Glendale may also be able to lower some fuel and infrastructure costs as the first deployments of vehicles reveal what charging strategies work best with Glendale's operations. CTE modeled a more aggressive vehicle to charger ratio to increase charger utilization and decrease space needs; however, Glendale may find that more (or fewer) chargers are needed.

Additionally, as discussed in the Fuel Assessment above, the rates charged by GWP for demand have increased and may continue to increase. Sites with high maximum demand estimates like GPD therefore have much higher fuel costs with electrification. Glendale should work closely with GWP to determine the optimal utility rate each year, as well as if any time-of-use demand rates could be put in place for overnight EV charging. Additionally, steps to limit maximum demand such as staggering charging or using a charge management software to cap demand will reduce the peak demand and therefore the utility bill.

Table 34: Cumulative Total Cost of Ownership

Cumulative Transition Costs	Cumulative Baseline Costs	Cumulative Difference	
$545,203,000	$391,414,000	$153,889,000	+39%

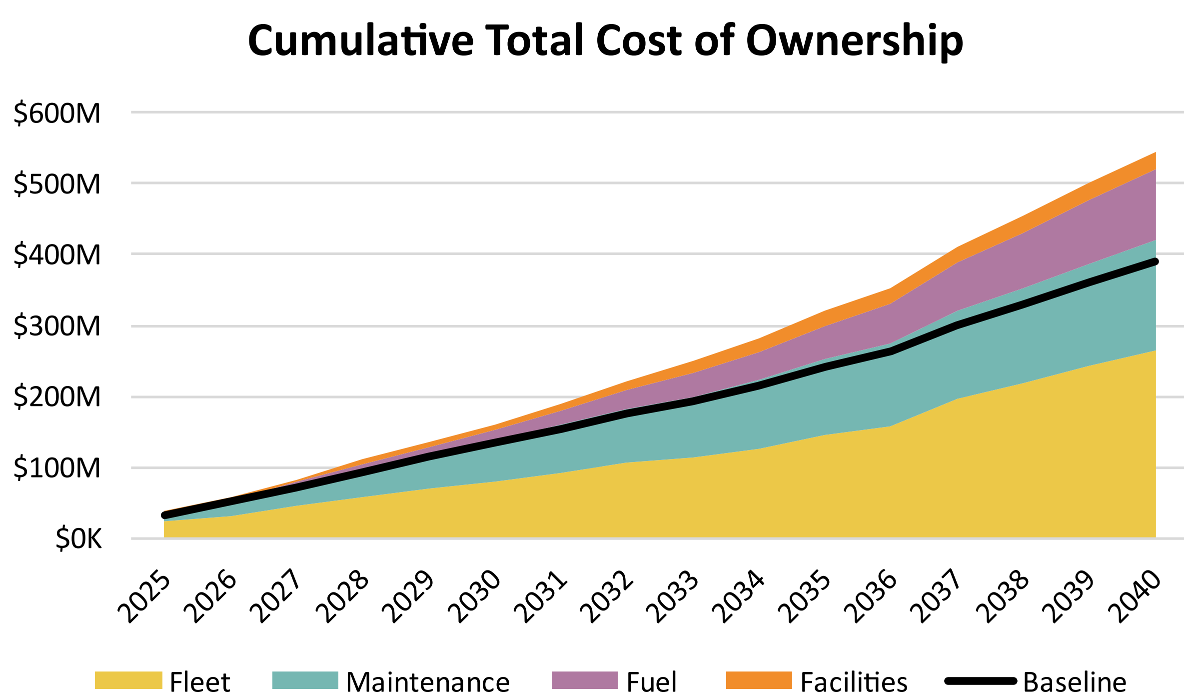

Figure 33. Cumulative Total Cost of Ownership

Funding Strategies

Below are potential zero-emission vehicle and infrastructure funding opportunities available to the city of Glendale, CA. Use the links provided to find more information about the funding programs as well as information on how to apply.

HVIP: HVIP provides point-of-sale vouchers to buyers to help offset higher costs of zero-emission vehicles. Voucher requests are currently open. Eligible vehicles include shuttle buses, vans, step vans, utility vehicles, box trucks, flatbed trucks, tractors, and more. Before applying, purchasers should review the HVIP vehicle catalog to view the zero-emission vehicles approved for the program. Once a vehicle is chosen, the purchaser will contact the approved dealer(s) to proceed. Dealers will apply for the program on the purchaser's behalf.[26]
https://californiahvip.org/funding/#:~:text=HVIP%20will%20reserve%20%2425%20million,to%20fleets%20of%20any%20size,
https://californiahvip.org/purchasers/

VW Environmental Mitigation Trust Funding: The VW settlement provides more than $400 million in funds to California for the state to mitigate excess nitrogen oxide emissions within the atmosphere that are caused by VW's illegal use of emissions testing defeat devices in some VW diesel vehicles. This funding is allocated mostly on "scrap and replace" projects for heavy-duty vehicles such as school buses, shuttle buses, forklifts, and more. Funding from the settlement requires the existing vehicles/engines, except for ocean-going vessel shore power and light-duty zero-emission vehicle infrastructure, to be scrapped and replaced with zero-emission vehicles.[27] Air Quality Management Districts were tasked with managing the funding allocated to five equipment categories. The funding is available statewide.
https://www.californiavwtrust.org/

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[26] "Funding Updates - Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project: California HVIP." Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project | California HVIP, August 23, 2022. https://californiahvip.org/funding/#:~:text=HVIP%20will%20reserve%20%2425%20million,to%20fleets%20of%20any%20size., "Purchasers - Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project: California HVIP." Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project | California HVIP, August 19, 2022. https://californiahvip.org/purchasers/.

[27] "How to Apply for VW Environmental Mitigation Trust Funding." How to Apply for VW Environmental Mitigation Trust Funding. Accessed August 23, 2022. https://ww2.arb.ca.gov/our-work/programs/volkswagen-environmental-mitigation-trust-california/how-apply-vw-environmental.

Low Carbon Fuel Standard ZEV Infrastructure Crediting: A zero-emission vehicle infrastructure crediting provision was added to the 2018 LCFS amendments to support zero-emission vehicle deployments. This new provision allows users to generate LCFS credit for all fuel dispensed along with infrastructure credits, which is calculated by subtracting the amount of dispensed fuel from the capacity of the station or charger. This provision applies to hydrogen refueling infrastructure and direct current fast charging infrastructure.[28] https://ww2.arb.ca.gov/resources/documents/lcfs-zev-infrastructure-crediting, https://www.srectrade.com/markets/lcfs/california

National Electric Vehicle Infrastructure Formula Program: The Federal Highway Administration's program provides funding to states to strategically deploy electric vehicle charging infrastructure and to establish an interconnected network to facilitate data collection, access, and reliability. There is $5 billion available in funding, with the state's share being approximately $384 million over five years.[29] Caltrans and the California Energy Commission are responsible for implementing the funding in California. The program is funded through FY2026 under the Bipartisan Infrastructure Law. https://www.energy.ca.gov/programs-and-topics/programs/national-electric-vehicle-infrastructure-nevi-formula-program

Charging and Fueling Infrastructure Discretionary Grant Program: This competitive grant program administered by the Federal Highway Administration provides funding to strategically deploy publicly accessible electric vehicle charging infrastructure and other alternative fueling infrastructure along designated alternative fuel corridors. At least 50 percent of this funding must be used for a community grant program where priority is given to projects that expand access to EV charging and alternative fueling infrastructure within rural areas, low- and moderate-income neighborhoods, and communities with a low ratio of private parking. The program is funded through FY2026 under the Bipartisan Infrastructure Law.[30] https://www.transportation.gov/rural/ev/toolkit/ev-infrastructure-funding-and-financing/federal-funding-programs

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[28] "California Air Resources Board." LCFS ZEV Infrastructure Crediting | California Air Resources Board. Accessed August 23, 2022. https://ww2.arb.ca.gov/resources/documents/lcfs-zev-infrastructure-crediting.

[29] "Federal Funding Programs." U.S. Department of Transportation. Accessed August 23, 2022. https://www.transportation.gov/rural/ev/toolkit/ev-infrastructure-funding-and-financing/federal-funding-programs.

[30] "Federal Funding Programs." U.S. Department of Transportation. Accessed August 23, 2022. https://www.transportation.gov/rural/ev/toolkit/ev-infrastructure-funding-and-financing/federal-funding-programs.

Diesel Emissions Reduction Act Program: Administered by the Environmental Protection Agency, this program protects human health and improve air quality by reducing harmful emissions from diesel engines. The program can be used to replace heavy-duty diesel vehicles and equipment with electric vehicles and chargers. DERA has multiple grant programs for different types of applicants and projects including National Grants, Tribal and Insular Area Grants, State Grants, and School Bus Rebates.[31] https://www.transportation.gov/rural/ev/toolkit/ev-infrastructure-funding-and-financing/federal-funding-programs

Clean Vehicle Rebate Project (CVRP): The Clean Vehicle Rebate Project for Fleets offers rebates to public agencies, including local or state government entities in California for the purchase or lease of new, eligible zero-emission and plug-in hybrid light-duty vehicles. This program is sponsored by the California Air Resources Board (CARB) and administered by the Center for Sustainable Energy. At the time of lease or purchase, the vehicles must be new and operated and registered in the state of California for at least 30 months. Leased vehicles must be on a 30-month minimum agreement. Additionally, vehicles must be on the CVRP list of eligible vehicles. Facilities in disadvantaged communities in CA are eligible for increased rebates.[32] https://cleanvehiclerebate.org/en/fleet/public-agencies

Southern California Incentive Project (SCIP): The Southern Incentive Project (SCIP) offers rebates to entities in Los Angeles, Orange, Riverside, and San Bernardino counties for the purchase and installation of eligible public electric vehicle chargers. There is currently $29 million available in funds. Rebates include up to $70,000 per DC fast charger (DCFC) and up to $40,000 per DC fast charger. Some disadvantaged communities are eligible for rebates up to $80,000 per DC fast charger installation or 80% of total project cost, depending on the prices. Eligible applicants include public or government entities.[33] https://calevip.org/incentive-project/southern-california

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[31] "Federal Funding Programs." U.S. Department of Transportation. Accessed August 23, 2022. https://www.transportation.gov/rural/ev/toolkit/ev-infrastructure-funding-and-financing/federal-funding-programs.

[32] "Public Fleets." Clean Vehicle Rebate Project. Accessed August 23, 2022. https://cleanvehiclerebate.org/en/fleet/public-agencies.

[33] "Southern California Incentive Project (SCIP)." CALeVIP. Accessed August 23, 2022. https://calevip.org/incentive-project/southern-california.

CEC Clean Transportation Program: Government Fleet Electric Vehicle Charger Station Grants: The California Energy Commission (CEC) Clean Transportation Program provides grants to light-duty local government and tribal government fleets for the purchase, installation, and maintenance of Level 2 and direct current (DC) fast chargers. Applicants may receive up to $12,500 per Level 2 port and up to $100,000 per DC fast charging port. Eligible projects must install a minimum of 100 charging ports. Applicants must be in California and provide a cost share of at least 30%.[34] https://afdc.energy.gov/laws/13405

The Potential for Hydrogen in the City's Fleet

While many applications and use cases for municipal fleet vehicles are well suited to electric vehicles, some applications cannot easily be met with BEVs. Use cases where vehicles have longer range and shorter downtimes may prove a challenge for current and future BEVs. These applications could be addressed by adopting FCEVs. FCEVs have a longer range than most BEVs and can be fueled in minutes vs. hours required by BEVs.

Market Analysis for FCEVs

FCEVs are electric drive vehicles powered by a battery system. The battery is recharged while the vehicle is in operation by a fuel cell that converts hydrogen to electricity. They produce no tailpipe emissions, are more energy-efficient than vehicles with conventional internal combustion engines, and only emit warm air and water vapor. The deployment of FCEVs and the hydrogen infrastructure needed to fuel them is still in its early phases.

FCEVs have had limited deployments due to the limited number of commercially available vehicles. Lack of hydrogen fueling stations and the cost of hydrogen fuel are the primary challenges for OEMs introducing FCEVs. Most OEMs have developed prototypes, although only a few moved forward with models that are available to customers. This section outlines the status of FCEVs and potential for future development.

[34] "Government Fleet Electric Vehicle Charger Station Grants." U.S. Department of Energy Alternative Fuels Data Center. Accessed November 25, 2024. https://afdc.energy.gov/laws/13405

Light-Duty FCEVs

Light-duty FCEVs are now being sold by several automakers in areas with access to hydrogen fueling stations, such as southern and northern California and some regions in New England. Certain quantities of test vehicles are also accessible to groups that have access to hydrogen fueling facilities.

Today, light-duty vehicles are available from several manufacturers including Toyota and Hyundai. The Toyota Mirai (Figure 34), a sedan, and the Hyundai Nexo (Figure 35), an SUV, are two of the most popular light duty FCEVs in the market currently. Depending on the version, the Toyota Mirai has a range between 357-402 miles with a MSRP of $49,500. The Hyundai Nexo has a range between 354-380 miles with a MSRP of $60,135. In 2020, Honda released the Clarity, a light duty FCEV sedan. However, this vehicle was discontinued in 2021 due to slow sales. Currently, OEMs are mostly leasing the FCEVs to customers. To encourage adoption of FCEVs, some OEMs are paying for the hydrogen fuel through fuel cards provided to each customer.

Figure 34. 2023 Toyota Mirai FCEV[35]

[35] https://pressroom.toyota.com/my-vehicles/mirai/

Figure 35. 2023 Hyundai Nexo FCEV[36]

The vehicles have largely received positive reviews, despite industry-wide issues with infrastructure and fuel supply. It should be noted FCEV's exhibit some limitations on how load is applied, with extended high-load applications experiencing fuel-cell overheating. Although vehicles are protected from damage or premature wear, customer experience may be affected when consistent high-load applications are considered. This consideration should be researched at an appropriate time prior to vehicle purchase as technology is rapidly advancing, and new models are being introduced on a near-annual basis.

Availability and Suitability – in the near-term, the City could transition its light-duty sedans and SUVs to FCEV models. However, the City's duty cycle for most of their light-duty sedans and SUVs are better suited to BEVs. As a result, the City should elect to transition to BEVs because they are lower cost and can be charged on-site once charging stations are installed. The current light-duty applications that are challenging to meet with BEVs are pursuit vehicles and motorcycles. No manufacturer is currently working on a hydrogen powered motorcycle. While currently light-duty FCEVs could be used by police for multiple purposes, pursuit vehicles could prove a challenge for FCEVs. No OEM is outfitting a FCEV for police use and speeds are governed. The City would have to work with an OEM to address the speed and fuel cell overheating issues before a FCEV model could be used for pursuit.

Medium- and Heavy-Duty FCEVs

The U.S. Department of Energy (DOE) released a study in which they predict that by 2030, nearly half of medium- and heavy-duty trucks will be cheaper to buy, operate, and maintain as zero emissions vehicles than traditional diesel-powered

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[36] https://www.hyundainews.com/en-us/gallery/photos

combustion engine vehicles[37]. However, today there are not any readily available medium-duty or heavy-duty FCEVs in the market suitable for municipal fleets. Transit buses are available from two manufacturers and are in the early stages of deployment. Heavy-duty trucks have hydrogen options available on a demonstration basis. Current research is focused on Class 8 trucks because this market application is likely a better fit for fuel cell electric propulsion systems because of the fast fueling and longer range. Also, added weight for battery electric models limits the amount of cargo that can be carried which lessens profitability for carriers. Class 6 FCEV truck models, such as those used for package delivery service, have all been demonstrations. Currently, few manufacturers have publicly committed to a commercial product. CARBs Advanced Clean Fleet Regulation is expected to push the industry forward by requiring OEMs to develop ZEV products and setting purchase requirements for fleets. Various federal and state programs are underway to develop medium and heavy-duty ZEVs. Individual OEMs have also announced the development of hydrogen powered commercial trucks. FCET development programs and demonstrations include:

- CARB Advanced Technology Demonstration and Pilot Projects: The agency is funding development and demonstration of zero-emission vehicles for a variety of medium- and heavy-duty applications.[38]
- Zero and Near Zero Emission Freight Facilities: ZANZEFF is another CARB program providing funding to accelerate the adoption of clean technologies for freight applications.[39]
- Million Mile Fuel Cell Truck (M2FCT): DOE funded consortium focused on commercialization of fuel-cell trucks for long-haul applications.[40]
- DOE SuperTruck: As part of DOE's SuperTruck program, Daimler is developing and testing a Class 8 hydrogen fuel cell truck. [41]
- DOE H2 Program: Fuel Cell Hybrid Electric Delivery Van, CTE is leading a project to develop and demonstrate a class 6 delivery truck operated in the UPS fleet.[42]

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[37] Decarbonizing Medium-& Heavy-Duty On-Road Vehicles: Zero-Emission Vehicles Cost Analysis, NREL 2022, web link: https://www.nrel.gov/docs/fy22osti/82081.pdf

[38] CARB listing of projects: https://ww2.arb.ca.gov/lcti-advanced-technology-demonstration-and-pilot-projects

[39] CARB ZANZEFF Program web site: https://www.caclimateinvestments.ca.gov/zero-near-zero-emission-freight-facilities

[40] DOE M2FCT Consortium web site: https://millionmilefuelcelltruck.org/

[41] DOE 2022 Annual Merit Review: https://www.hydrogen.energy.gov/pdfs/review22/ta056_rotz_2022_p.pdf

[42] DOE 2022 Annual Merit Review: https://www.hydrogen.energy.gov/pdfs/review22/ta016_hanlin_2022_p.pdf

- DOE H2 Program: Ford, High Efficiency Fuel Cell Application for Medium Duty Truck Vocations, Ford is leading a project to develop and demonstrate a Class 3-6 FCET.[43]
- Nicola Corporation: Nicola plans to offer a fuel cell powered class 8 tractor in 2023.[44]
- General Motors: GM has announced plans to offer a medium-duty truck platform powered by its HydroTec fuel cell.[45]
- Hyzon Motors: Hyzon develops hydrogen powered commercial vehicles including class 8 tractors and a refuse truck.[46]
- Cummins: the company announced its new brand, Accelera, launched in March 2023 to provide a portfolio of zero-emission powertrains including fuel cell and battery electric [47]

This market is expected to grow as additional policies and incentives are established that promote the production of fuel cell technology and the installation of hydrogen fueling stations expand. Current demonstrations can show that fuel cell technologies for medium- and heavy-duty trucks are feasible, however models specific to the City's applications might not be suitable in the near term. At the current state of development, medium- and heavy-duty FCEVs are not likely to be available before 2030.

Once FCEVs are available, several of the City's applications could potentially be met with this technology.

- Trash Trucks – fast fueling, longer range, and the ability to carry more load make this application a good fit for FCEVs.
- Medium-Duty Utility Trucks – fast fueling, longer range, and the ability to power on-site equipment without depleting the battery make this application a good fit for FCEVs.
- Fire Engines/Ladder Trucks – fast fueling is optimal for vehicles that need to be ready always. Emergency vehicles are also used at a site to power ladders, water pumps, and other loads. OEMs, however, have expressed concerns with hydrogen powered vehicles at an event involving a fire.

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[43] DOE 2022 Annual Merit Review: https://www.hydrogen.energy.gov/pdfs/review22/ta057_bower_2022_p.pdf

[44] Nicola FCET web site: https://nikolamotor.com/tre-fcev/

[45] GM Authority web site: https://gmauthority.com/blog/2021/08/future-medium-duty-chevy-truck-to-use-hydrotec-fuel-cells/

[46] Hyzon Motors web site: https://www.hyzonmotors.com/

[47] Cummins web site: https://www.cummins.com/meet-accelera

- Police Pursuit Vehicles – fast fueling is also optimal for vehicles that need to 'hot swap', where one shift switches with the next without shutting the vehicle down.

Hydrogen Infrastructure

Hydrogen fueling stations can be broken down into heavy-duty, and light-duty categories. Light-duty facilities use a fueling protocol that is internationally recognized and approved by all vehicle OEM's. This protocol ensures minimum standards for process safety at the vehicle/dispenser interface, a complete fill of vehicles, and other considerations affecting customer experience. These facilities are typically designed for passenger vehicles and can accommodate fueling speeds up to ~2.5kg/min. Passenger vehicles do not carry more than 6kg of fuel on board at this time.

Heavy-duty facilities do not have a single, approved fueling protocol at this time, but efforts are underway to establish such standards. Heavy-duty facilities are much more open-ended, and typically achieve fueling rates of more than 2.5kg/min. Typical hydrogen bus fueling facilities are capable of dispensing 30kg of fuel in less than 12 minutes.

Hydrogen fueling stations can be further defined based on how hydrogen is delivered. Most light-duty facilities today use gaseous delivered hydrogen (GH2). Available transport trailers can accommodate up to ~400kg per delivery, with typical installations receiving no more than one delivery per day. As hydrogen consumption increases, the cost and logistical constraints of multiple daily deliveries can be onerous.

Hence, most heavy-duty facilities today use liquified hydrogen gas (LH2) as the delivered feedstock, instead of hydrogen in gaseous form. LH2 transport trailers can accommodate up to ~4000kg per delivery, requiring much less frequent trips. The HRS further benefits from the increased density by maintaining the fuel as a liquid, reducing the cost and space required when compared to gaseous storage systems. Many additional benefits and drawbacks can be explored between GH2 and LH2 delivered facilities which affect everything from cost to performance.

Passenger vehicles can be fueled at a light-duty hydrogen fueling facility. Southern California is host to a few dozen public-access facilities, with private stations being exceedingly rare. Below is a breakdown of typical capital cost. This assumes the installation has sufficient space to accommodate a standard, pre-engineered equipment layout within an existing paved facility. The typical installation will include two independent fueling dispensers capable of simultaneous use. Fuel is delivered via gaseous delivery trailers and is stored at the facility in high-pressure gaseous storage vessels. Fuel is then compressed and cooled prior to dispensing into the vehicle.

Typical characteristics of a Light-duty hydrogen fueling facility for passenger vehicles:

1. No. of dispensers: 2
2. Typical fuel delivery: up to ~400kg GH2
3. H70 grade fuel (700 bar settled pressure onboard vehicle)
4. Pre-cooling of hydrogen prior to dispensing is required by J2601 fueling protocol.
5. Cost: ~$5.5MM
   a. Equipment: $3MM
   b. Construction and installation: $1MM
   c. Engineering, project management, and permitting: $0.5MM
   d. Electrical power utility service and associated cost: $0.5MM
   e. Miscellaneous costs: $0.5MM

Heavy-duty hydrogen fueling stations are predominantly used in the transit industry today. Aside from most facilities using LH2, they differ from light-duty by dispensing H35 grade fuel (350 bar settled pressure onboard vehicle). Since buses have more excess room onboard to store fuel when compared to passenger vehicles, a lower pressure threshold leads to lower cost and complexity. A concerted effort is underway to develop both vehicles and infrastructure to support class-8 trucks, however vehicles are unlikely to be deployed commercially for a few years to come. Due to space constraints on most commercial vehicles, simultaneous efforts are underway to increase storage pressure to 700 bar (H70). Typical process description for a heavy-duty HRS using LH2 as a feedstock is as follows: hydrogen stored as a liquid on-site in a cryogenic bulk storage vessel. Liquid is drawn from the tank where it is pumped to high pressure prior to being vaporized through large ambient heat exchanger (vaporizer). Hydrogen is then stored at one or multiple pressures in gaseous form prior to being routed through a dispenser and into customer vehicles. Below is a breakdown of typical specifications and cost for a heavy-duty fueling facility designed for hydrogen powered buses (FCEB's) which could be applicable to other heavy-duty applications such as trash trucks.

Typical characteristics of a Heavy-duty hydrogen fueling facility for buses and heavy-duty vehicles:

1. No. of dispensers: 2
2. Typical fuel delivery: up to ~4000kg LH2
3. H35 grade fuel (350 bar settled pressure onboard vehicle)
4. Pre-cooling of hydrogen prior to dispensing is not required but will improve speed of fueling and how full the vehicle is filled.
5. Cost: ~$7MM
   a. Equipment: $4MM
   b. Construction and installation: $1.5MM
   c. Engineering, project management, and permitting: $0.5MM

d. Electrical power utility service and associated cost: $0.5MM
e. Miscellaneous costs: $0.5MM

The City could adopt a similar strategy as used for its CNG vehicles, where fuel is supplied through a third-party agreement. The City would become an anchor fleet for a hydrogen fuel provider that could help justify building and operating a new station. As a guaranteed station load, the City could work with the station provider on a long-term fuel contract that would help budget for fueling costs. Current costs for transit agencies that are operating FCEBs average between $9 and $12 per kg. Considering how few FCEVs are on the road, calculating the amount of hydrogen needed to power the City's fleet can be a challenge. CTE estimated the fuel economy of each type of vehicle based on the data available for light-duty FCEVs and demonstrations of medium- and heavy-duty FCETs. If the City's vehicles accumulate similar miles as that provided for the 2018-2019 fiscal years, the fleet would require around 283,000 kg of hydrogen if all were converted to FCEVs. This amounts to 5,400 kg per week. At the current cost of $10 per kg, that would amount to a fuel cost of more than $2.8 million per year.

During the early stage of transition, the City could benefit from using a mobile fueler to provide hydrogen. The use of this type of solution would allow the City to cost-effectively increase its number of FCEVs until a full size station is warranted. The Rochester-Genesee Regional Transportation Authority recently approved a contract for a 5-year lease and maintenance of a mobile fueler at the cost of approximately $2 million.[48] This does not include the cost of fuel, which can be higher than typical costs for permanent stations (~$15 per kg). The mobile fueler has a capacity of around 1,600 kg, which could provide 1,500 kg of hydrogen per day. The unit can be outfitted to fuel at 350 or 700 bar.

Local Station Availability

The state of California has helped fund hydrogen stations in both Southern and Northern California. Using these existing stations could be an interim or permanent solution for fueling the City's light-duty FCEV fleet. The Hydrogen Fuel Cell Partnership tracks the location and status of hydrogen stations in California.[49] Figure 36 provides a snapshot of the hydrogen stations located around Glendale. The station locator provides addresses and status of fueling at stations in the state.

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[48] RGRTS December 2022 Regular Board Meeting Minutes: https://www.myrts.com/Portals/0/Documents/Board/Board%20Meeting%20Minutes/December%202022%20Regular%20Board%20Meeting%20Minutes.pdf?ver=2023-02-01-113005-470 See pages 50, 52.

[49] Hydrogen Fuel Cell Partnership Station Locator web site: https://h2fcp.org/stationmap

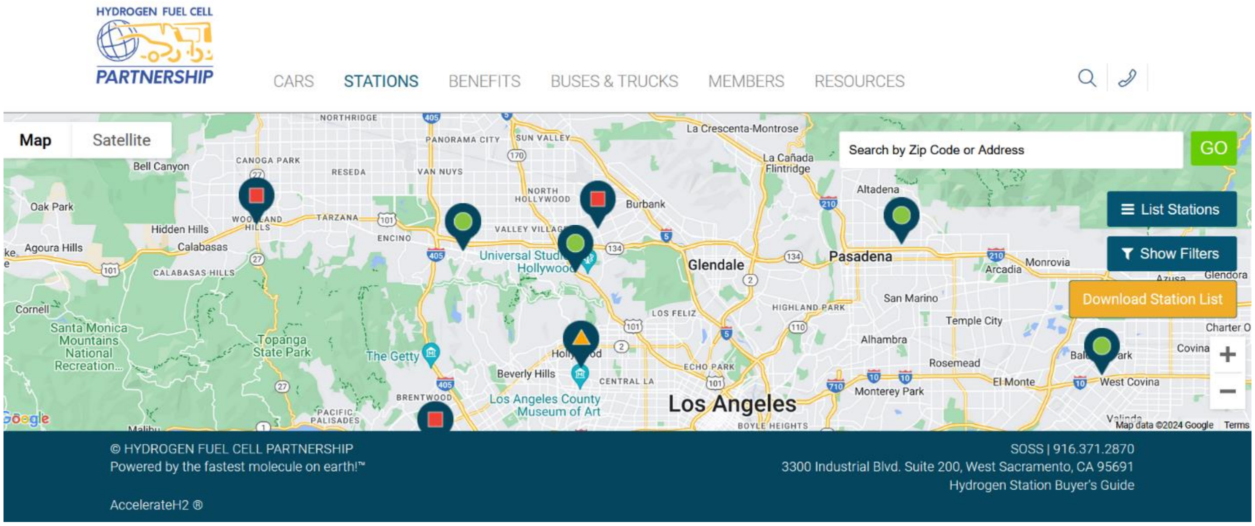

Figure 36. Screenshot of the Hydrogen Fuel Cell Partnership's Hydrogen fueling station locator

Table 35 lists the stations nearest the City that could be used for light-duty fueling. Current costs for hydrogen are quite high and began to rise beginning in late 2022. The average price at California retail stations in October 2024 was $34.55/kg.[50] FCEVs are more efficient compared to conventional vehicles, with current light-duty models capable of achieving 72 miles per kg. With the high capital costs for installing a station, this might be a cost-effective solution until the City has enough FCEVs to make a case for constructing on-site fueling.

Table 35. Hydrogen Stations near Glendale

Station	Location	Pressure offered	Renewable	Approximate Distance from Glendale (City Hall)
Burbank	800 N Hollywood Way, Burbank, CA 91505	H70	100%	7
Studio City	3780 Cahuenga Blvd, Studio City CA 91604	H35, H70	100%	9
Pasadena	475 North Allen Ave, Pasadena, CA 91106	H70	100%	9

[50] Hydrogen Central Article: https://hydrogen-central.com/california-hydrogen-pump-prices-for-light-duty-vehicles-reach-new-highs/

Station	Location	Pressure offered	Renewable	Approximate Distance from Glendale (City Hall)
Fairfax – LA	7751 Beverly Blvd, Los Angeles, CA 90036	H70	33%	10
Sherman Oaks	14478 Ventura Blvd Sherman Oaks, CA 91423	H35, H70	100%	14

Conclusions and Recommendations

Since the last assessment, the EV market has progressed leading to a more feasible transition for Glendale's fleet. CTE has also improved upon the previous analysis, providing higher confidence in the feasibility for EVs in Glendale's duty cycles and optimizing the recommended charging infrastructure, leading to lower infrastructure capital costs. Developments such as the implementation of the ACF regulation and increasing demand costs have introduced aspects that need further attention from Glendale.

As discussed in the Fleet Assessment, there is a mismatch in the vehicles that the ACF regulation considers suitable for an EV replacement and those that Glendale considers suitable for heavy pickups (greater than ¾ ton, or class 2b-3). To meet ACF purchase percentage requirements while continuing to replace vehicles as needed, Glendale will need to consider the assets up for replacement and pursue one of the following strategies:

1. **Delay purchase of vehicles** to decrease the percentage of ICE vehicles purchased each year.
2. **Replace some Class 2b-3 pickups with available EV models** such as a ½ ton pickup, a van-type cab and chassis, or a heavier Class 4 trucks.
3. Explore other avenues for **ACF exemptions.**[51]

As discussed in the Fuel Assessment, CTE projects much higher electricity costs than the last assessment in large part due to rate increases at GWP. Most electricity costs are due to high demand rates. Therefore, CTE recommends that the City may be able to lower utility costs with the following strategies:

- **Limit maximum demand** by reducing the number of chargers in use at once, reducing charging speeds when possible, by charging overnight, or investing

[51] October 2024 ACF Exemption Guidance

in a charge management system to automatically limit demand according to the City's parameters.

- **Discuss potential EV charging rates with GWP**. Many utilities such as Southern California Edison[52] offer different rates for EV-only meters to mitigate demand charges. Additionally, the City could advocate for a time-of-use component for demand rates to take advantage of overnight charging. Furthermore, the City should collaborate with GWP every few years to determine the optimal rate schedule for each terminal as the demand and energy needs increase.

- Consider **other infrastructure to reduce the peak demand** from the grid. Infrastructure such as on-site battery storage can be charged when electricity is cheaper during off-peak hours or from on-site solar generation and then discharged during peak hours to reduce the maximum demand on-peak which may reduce costs and improve resilience.

Finally, CTE recommends the following as Glendale continues its transition process:

- **Remain proactive with grant funding** to reduce the capital costs of vehicles early in the transition.
- **Continue to revisit the transition plan** every 2-3 years as ZE technologies and regulations evolve and the City becomes more experienced with EVs.
- **Begin resilience planning for the EV fleet** as resilience practices and procedures will change for an EV fleet and the City will be able to depend less and less on ICE vehicles as they are phased out.
- **Remain engaged with the Police and Fire Departments** to pilot ZEVs and find models that meet their needs. Support of the vehicle operators in every department will be critical for successful deployment.

[52] Southern California Edison Business EV Rates

Appendix A: City of Glendale Vehicle Market Analysis

The tables in this appendix contain the available ZEVs that are most likely a good fit for Glendale's fleet. CTE eliminated luxury models from the list. Prices are either a price range or a base price.

The vehicles are separated into five primary categories:

Table A1. Market Analysis Vehicle Categories

Light Duty	Medium Duty	Heavy Duty	Emergency Response	Non-road
• Sedan • SUV • Small SUV • Pickup • Sweeper Truck • Motorcycles • Van, Cargo • Van, Passenger	• Dump Truck • Garbage Truck • Medium Duty Vans • Medium Duty Trucks	• Refuse Trucks • Dump Trucks • Roll-off Trucks • Heavy Trucks • Flatbed Trucks • Manlift Trucks • Crane Trucks	• Fire Engines • Pursuit Vehicles	• Forklift • Backhoe • Loader • Excavator • Golf Cart • Lawn Mower • Low Speed Vehicle (LSV) • Utility Vehicle

Table A2. Light Duty Market Options

	Arrival	Audi	BMW		Boulder Electric Vehicles	Cadillac
Vehicle Type	Van, Cargo	SUV	Sedan/ Wagon	SUV	Truck, Flatbed	SUV
Price*	>$100,000	$49,000 – 110,000	$55,000 – 105,000	$87,100	*Contact OEM*	>$61,000
Battery Size	67-139 kWh	82-114 kWh	54-111 kWh	111 kWh	72 kWh	119 kWh
Range (miles)	112 - 211	242 - 300	245 - 310	217-307	90	314-400
Run Time (hours)	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM

Table A3. Light Duty Market Options Continued

	Chevrolet			Dodge	Ford			General Motors
Vehicle Type	SUV	Sedan/ Wagon	½ ton truck	Van, Cargo	Van, Cargo	½ Ton truck	Sedan/Wagon	Van, Cargo
Price*	$51,800	$26,500 – 51,800	$74,800	$77,995 – 86,995	$51,000 – 58,000	$49,995 – 91,995	$42,435	$74,900
Battery Size	99 kWh	60 – 66 kWh	168-208 kWh	47 – 79 kWh	68 – 90 kWh	98 – 131 kWh	70 kWh	165 kWh
Range (miles)	279	259	393-450	Up to 162	126 -159	240 -320	230	250 - 272
Run Time (hours)	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM

Table A4. Light Duty Market Options Continued

	General Motors	Genesis		GMC		Hyundai	
Vehicle Type	Van, Cargo	Sedan/ Wagon	SUV	½ Ton truck	SUV	Sedan/ Wagon	SUV
Price*	$74,900	$66,450 – 79,825	$59,290	$98,845	$96,550	$37,500 – 51,100	$33,550
Battery Size	165 kWh	77 – 87 kWh	77 – 87 kWh	199	199	53 – 77 kWh	48 - 135
Range (miles)	250 - 272	236 –282	248 – 294	305	305	240 -330	220 - 380
Run Time (hours)	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM

Table A5. Light Duty Market Options Continued

	Kia	Nissan	Polestar	Rivian			Toyota
Vehicle Type	SUV	Sedan/ Wagon	Sedan/ Wagon	Truck	Van	SUV	Sedan/Wagon
Price*	$48,500 – 54,900	$28,140 – 60,190	$49,900 – 74,800	$71,700 – 92,000	$86,325	$43,650 – 78,000	$43,070 - $47,180
Battery Size	77 – 99 kWh	40 – 87 kWh	78 – 111 kWh	105 – 180 kWh	153 – 161 kWh	106 – 163 kWh	71 kWh
Range (miles)	218 - 304	150 - 304	247 - 320	270 - 410	153 - 161	274 - 321	236 - 252
Run Time (hours)	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM

Table A6. Light Duty Market Options Continued

	Volvo	Volkswagen	
Vehicle Type	SUV	SUV	Van, Mini**
Price*	$36,350 – 55,300	$43,995 – 47,795	$59,995 – 67,995
Battery Size	77 kWh	81 kWh	91 kWh
Range (miles)	255 - 295	263 - 291	*Contact OEM*
Run Time (hours)	Contact OEM	Contact OEM	Contact OEM

Table A7. Light Duty Options

Light Duty 4WD/AWD SUV Options	
OEM	Specification Ranges
Audi BMW Cadillac Chevrolet Genesis GMC Hyundai Kia Mercedes-Benz Rivian Subaru Volkswagen Volvo	Class: AWD SUV Price: $36,350 – 109,300 Battery Size: 72 – 199 kWh Range: 271 – 410 miles

Table A8. Medium Duty Market Options

	Battle Motors	Blue Arc	BYD	Freightliner	GreenPower	Kenworth
Vehicle Type	Chassis Cab	Van, Cargo	Refuse Truck	Vocational/Cab Chassis	Van, Passenger	Vocational/Cab Chassis
Price*	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM
Battery Size	240 – 400 kWh	158 kWh	211 kWh	194 kWh	118 kWh	141 – 282 kWh
Range (miles)	130 – 150	200	80	190	150	190 - 218
Run Time (hours)	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM

Table A9. Medium Duty Market Options Continued

	Lion Electric	Mack		Peterbuilt
Vehicle Type	Vocational/Cab Chassis	Refuse Truck	Vocational/Cab Chassis	Vocational/Cab Chassis
Price*	Contact OEM	Contact OEM	Contact OEM	Contact OEM
Battery Size	210 – 282 kWh	Contact OEM	Contact OEM	141 – 282 kWh
Range (miles)	190 – 218	100	230	100 - 200
Run Time (hours)	Contact OEM	Contact OEM	Contact OEM	

Table A10. Medium Duty Market Options Continued

	Phoenix Motorcars				
Vehicle Type	Shuttle Bus	Truck, Box Truck	Truck, Dump	Truck, Flatbed	Truck, Utility
Price*	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM
Battery Size	90 – 131 kWh	90 – 131 kWh	90 – 131 kWh	90 – 131 kWh	90 – 131 kWh
Range (miles)	135 - 165	135 - 165	135 - 165	135 - 165	135 - 165
Run Time (hours)	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM

Table A11. Medium Duty Market Options Continued

	Volvo	Workhorse		
Vehicle Type	Vocational/Cab Chassis	Vocational/Cab Chassis	Van, Cargo	Chassis
Price*	Contact OEM	Contact OEM	Contact OEM	Contact OEM
Battery Size	377 kWh	118 kWh	118 kWh	210 kWh
Range (miles)	190 - 230	150	150	150
Run Time (hours)	Contact OEM	Contact OEM	Contact OEM	Contact OEM

Table A12. Heavy Duty Market Options

	Battle Motors	BYD	Elgin Sweeper	Freightliner	Fulongma	Kenworth	
Class	Refuse Truck	Refuse Truck	Street Sweeper	Semi Truck	Street Sweeper	Semi Truck	Vocational/ Cab Chassis
Price*	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM
Battery Size	240 – 400 kWh	221 – 281 kWh	400 kWh	396 kWh	218 – 314 kWh	396 kWh	141 – 282 kWh
Range (miles)	150 - 200	125	242	150	230 - 242	150	100 - 200
Run Time (hours)	Contact OEM	Contact OEM	8	Contact OEM	6-8	Contact OEM	Contact OEM

Table A13. Heavy Duty Market Options Continued

	Lion Electric	Mack		McNeilus / Oshkosh	Peterbuilt	Volvo
Class	Semi Truck	Refuse Truck	Vocational/Cab Chassis	Refuse Truck	Cab Chassis	Semi Truck
Price*	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM
Battery Size	630 kWh	376 kWh	150 – 240 kWh	499 kWh	141 – 282 kWh	377 – 565 kWh
Range (miles)	275	100	100 - 200	Contact OEM	100 - 200	175 - 275
Run Time (hours)	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM

Table A14. Non-Road Market Options

	Bomag	Club Car	Columbia	Cushman			EZ-GO	Genie	Global Electric
Class	Roller	Utility Vehicle	Low Speed Vehicle	Low Speed Vehicle	Utility Transport	Utility Vehicle	Utility Transport	Boom Lift	Low Speed Vehicle
Price*	Contact OEM	$8,000 - 27,000	Contact OEM	Contact OEM	Contact OEM	Contact OEM	$10,299 – 16,044	Contact OEM	$15,240 – 21,240
Battery Size	48 V	48 V	48 V	39.2 V	56 V	56 V	56 V	48 V	Contact OEM
Range (miles)	Contact OEM	50 - 60	40	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	78 - 113
Run Time (hours)	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM

Table A15. Non-Road Market Options Continued

	Greenworks	Haulotte	HDK Electric Vehicles	JLG		John Deere		MeanGreen
Class	Tractor, Compact	Boom Lift	Utility Transport	Boom Lift	Scissor Lift	Utility Vehicle	Lawn Mower	Lawn Mower
Price*	$4,599 – 4,799	Contact OEM	Contact OEM	$169,535	$32,383	$15,500	$6,400	$16,000 – 71,500
Battery Size	Contact OEM	48 – 72 V	48 V	16 kWh	24 V	12 kWh	3 kWh	7 – 35 kWh
Range (miles)	2	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM
Run Time (hours)	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM	2.25 - 8

Table A16. Non-Road Market Options Continued

	Polaris	Skyjack	Solectrac	Wirtgen	Yamaha
Class	Utility Vehicle	Scissor Lift	Utility Transport	Roller	Utility Transport
Price*	$11,000 –14,000	$14,495	$29,249	Contact OEM	$9,000
Battery Size	48 V	24 V	48 V	48 V	48 V – 54.4 kWh
Range (miles)	45- 68	Contact OEM	Contact OEM	Contact OEM	Contact OEM
Run Time (hours)	Contact OEM	Contact OEM	Contact OEM	Contact OEM	Contact OEM

Appendix B: Feasibility by Vehicle Type

Table B1. Operational requirements, fuel economies, and vehicle costs for the fleet sorted by vehicle type and fuel type. Numbers in red were estimated by CTE.

Vehicle Type	Class	Fuel Type	Average Fuel Economy	Fuel Economy unit	Number of Assets	Active Days per Year	Average Daily Usage	Strenuous Daily Usage	Usage Unit	Planned Service Life (years)	EV Capital Cost ($)	Baseline Capital Cost ($)
Asphalt Paver	Non-road	Diesel	2.00	gal/hr	1	50	7.8	11.7	Hours	10	$80,939	$50,587
Backhoe Loader	Non-road	Diesel	1.13	gal/hr	13	50	3.9	5.9	Hours	13	$237,936	$148,710
Boom lift	Non-road	Diesel	2.00	gal/hr	1	10	1.8	2.7	Hours	10	$172,225	$52,565
Bunker Rake	Non-road	Gasoline	1.00	gal/hr	6	50	1.8	2.7	Hours	10	$21,445	$13,403
Excavator, Compact	Non-road	Diesel	0.55	gal/hr	3	50	3.0	4.5	Hours	10	$90,000	$33,846
Concrete Cutter	Non-road	Diesel	2.01	gal/hr	1	10	3.7	5.6	Hours	15	$325,643	$203,527
Digger Derrick	Non-road	Diesel	1.00	gal/hr	1	10	1.5	2.3	Hours	15	$215,590	$134,744
Forklift, Light	Non-road	EV	9.00	kWh/hr	5	50	4.8	7.2	Hours	12	$37,092	$37,092
Forklift, Light	Non-road	Diesel	1.00	gal/hr	1	10	2.3	3.5	Hours	12	$37,092	$25,736
Forklift, Light	Non-road	Propane	1.53	gal/hr	2	10	2.3	3.5	Hours	12	$37,092	$25,736
Hammer	Non-road	Diesel	2.00	gal/hr	1	5	2.0	3.0	Hours	12	$143,888	$89,930
Forklift, Heavy	Non-road	Diesel	1.16	gal/hr	2	50	1.9	2.8	Hours	12	$299,667	$109,246
Forklift, Heavy	Non-road	EV	11.00	kWh/hr	1	50	1.9	2.9	Hours	12	$299,667	$299,667
Tractor, Compact	Non-road	Diesel	0.45	gal/hr	2	5	2.4	3.6	Hours	11	$68,264	$42,665
Loader, Skid Steer, Compact	Non-road	Diesel	1.87	gal/hr	1	5	3.9	5.9	Hours	11	$240,000	$107,802
Loader, Skid Steer	Non-road	Diesel	0.79	gal/hr	1	50	3.2	4.8	Hours	11	$86,650	$54,156
Loader, Track Steer, Compact	Non-road	Diesel	1.73	gal/hr	1	50	1.5	2.3	Hours	15	$325,000	$83,209
Mower	Non-road	Diesel	1.06	gal/hr	8	30	4.7	7.1	Hours	8	$71,500	$25,265

Vehicle Type	Class	Fuel Type	Average Fuel Economy	Fuel Economy unit	Number of Assets	Active Days per Year	Average Daily Usage	Strenuous Daily Usage	Usage Unit	Planned Service Life (years)	EV Capital Cost ($)	Baseline Capital Cost ($)
Mower	Non-road	Gasoline	1.19	gal/hr	2	30	5.0	7.5	Hours	8	$71,500	$25,265
Order picker	Non-road	EV	0.50	kWh/hr	1	5	2.0	3.0	Hours	10	$38,078	$38,078
Roller	Non-road	Diesel	0.61	gal/hr	2	10	1.9	2.9	Hours	13	$63,037	$39,398
Root cutter	Non-road	Gasoline	1.10	gal/hr	1	5	2.0	3.0	Hours	15	$27,242	$17,026
Scissor lift	Non-road	EV	0.81	kWh/hr	2	5	2.0	3.0	Hours	13	$19,036	$19,036
Stump Grinder	Non-road	Diesel	1.25	gal/hr	2	10	1.6	2.4	Hours	13	$112,563	$70,352
Stump Grinder	Non-road	Gasoline	1.10	gal/hr	1	10	2.0	3.0	Hours	13	$112,563	$70,352
Utility Sweeper	Non-road	Diesel	0.24	gal/hr	2	5	1.0	1.4	Hours	7	$57,613	$36,008
Utility Sweeper	Non-road	Gasoline	0.26	gal/hr	4	5	0.8	1.2	Hours	7	$57,613	$36,008
Utility Vehicle	Non-road	EV	1.00	kWh/hr	14	20	4.2	6.3	Hours	8	$21,426	$21,426
Utility Vehicle	Non-road	Diesel	0.12	gal/hr	3	5	1.2	1.9	Hours	8	$21,426	$13,391
Utility Vehicle	Non-road	Gasoline	0.11	gal/hr	16	25	5.2	7.8	Hours	8	$21,426	$13,391
Wheel Loader	Non-road	Diesel	1.13	gal/hr	3	100	2.0	3.0	Hours	10	$286,037	$178,773
1 Ton Pickup	Light	Diesel	13.69	mpg	2	20	33	50	Miles	10	$71,109	$44,443
1 Ton Pickup	Light	Gasoline	6.15	mpg	48	150	21	32	Miles	10	$71,109	$44,443
1/2 Ton Pickup	Light	Gasoline	13.47	mpg	38	150	33	49	Miles	9	$61,300	$36,007
1/2 Ton Pickup	Light	EV	0.54	kWh/mi	1	150	33	50	Miles	9	$61,300	$61,300
3/4 Ton Pickup	Light	Gasoline	7.63	mpg	46	200	20	29	Miles	10	$59,200	$37,000
Command, Pickup	Emergency	Gasoline	16.51	mpg	4	200	65	97	Miles	8	$81,584	$50,990
Command, Sedan	Emergency	Gasoline	36.37	mpg	1	150	12	19	Miles	10	$77,363	$48,352
Command, SUV	Emergency	Gasoline	17.66	mpg	8	260	33	49	Miles	10	$111,678	$69,799
Compact Pickup	Light	Gasoline	13.33	mpg	53	200	25	37	Miles	9	$44,640	$27,900
Emergency Specialty, Heavy	Emergency	Diesel	7.22	mpg	6	50	23	35	Miles	13	$465,824	$291,140

Vehicle Type	Class	Fuel Type	Average Fuel Economy	Fuel Economy unit	Number of Assets	Active Days per Year	Average Daily Usage	Strenuous Daily Usage	Usage Unit	Planned Service Life (years)	EV Capital Cost ($)	Baseline Capital Cost ($)
Emergency Specialty, Light	Emergency	Diesel	4.92	mpg	1	50	19	28	Miles	13	$81,458	$50,911
Emergency Specialty, Light	Emergency	Gasoline	5.79	mpg	1	50	27	40	Miles	13	$81,458	$50,911
Emergency Specialty, Medium	Emergency	Diesel	9.95	mpg	3	50	12	18	Miles	13	$408,776	$255,485
Emergency Specialty, Medium	Emergency	Gasoline	6.70	mpg	1	50	10	14	Miles	13	$408,776	$255,485
Fire Engine	Emergency	Diesel	3.49	mpg	16	200	31	46	Miles	20	$1,279,983	$673,675
Heavy Truck	Heavy	Gasoline	1.83	mpg	2	20	17	26	Miles	12	$477,747	$298,592
Heavy Truck	Heavy	Diesel	4.00	mpg	1	20	53	80	Miles	12	$477,747	$298,592
Heavy Truck	Heavy	CNG	3.20	mpg	7	20	125	188	Miles	12	$477,747	$298,592
Ladder Truck	Emergency	Diesel	2.13	mpg	4	200	23	35	Miles	20	$1,924,026	$1,012,645
Minivan	Light	Gasoline	15.64	mpg	41	200	20	30	Miles	9	$55,790	$34,869
Motorcycle	Pursuit	Gasoline	35.20	mpg	27	200	31	47	Miles	5	$50,398	$31,499
Motorcycle	Light	EV	0.24	kWh/mi	2	200	31	47	Miles	5	$20,085	$20,085
Refuse Truck	Heavy	CNG	5.24	mpg	38	200	46	69	Miles	9	$516,269	$322,668
Rescue, 1.5 ton Pickup	Emergency	Diesel	8.22	mpg	12	200	52	78	Miles	10	$278,170	$173,856
Sedan	Light	Gasoline	24.55	mpg	56	200	26	40	Miles	8	$44,629	$27,327
Sedan	Light	EV	0.33	kWh/mi	20	25	10	15	Miles	8	$44,629	$44,629
Street Sweeper	Heavy	CNG	5.24	mpg	6	200	28	43	Miles	7	$627,166	$391,979
SUV	Light	Gasoline	17.86	mpg	35	200	21	31	Miles	9	$56,326	$35,204
SUV	Light	EV	0.38	kWh/mi	1	200	16	24	Miles	9	$56,326	$56,326
SUV, Police	Pursuit	Gasoline	17.90	mpg	32	200	52	77	Miles	4	$99,306	$55,170
SUV, Patrol	Pursuit	Gasoline	10.46	mpg	71	200	52	77	Miles	4	$99,306	$55,170
Truck, Crane	Heavy	CNG	2.29	mpg	4	50	13	20	Miles	12	$389,917	$243,698
Truck, Crane	Heavy	Diesel	2.87	mpg	2	50	37	56	Miles	12	$389,917	$243,698

Vehicle Type	Class	Fuel Type	Average Fuel Economy	Fuel Economy unit	Number of Assets	Active Days per Year	Average Daily Usage	Strenuous Daily Usage	Usage Unit	Planned Service Life (years)	EV Capital Cost ($)	Baseline Capital Cost ($)
Truck, Crane	Heavy	Gasoline	2.56	mpg	1	50	9	14	Miles	12	$389,917	$243,698
Truck, Dump	Heavy	CNG	5.24	mpg	4	50	45	67	Miles	12	$221,258	$138,286
Truck, Dump	Heavy	Diesel	4.00	mpg	7	50	55	82	Miles	12	$221,258	$138,286
Truck, Dump	Medium	Gasoline	4.61	mpg	12	50	61	92	Miles	12	$110,152	$68,845
Truck, Flatbed	Medium	Gasoline	4.38	mpg	11	50	24	36	Miles	11	$126,254	$78,909
Truck, Manlift	Heavy	Diesel	2.87	mpg	3	50	78	116	Miles	12	$354,605	$221,628
Truck, Manlift	Heavy	CNG	2.29	mpg	3	50	52	79	Miles	12	$354,605	$221,628
Truck, Manlift	Medium	Diesel	4.77	mpg	4	50	35	52	Miles	12	$199,554	$124,721
Truck, Manlift	Medium	Gasoline	4.26	mpg	8	50	84	126	Miles	12	$199,554	$124,721
Truck, Rolloff	Heavy	CNG	6.40	mpg	2	50	11	17	Miles	11	$199,555	$124,722
Truck	Medium	Diesel	5.97	mpg	2	5	6	9	Miles	11	$185,088	$115,680
Truck	Medium	Gasoline	5.33	mpg	14	50	57	86	Miles	11	$185,088	$115,680
Van, Cargo	Light	Gasoline	10.43	mpg	21	50	41	62	Miles	10	$60,843	$36,461
Van, Cargo	Light	EV	0.48	kWh/mi	3	50	19	28	Miles	10	$60,843	$60,843
Van, Cargo	Medium	Diesel	7.58	mpg	3	50	12	18	Miles	10	$177,261	$110,788
Van, Cargo	Medium	Gasoline	5.04	mpg	12	50	48	72	Miles	10	$177,261	$110,788
Van, Passenger	Light	Gasoline	12.77	mpg	3	50	17	26	Miles	10	$90,347	$34,869
1 ton Pickup, Dump	Light	Gasoline	7.00	mpg	2	50	30	46	Miles	11	$65,602	$41,001
1 ton Pickup, Flatbed	Light	Gasoline	6.85	mpg	4	50	139	209	Miles	11	$98,171	$61,357
1 ton Pickup, Manlift	Light	Gasoline	4.68	mpg	1	50	23	34	Miles	10	$111,915	$69,947
1/2 ton Pickup, Refuse Bin	Light	Gasoline	9.91	mpg	6	150	48	72	Miles	9	$53,675	$33,547

Table B2: Vehicles by ACF status

Regulated by ACF **Not exempt in short term**	**Regulated by ACF** **Exempt in short term**	**Regulated by ACF** **Exempt Indefinitely**	**Not Regulated by ACF**
1 Ton Pickup Van, Cargo ¾ Ton Pickup 1.5 Ton Pickup	Truck, Manlift 1 Ton Pickup, Dump ½ Ton Pickup Refuse Bin Truck, Rolloff Truck, Dump Truck, Crane Truck, Street Sweeper Truck, Refuse	Emergency Vehicles	Light Duty Vehicles Non-Road Vehicles

Appendix C: Analyses by Site

CTE conducted each analysis for Glendale overall and by site. This appendix provides the results and charts by individual site.

Fleet Assessment

Public Works Yard

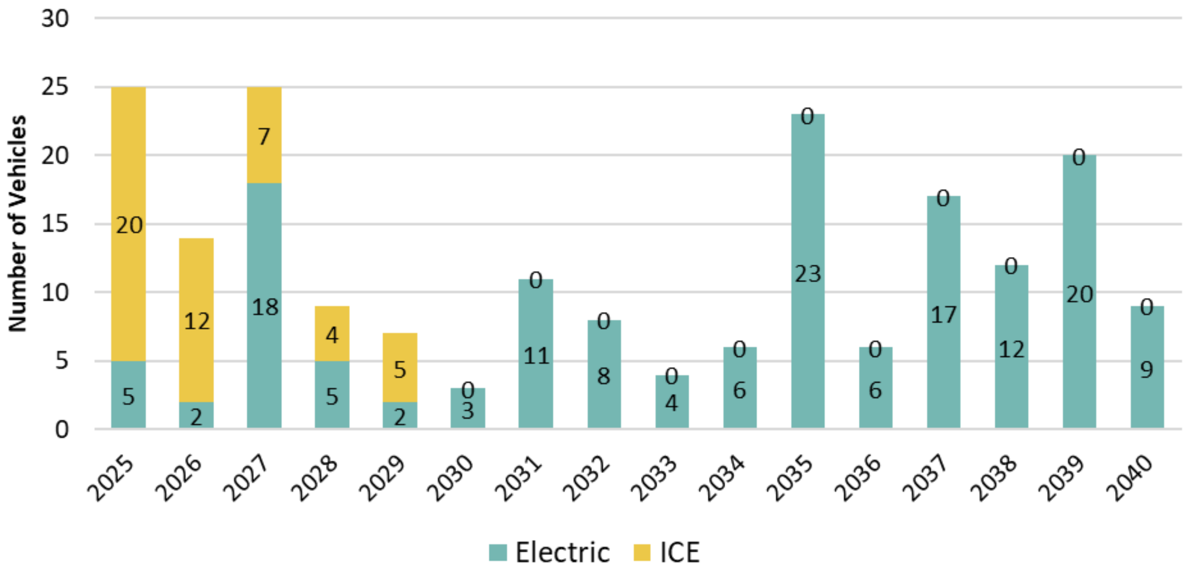

Figure C1. Annual Procurements for the Public Works Yard

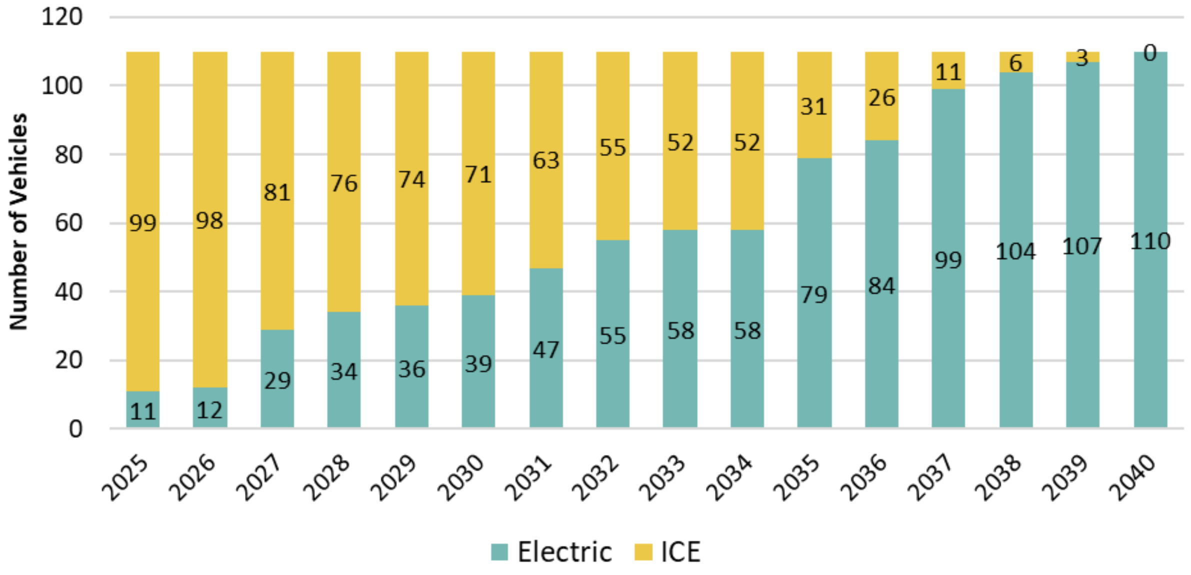

Figure C2. Annual Fleet Composition for the Public Works Yard

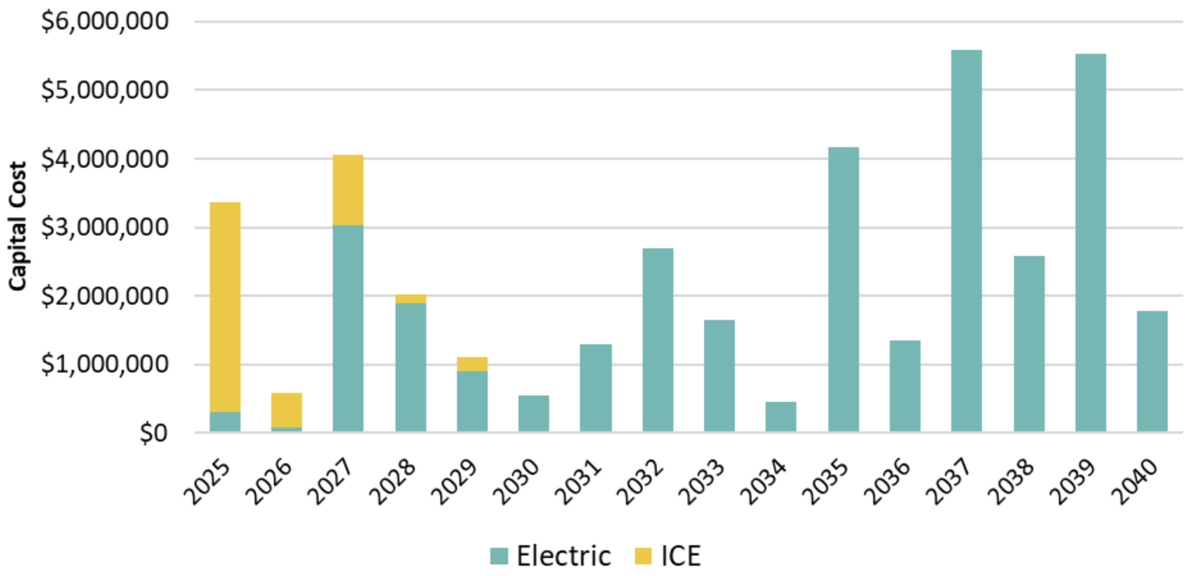

Figure C3. Annual Vehicle Capital Cost for the Public Works Yard

City Hall Complex

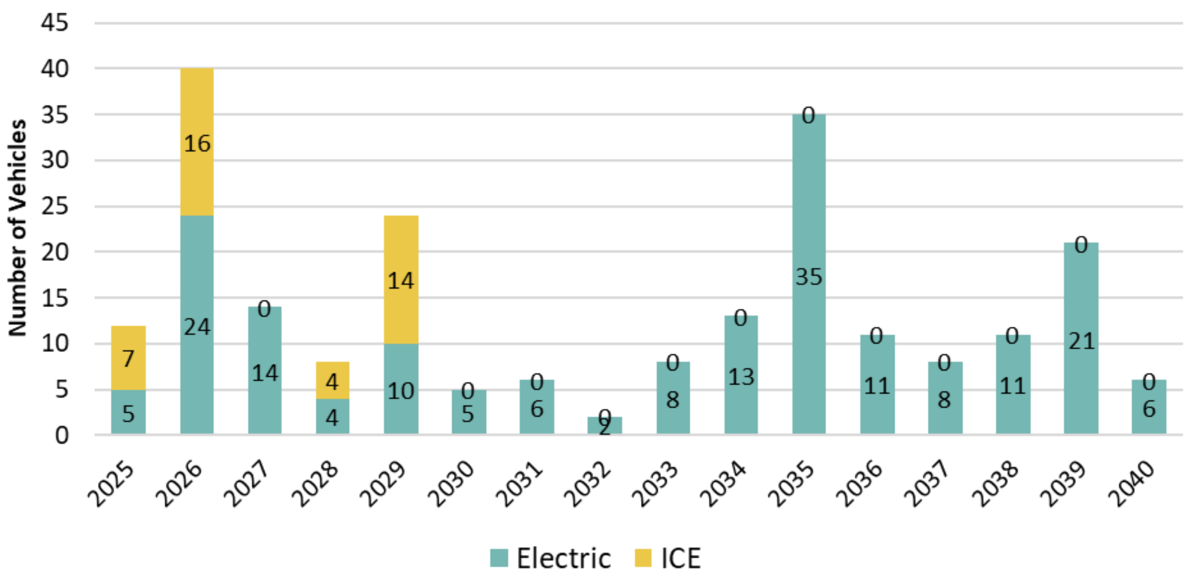

Figure C4. Annual Procurements for the City Hall Complex

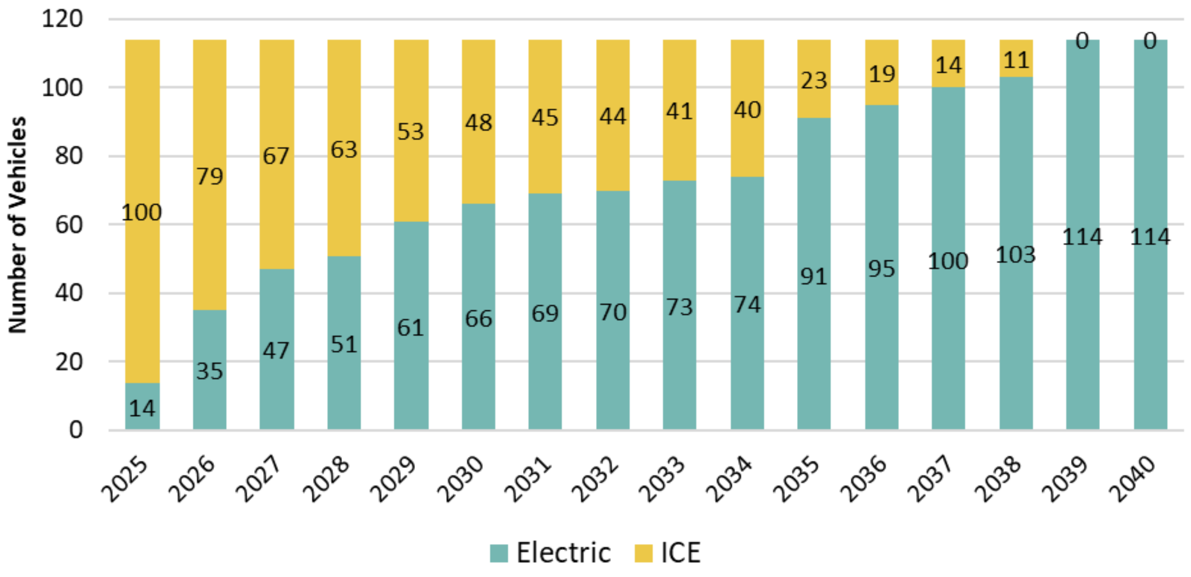

Figure C5. Annual Fleet Composition for the City Hall Complex

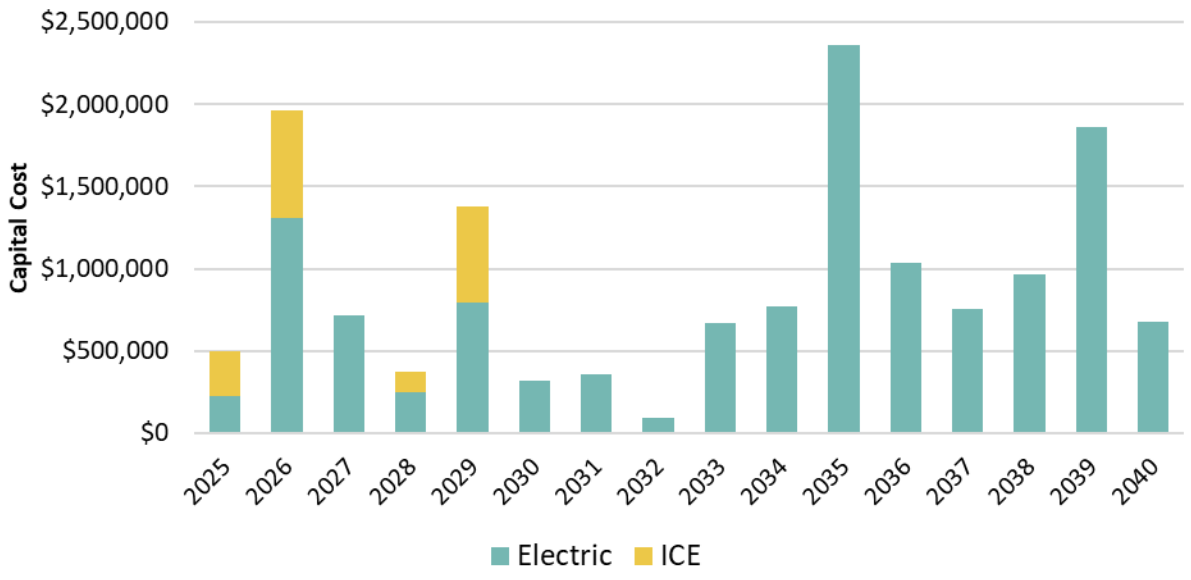

Figure C6. Annual Vehicle Capital Cost for the City Hall Complex

Glendale Water & Power

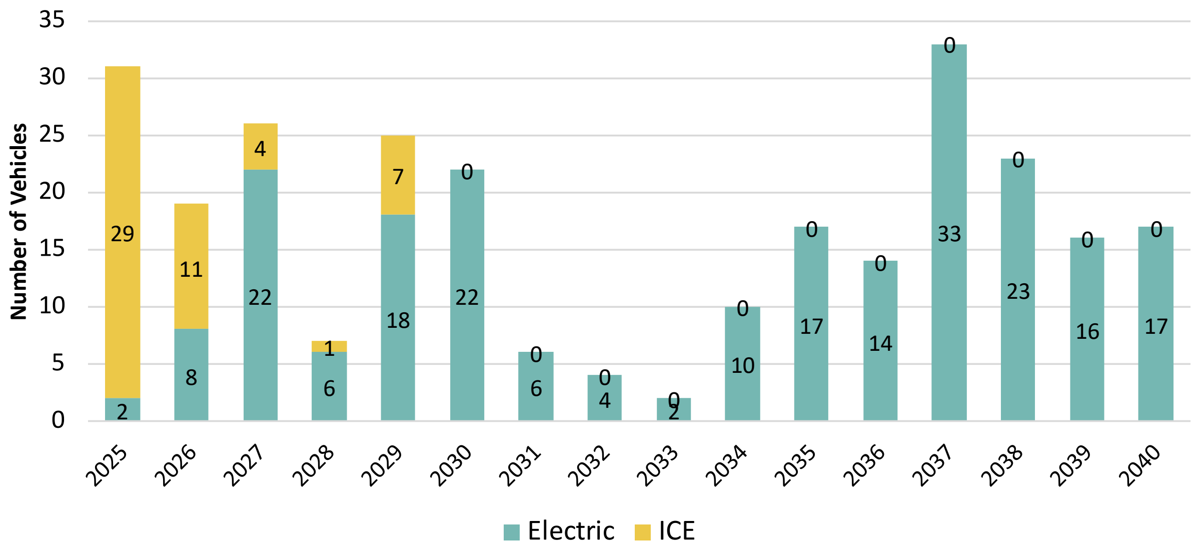

Figure C7. Annual Procurements for Glendale Water & Power

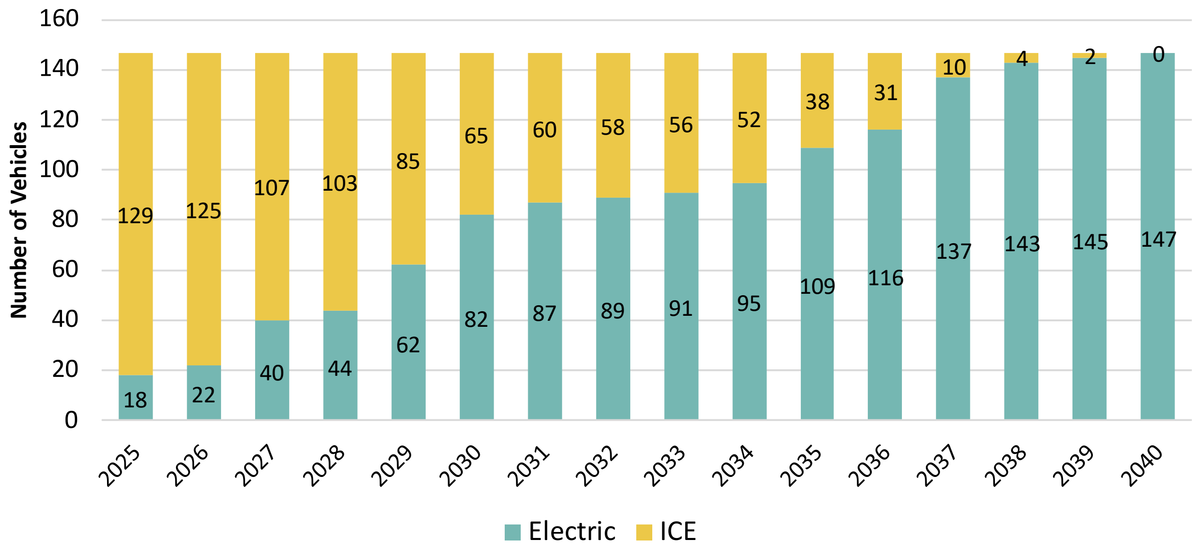

Figure C8. Annual Fleet Composition for Glendale Water & Power

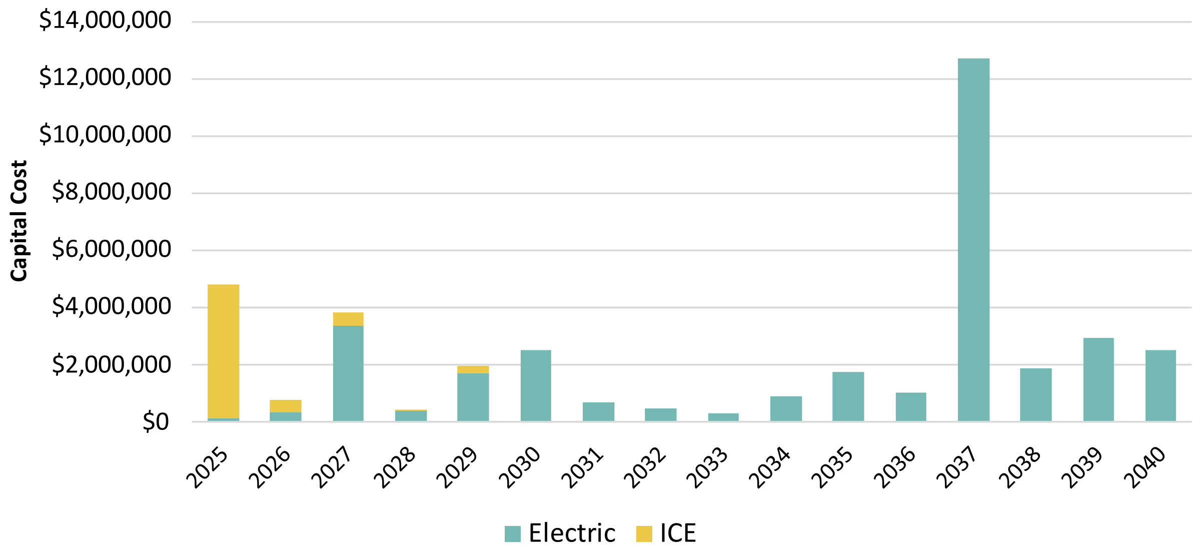

Figure C9. Annual Vehicle Capital Cost for Glendale Water & Power

Integrated Waste Facility

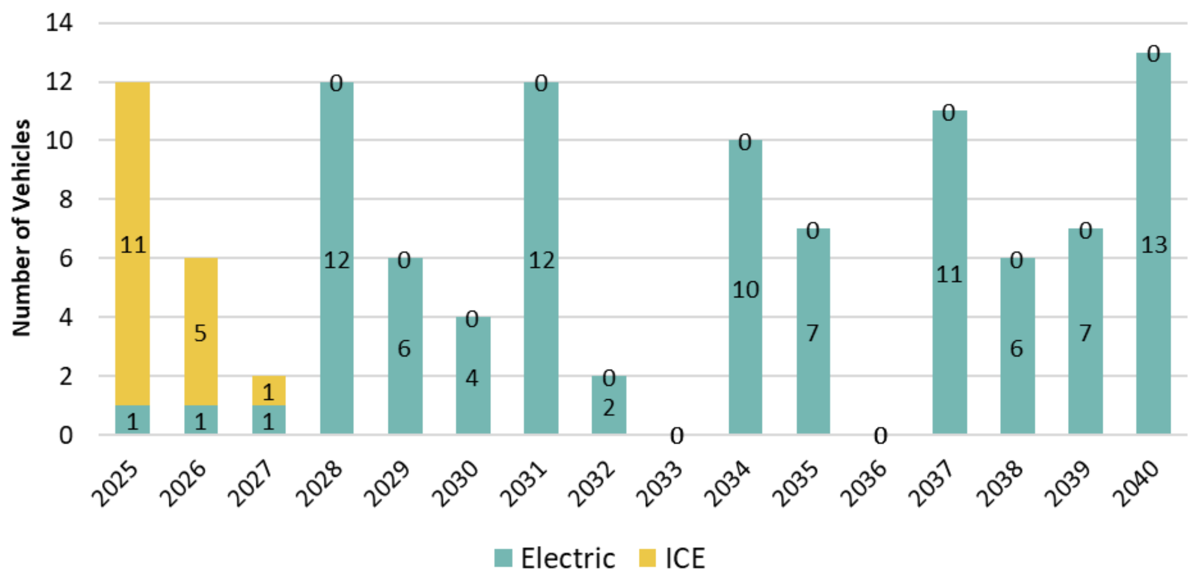

Figure C10. Annual Procurements for the Integrated Waste Facility

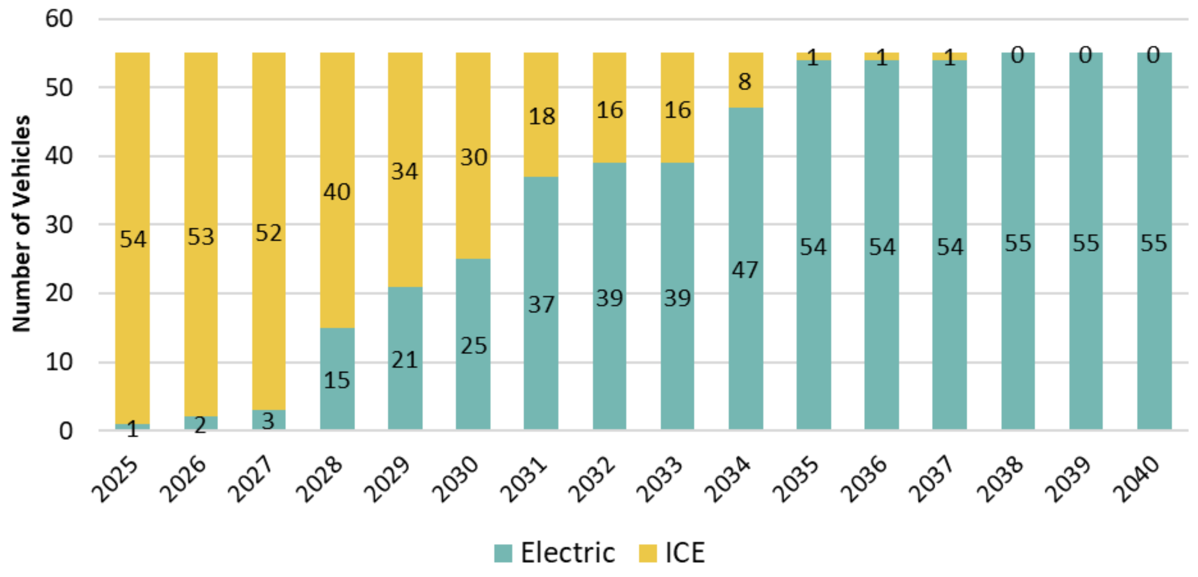

Figure C11. Annual Fleet Composition for the Integrated Waste Facility

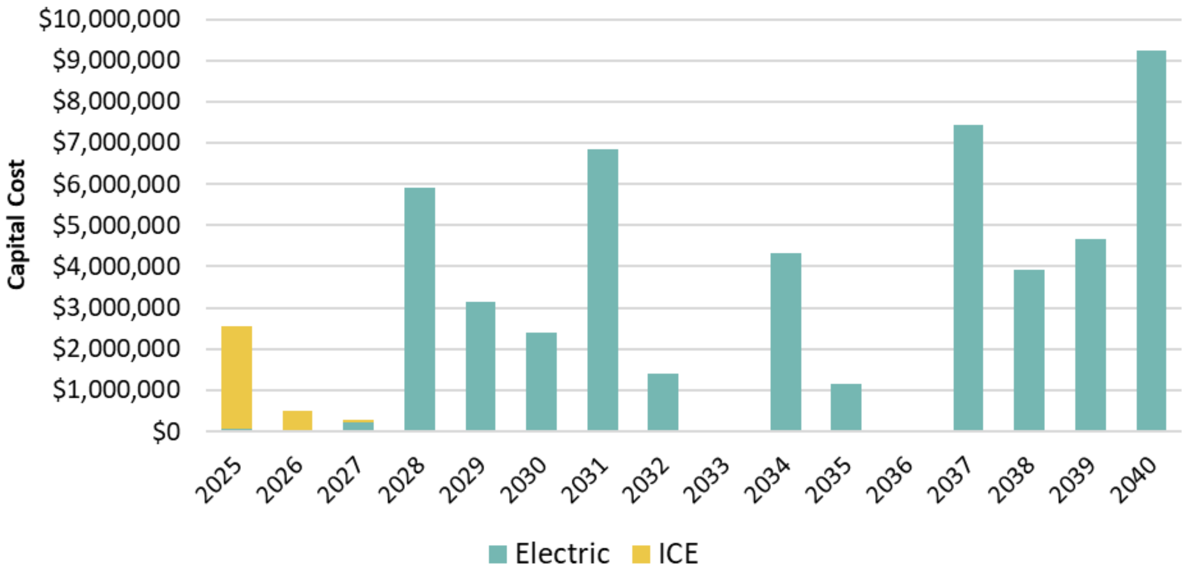

Figure C12. Annual Vehicle Capital Cost for the Integrated Waste Facility

Fire Station 21

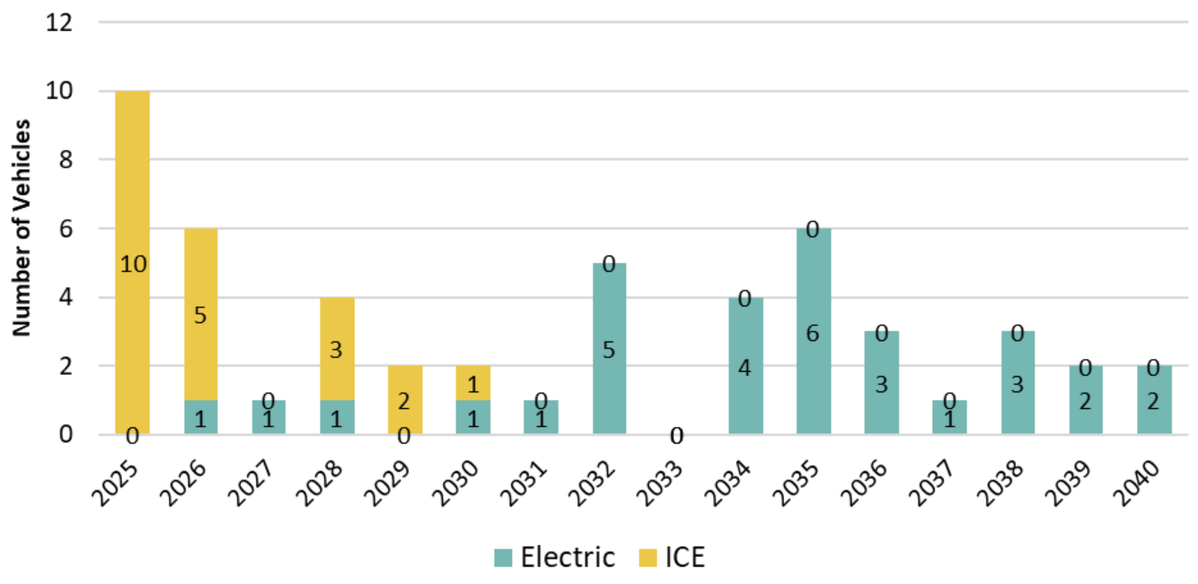

Figure C13. Annual Procurements for Fire Station 21

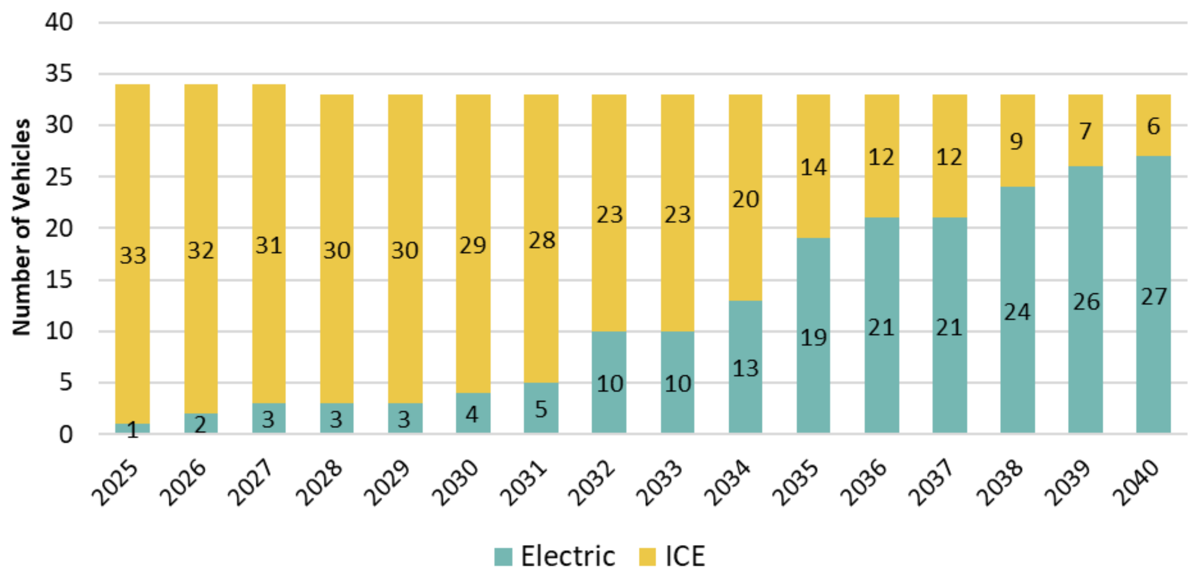

Figure C14. Annual Fleet Composition for Fire Station 21

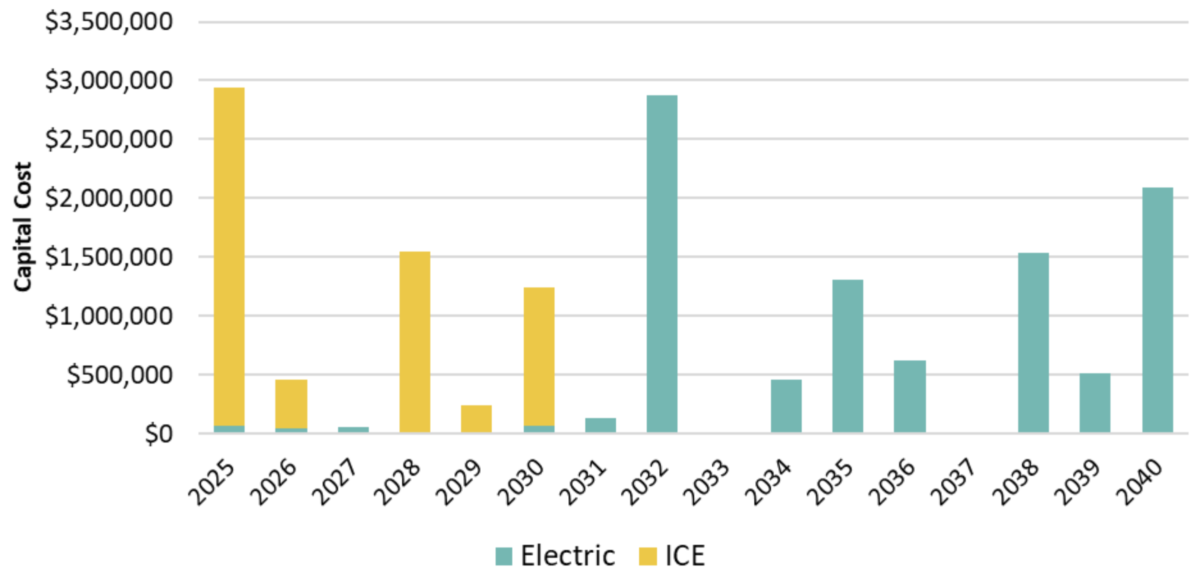

Figure C15. Annual Vehicle Capital Cost for Fire Station 21

Police Parking

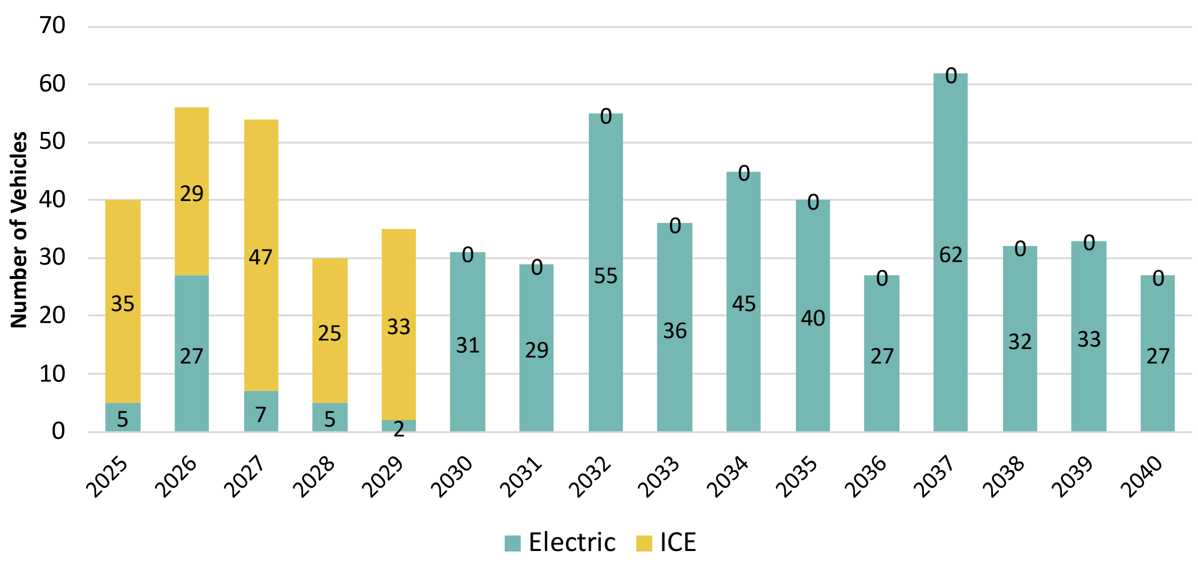

Figure C16. Annual Procurements for the Glendale Police Parking

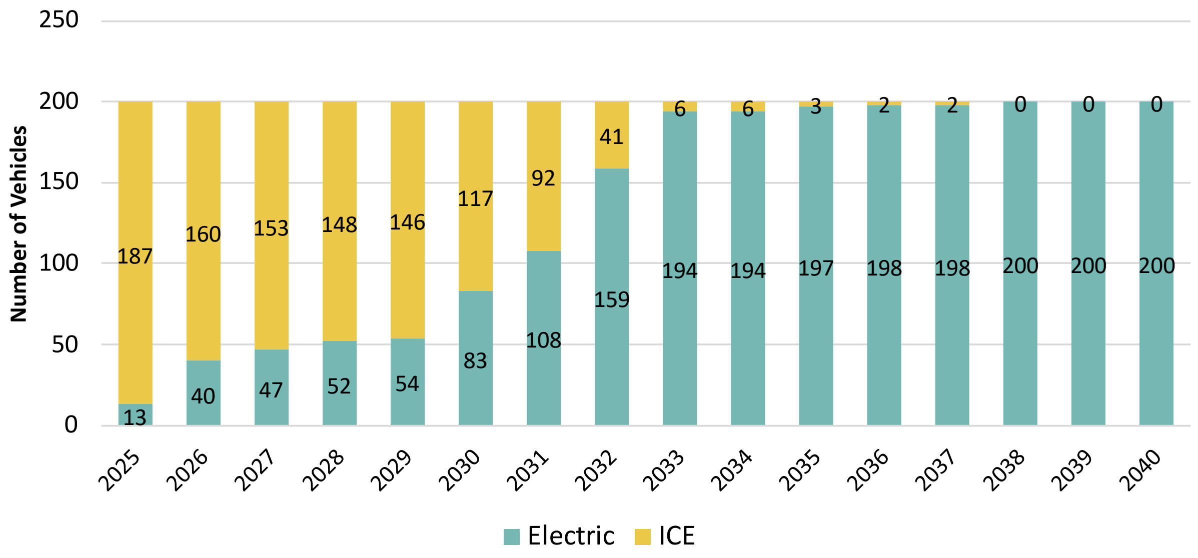

Figure C17. Annual Fleet Composition for the Glendale Police Parking

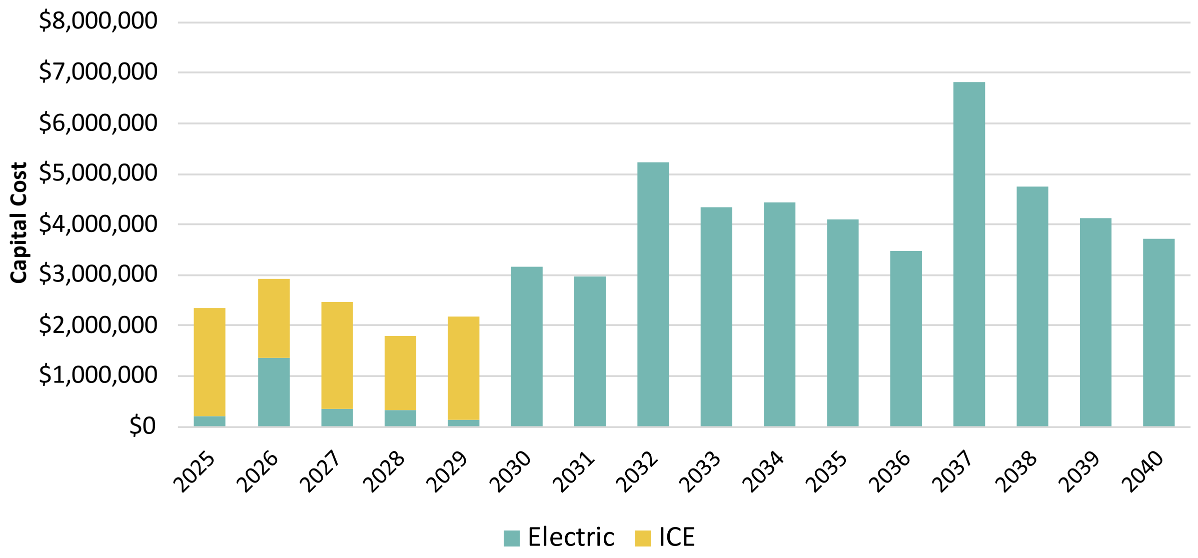

Figure C18. Annual Vehicle Capital Cost for the Glendale Police Parking

Other Sites

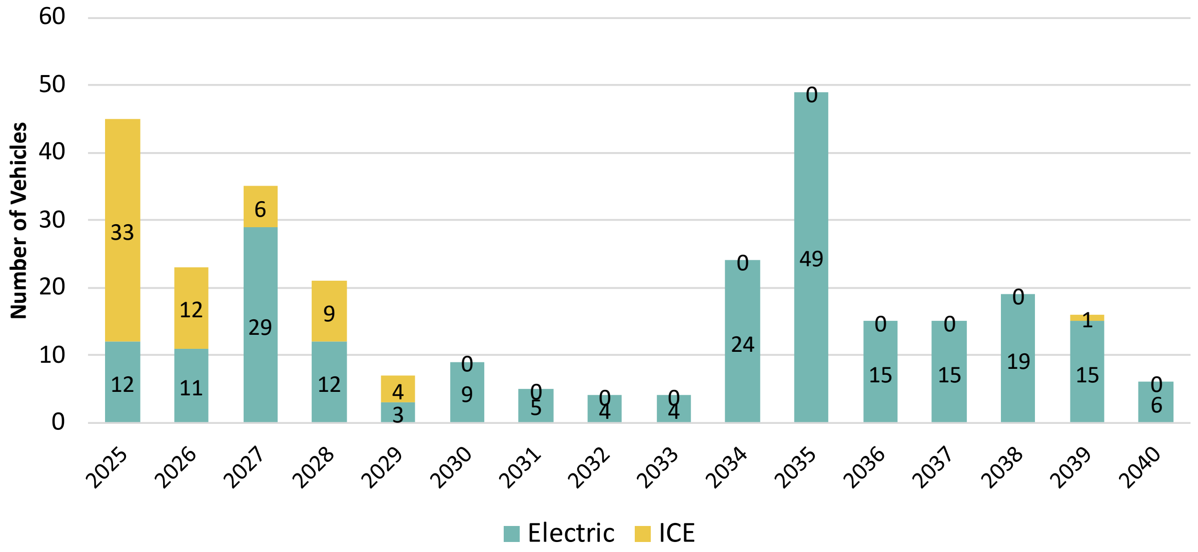

Figure C19. Annual Procurements for Other Sites

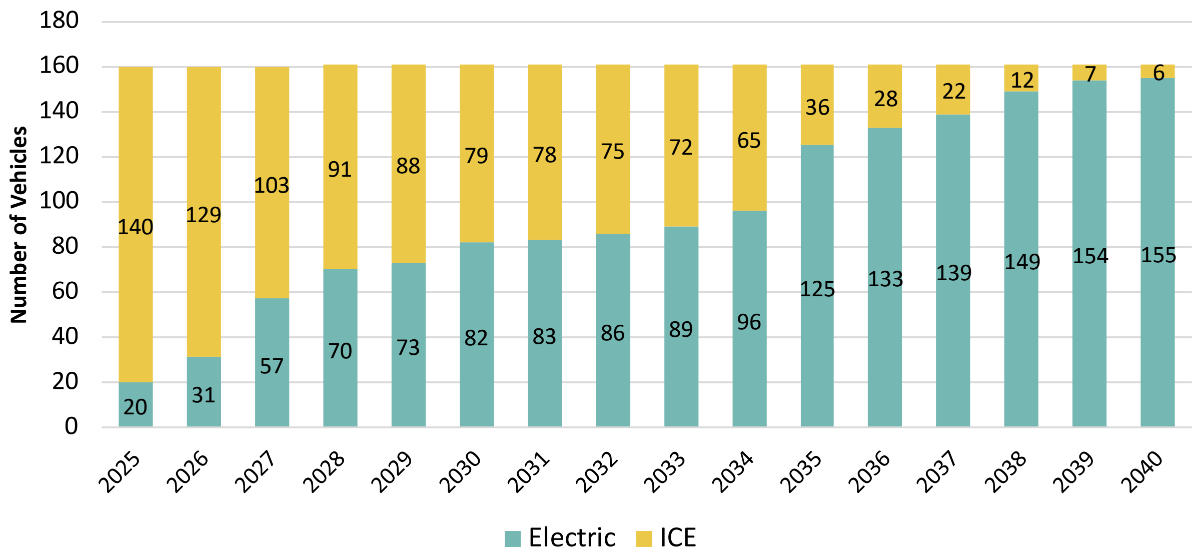

Figure C20. Annual Fleet Composition for Other Sites

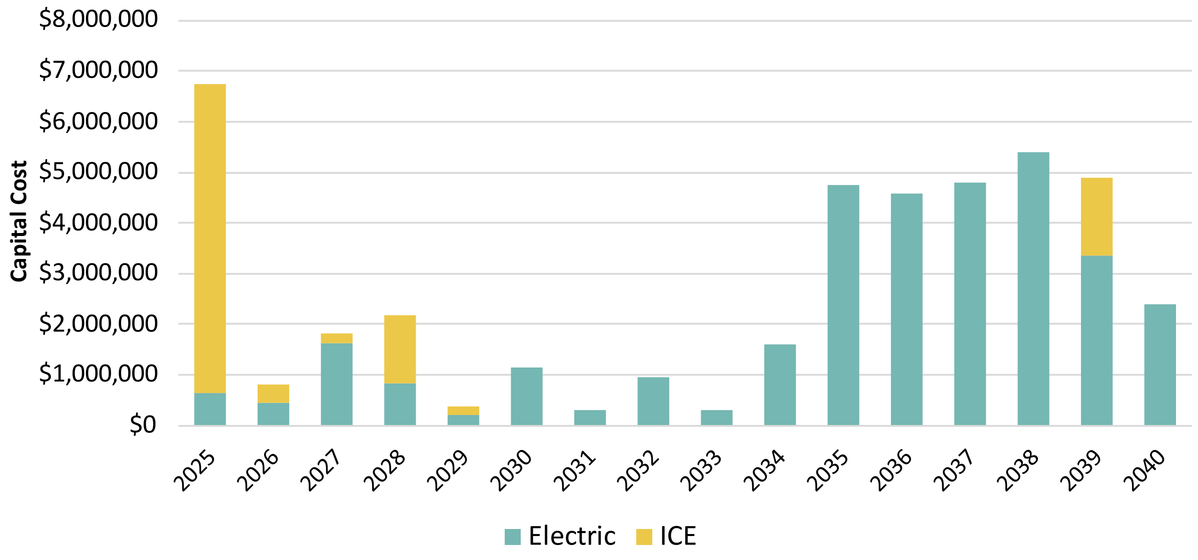

Figure C21. Annual Vehicle Capital Cost for Other Sites

Fuel Assessment

Table C1. Locations, Utility Rates, and 2040 Energy and Demand Estimates

Location	Utility Rate Modeled	2040 Annual Energy (kWh)	2040 Peak Demand (kW)
ARC	LD2A	1,698	17
BLN	LD2A	4,106	17
CCG	PC1B	88,101	307
CVC	LD2A	15,937	87
EMC	PC1B	26,079	191
EMS	LD2A	483	71
FMF	LD2A	2,315	87
FTC	LD2A	16,588	87
GPD	PC1B	1,050,150	6744
GWP	PC1B	536,156	1468
IW	PC1B	818,377	2911
Library	LD2A	1,169	17
Lnd	LD2A	1,841	19
Parks	PC1B	154,770	486
PD2	LD2A	3,202	72
Perkins	PC1B	1,169	530
PJS	LD2A	61,892	17
Plant	LD2A	187,887	90
PMY	PC1B	497,735	194
PW	PC1B	10,261	1318
S21	PC1B	179,718	1287
S22	PC1B	33,215	248
S23	LD2A	-	0
S24	PC1B	27,312	424
S25	PC1B	50,174	388
S26	PC1B	50,174	388
S27	PC1B	33,207	247
S28	PC1B	4,865	247
S29	PC1B	38,718	494
SPC	LD2A	3,384	73
SR	LD2A	1,746	1
Verdugo	LD2A	18,116	72
VJC	LD2A	4,578	71
Total		**3,925,124**	**18,668**

Public Works Yard

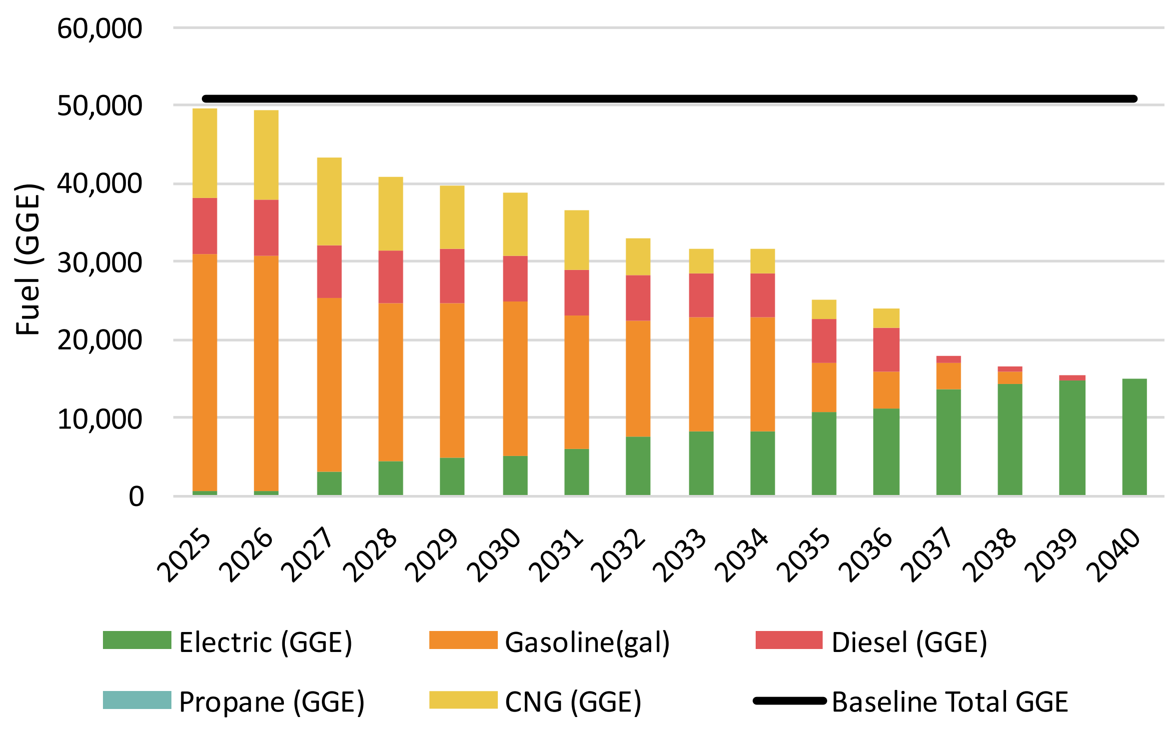

Figure C22. Annual Fuel Consumption for Public Works Yard

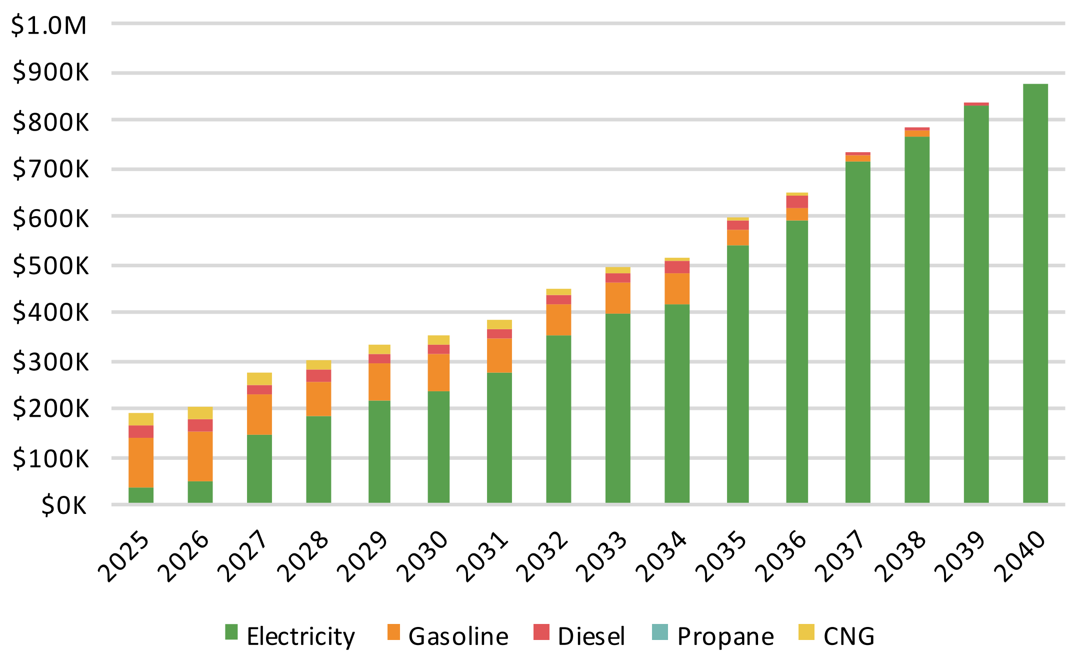

Figure C23. Annual Fuel Cost for Public Works Yard

Civic Center Complex

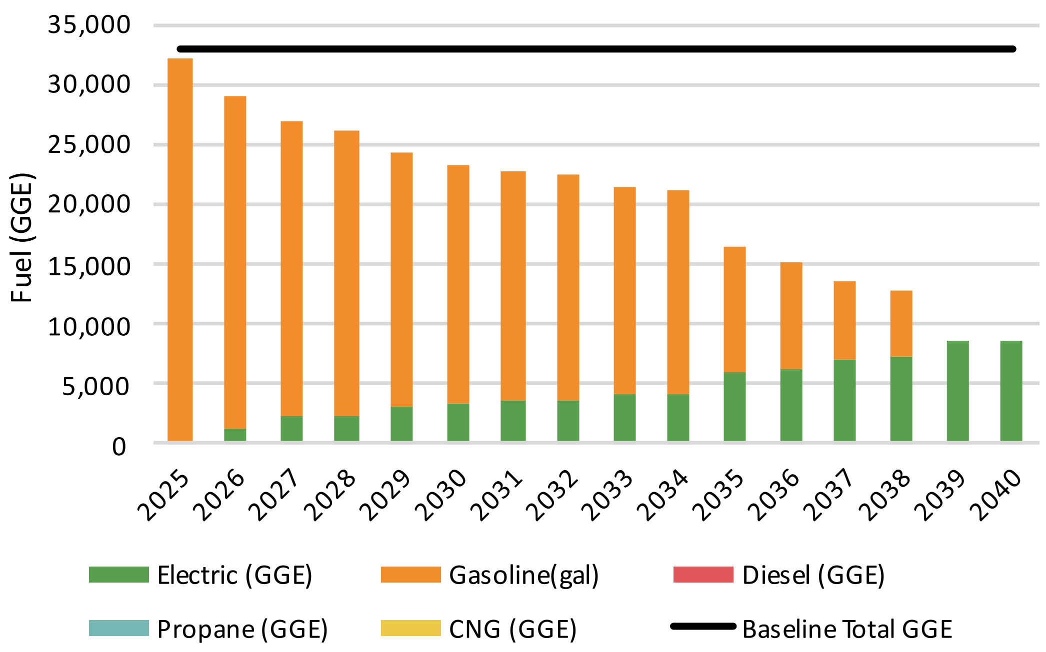

Figure C24. Annual Fuel Consumption for Civic Center Complex

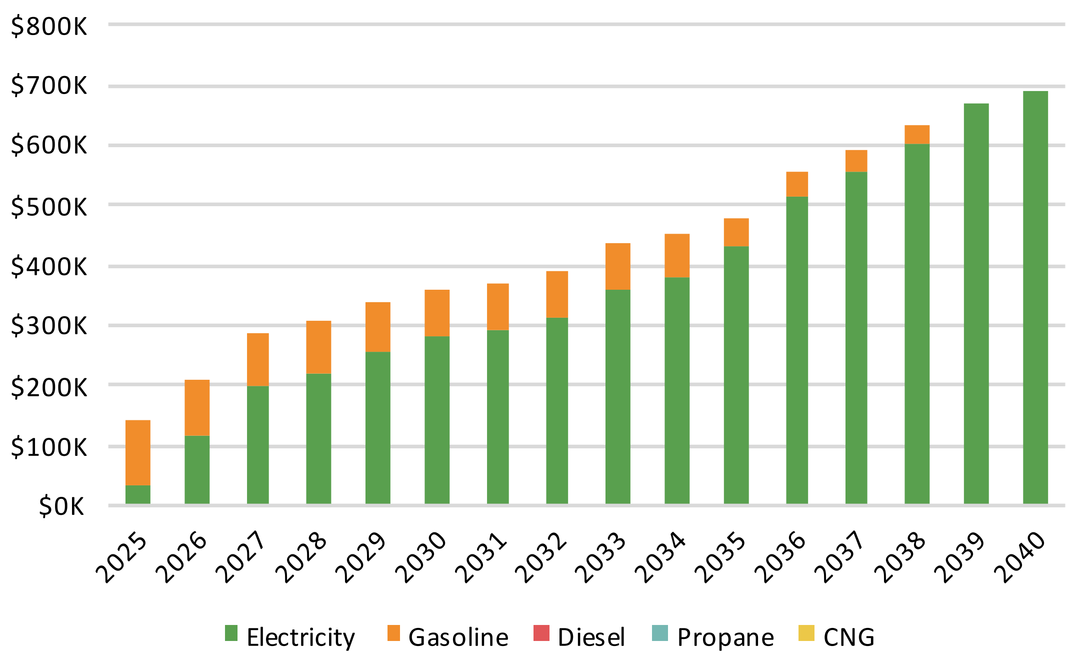

Figure C25. Annual Fuel Cost for Civic Center Complex

Glendale Water & Power

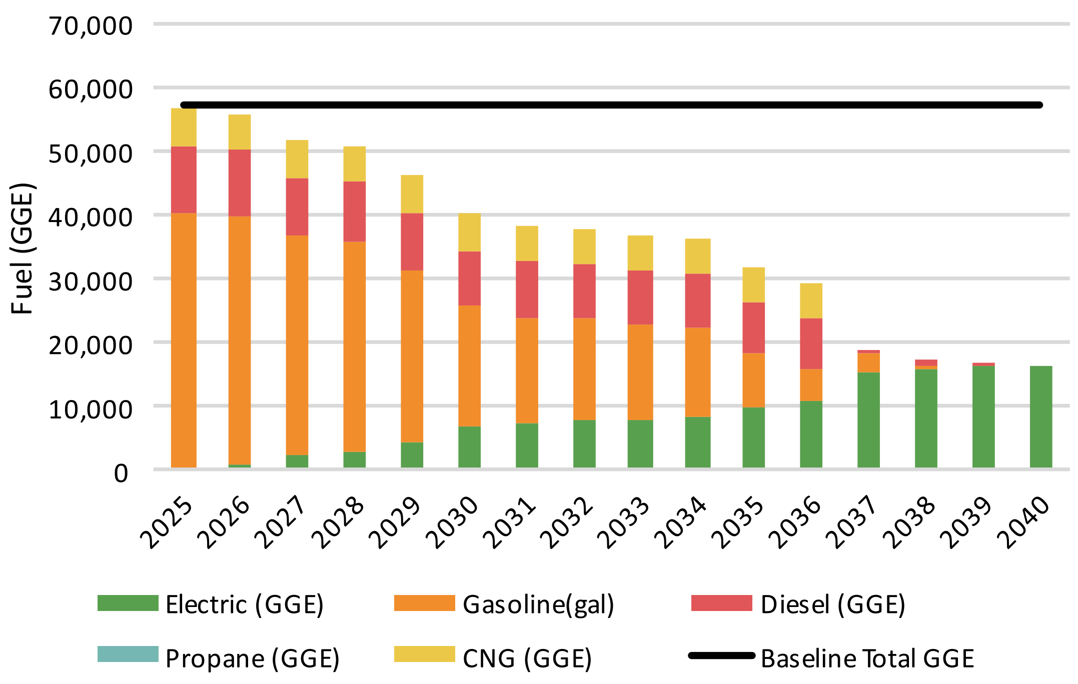

Figure C26. Annual Fuel Consumption for Glendale Water and Power

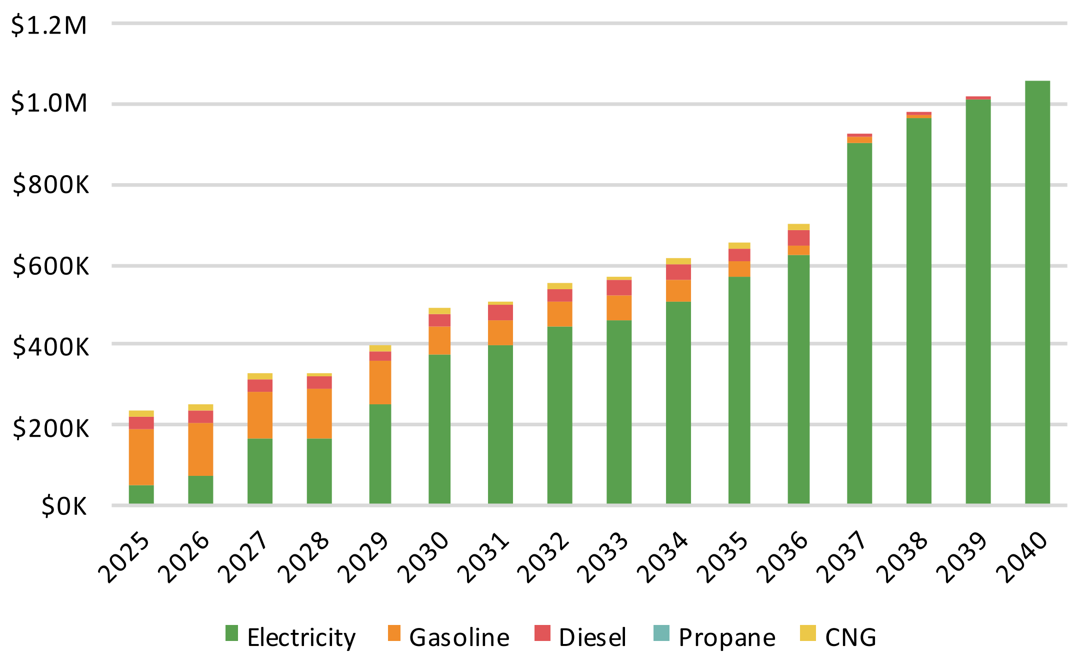

Figure C27. Annual Fuel Cost for Glendale Water and Power

Integrated Waste Facility

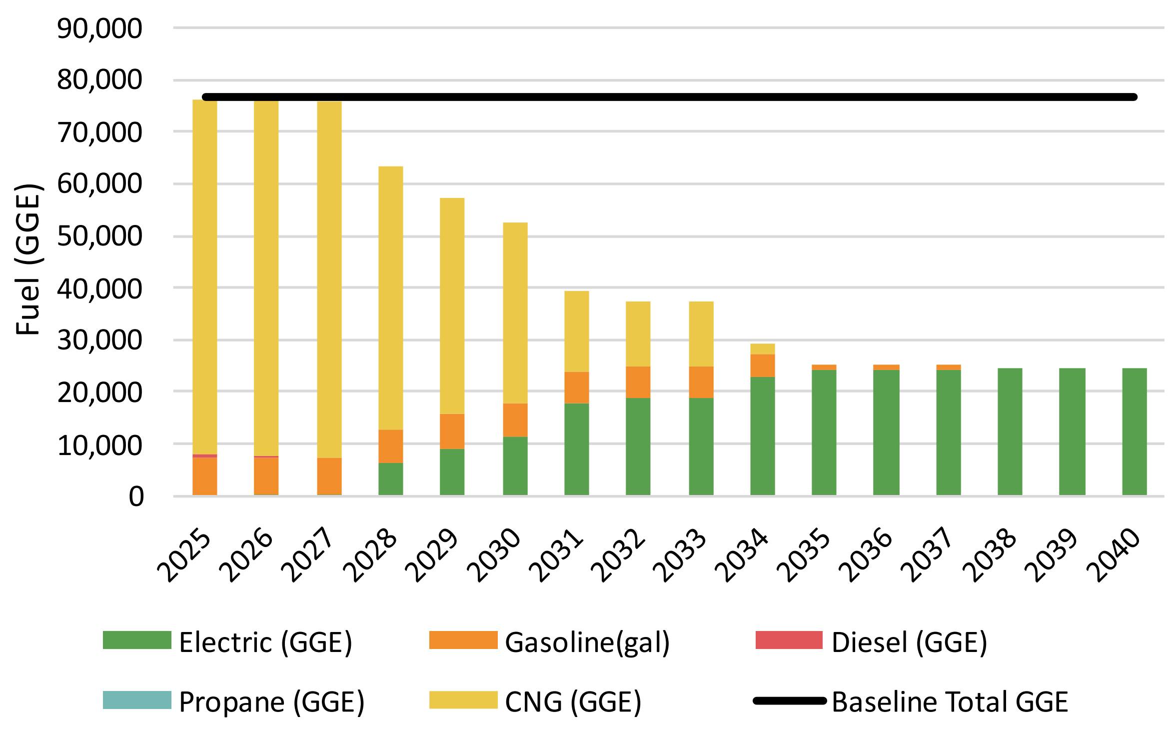

Figure C28. Annual Fuel Consumption for the Integrated Waste Facility

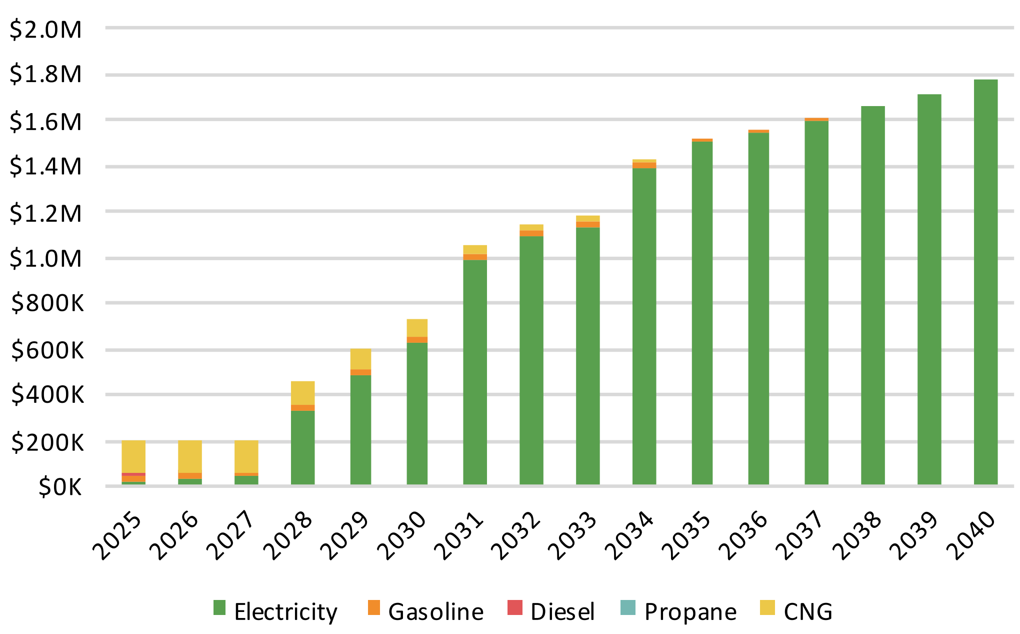

Figure C29. Annual Fuel Cost for Integrated Waste Facility

Fire Station 21

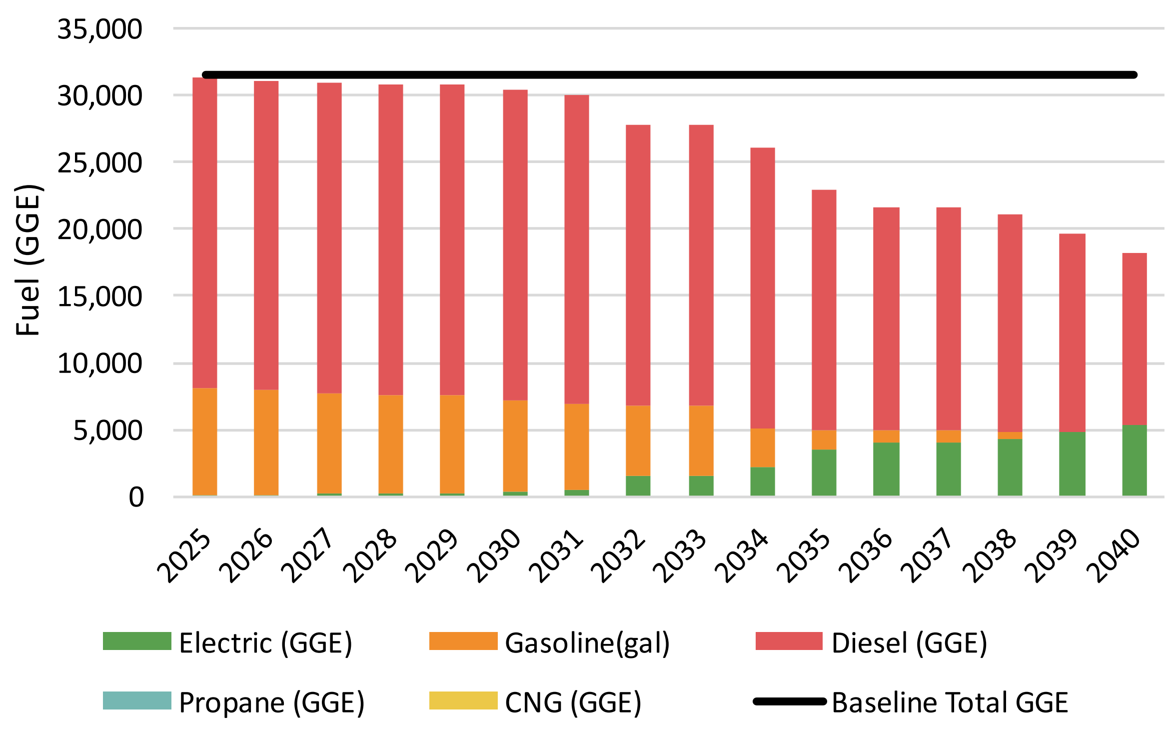

Figure C30. Annual Fuel Consumption for Fire Station 21

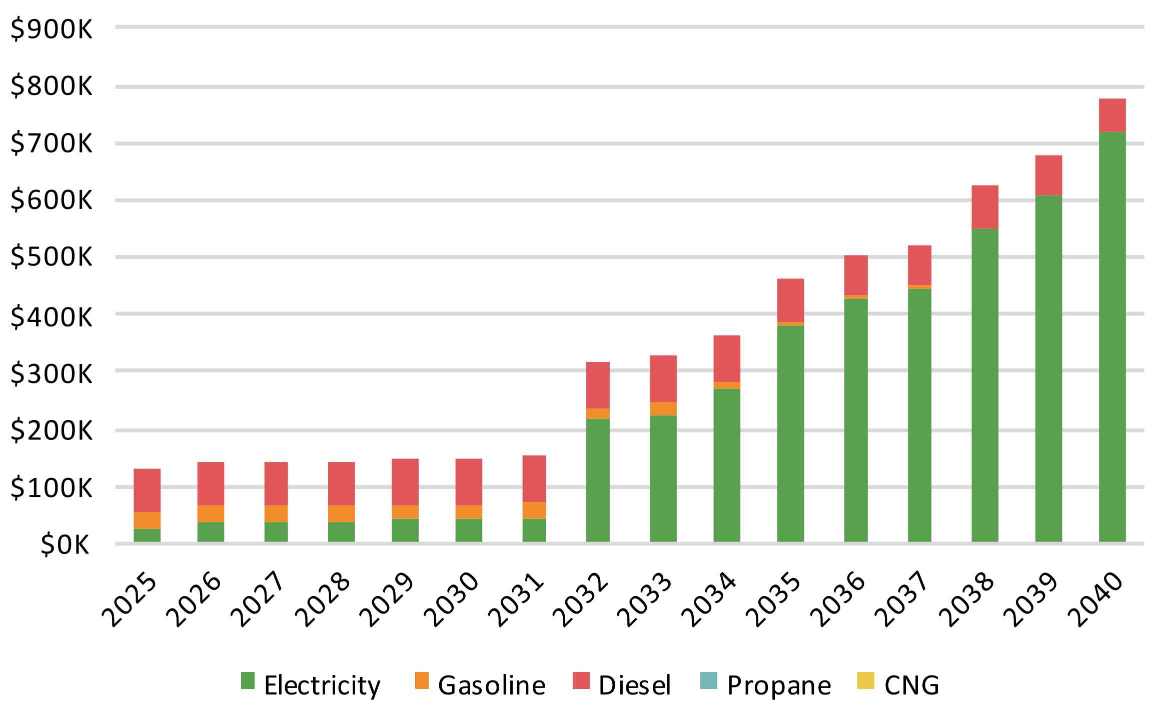

Figure C31. Annual Fuel Cost for Fire Station 21

Police Parking

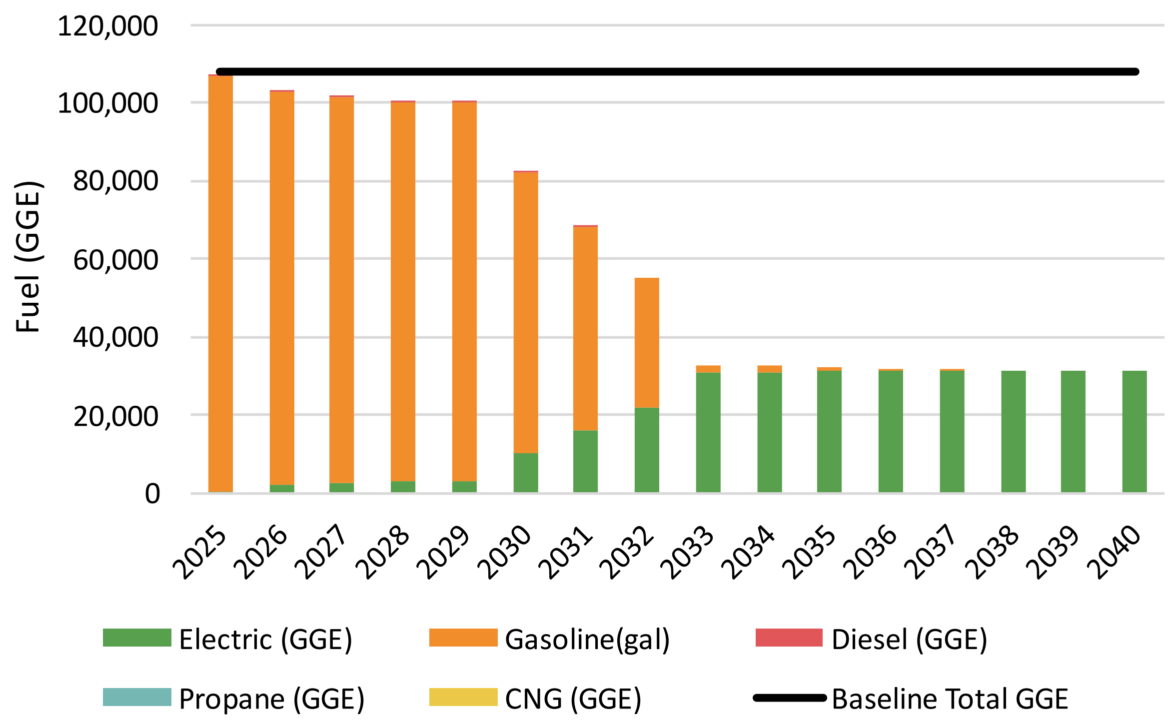

Figure C32. Annual Fuel Consumption for Police Parking

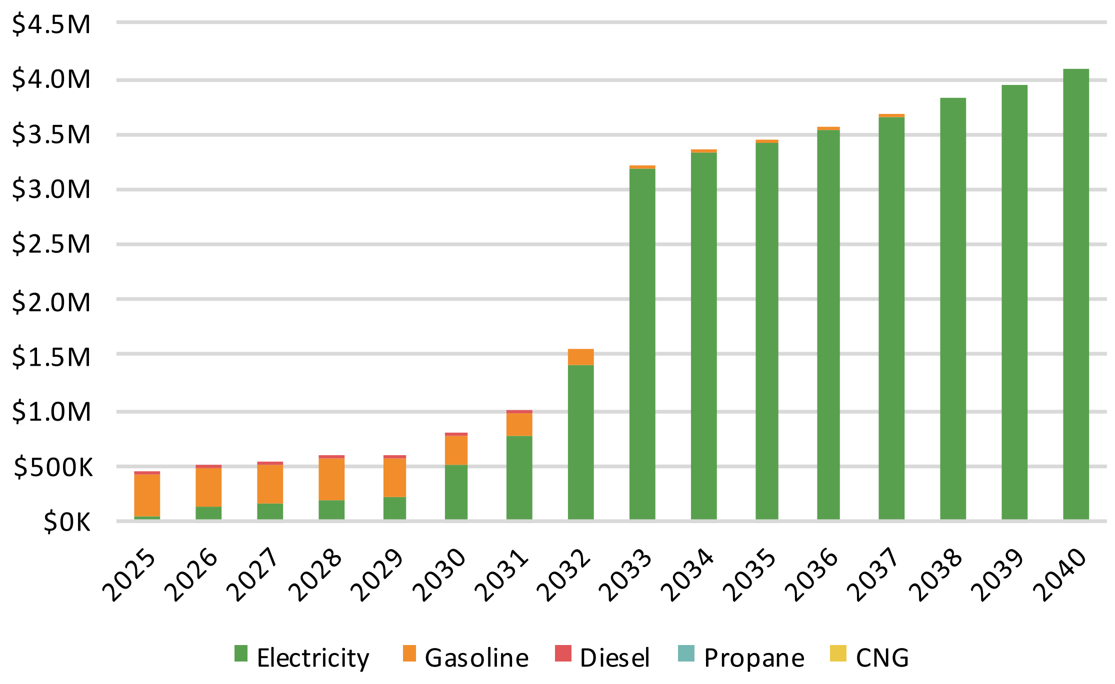

Figure C33. Annual Fuel Cost for Police Parking

Facilities Assessment

Public Works Yard

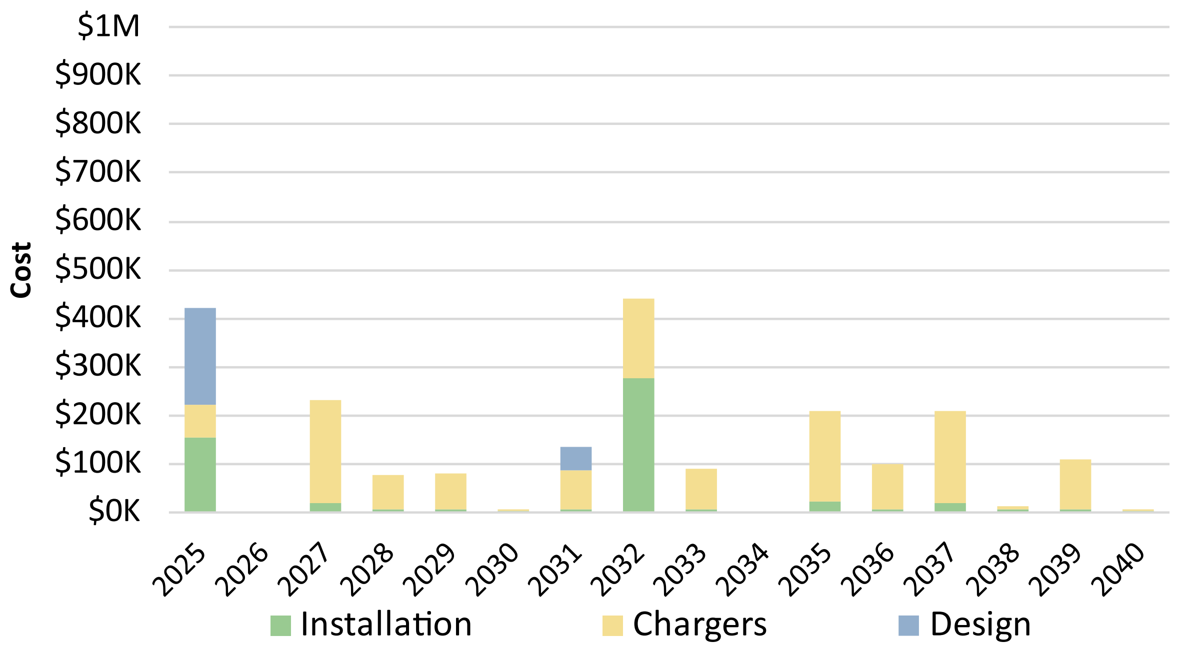

Figure C34. Annual Facility Costs for the Public Works Yard

Civic Center Complex

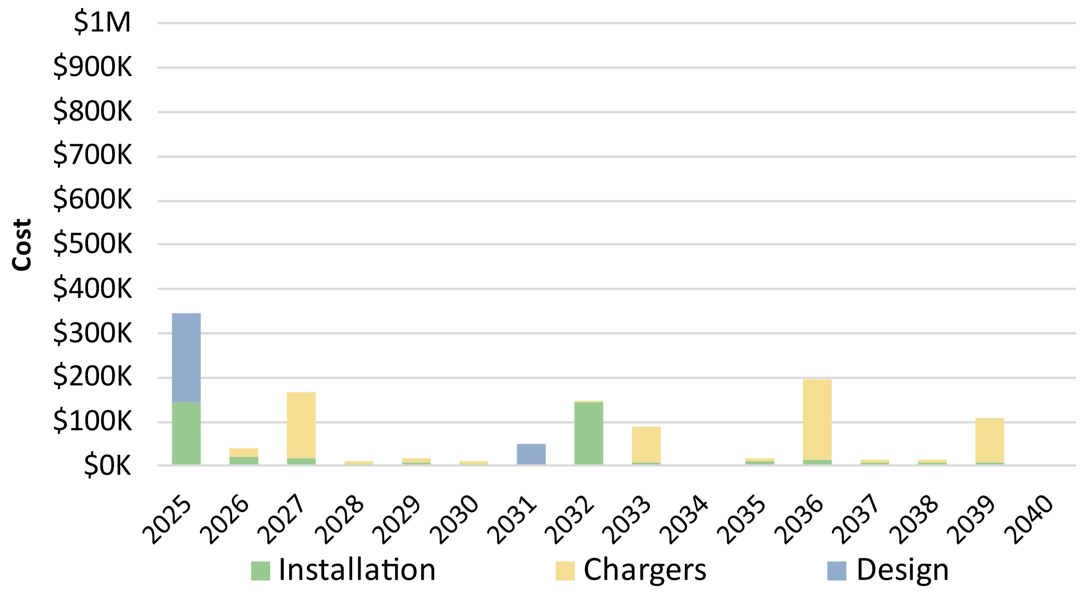

Figure C35. Annual Facility Costs for the City Hall Complex

Glendale Water & Power

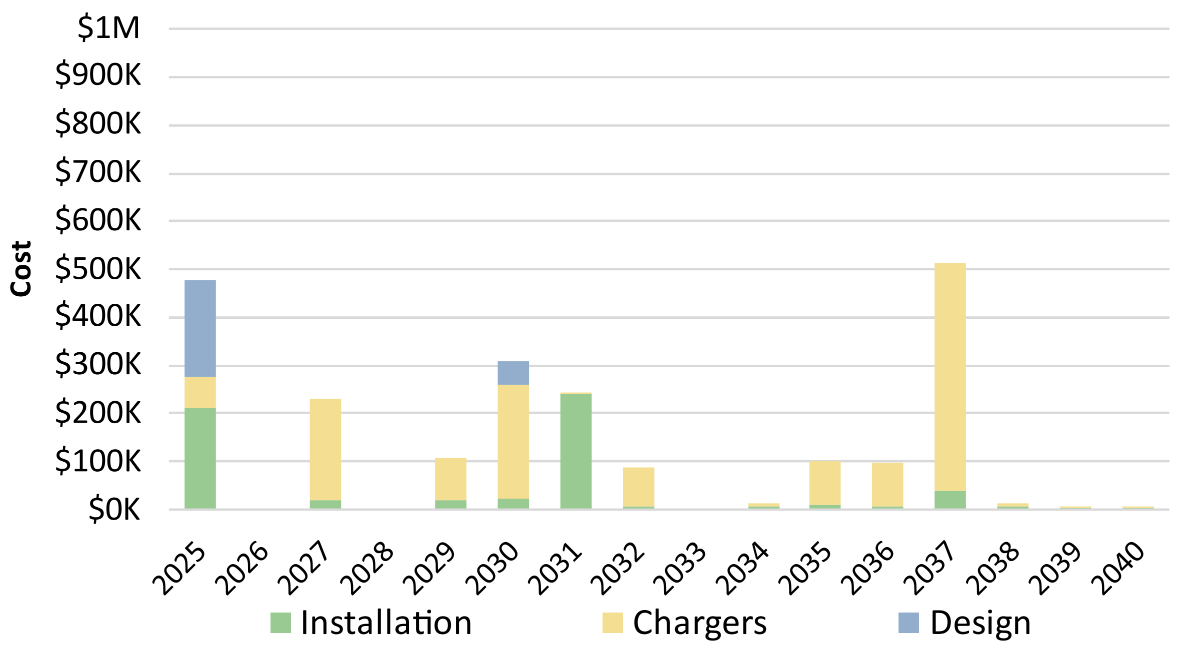

Figure C36. Annual Facility Costs for the Glendale Water & Power Utility Operations

Integrated Waste Facility

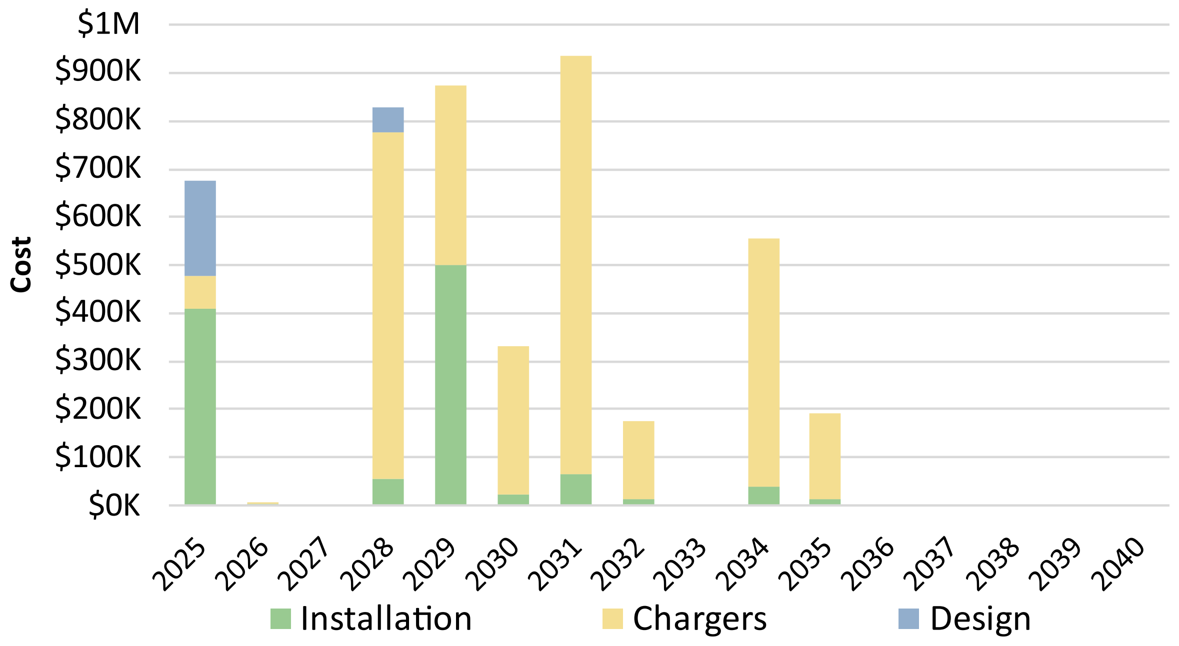

Figure C37. Annual Facility Costs for the Integrated Waste Yard

Fire Station 21

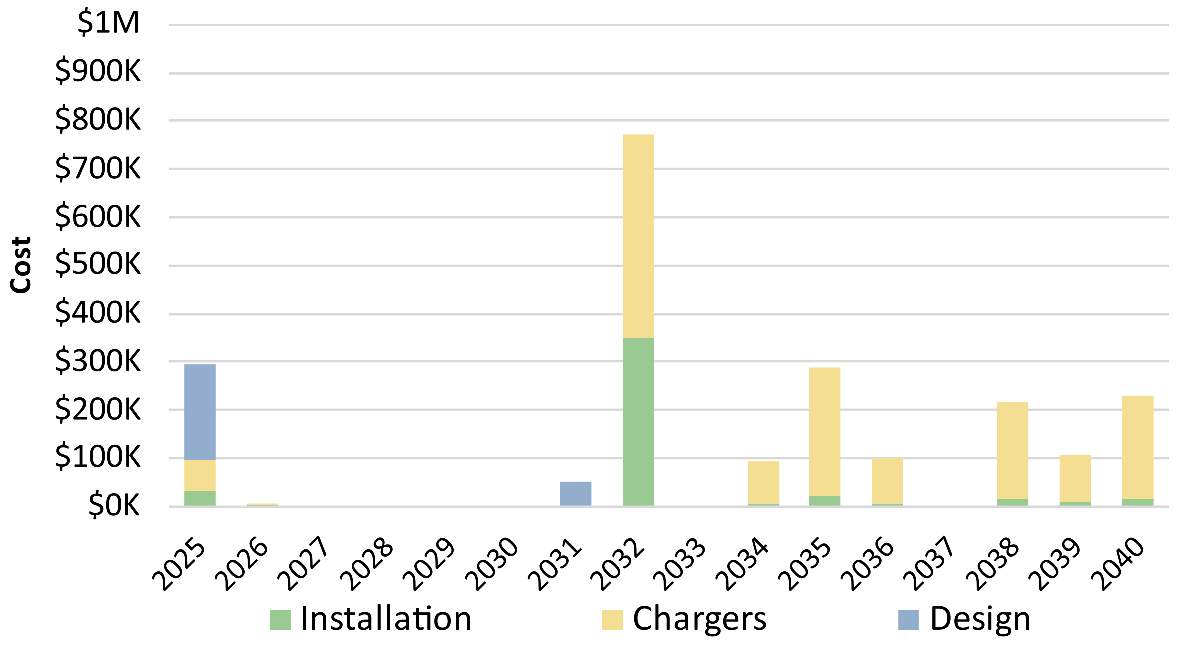

Figure C38. Annual Facility Costs for Fire Station 21

Police Parking

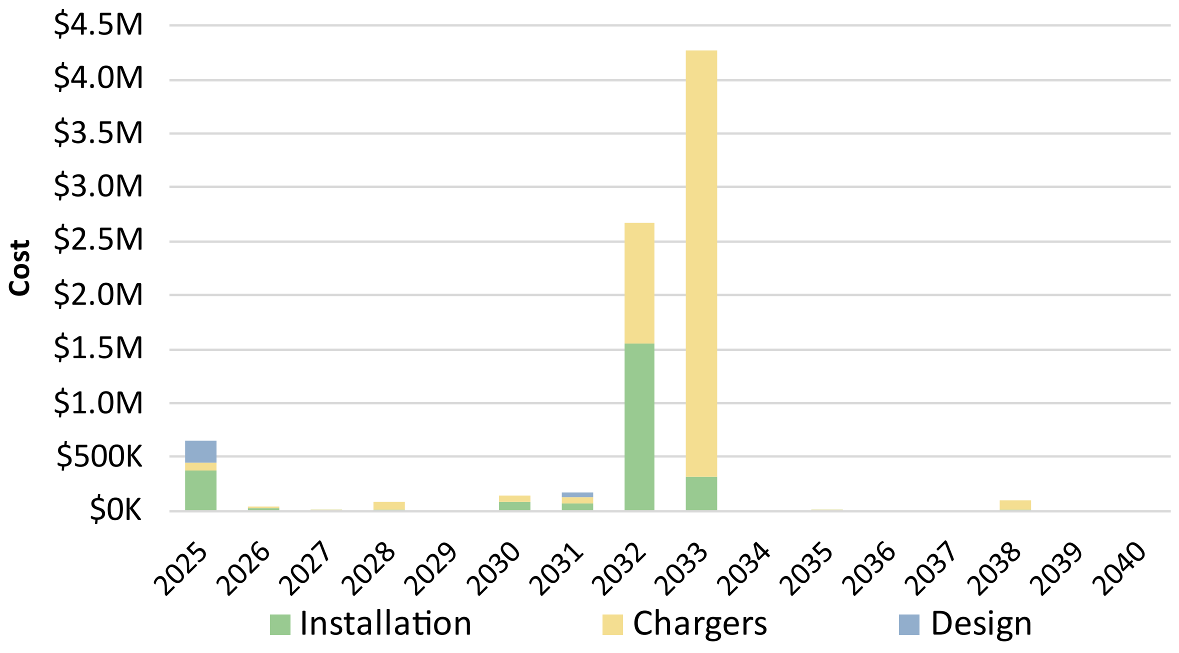

Figure C39. Annual Facility Costs for the Police Parking Area

Other Locations

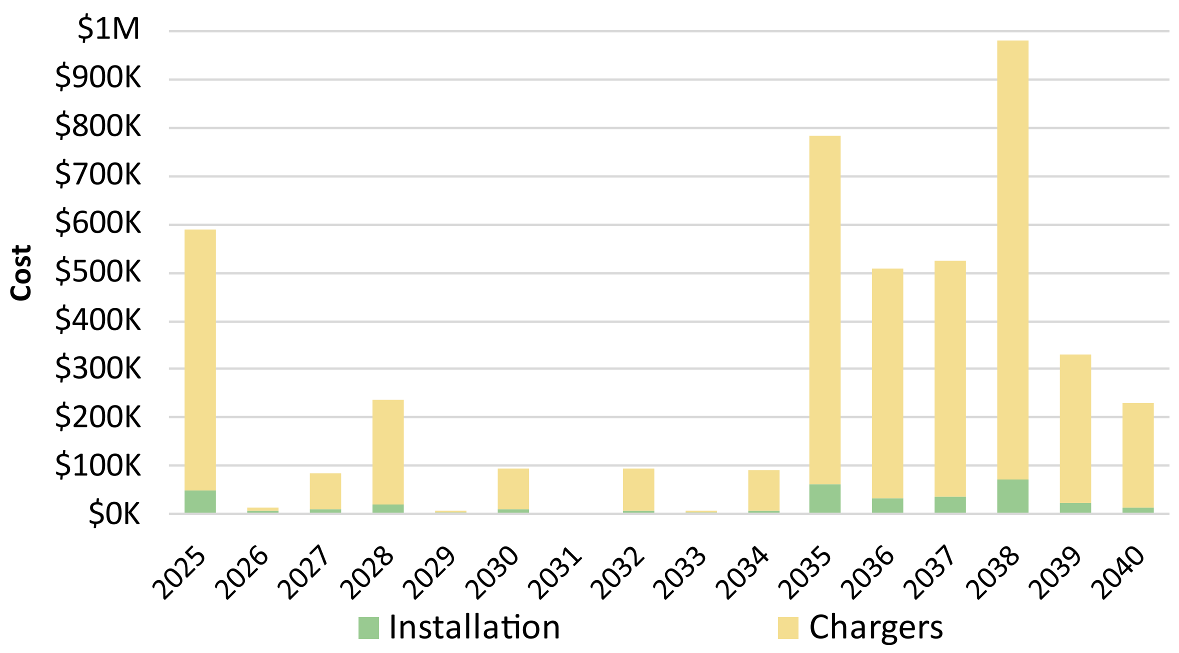

Figure C40. Annual Facility Costs for the Other Locations

Total Cost of Ownership

Public Works Yard

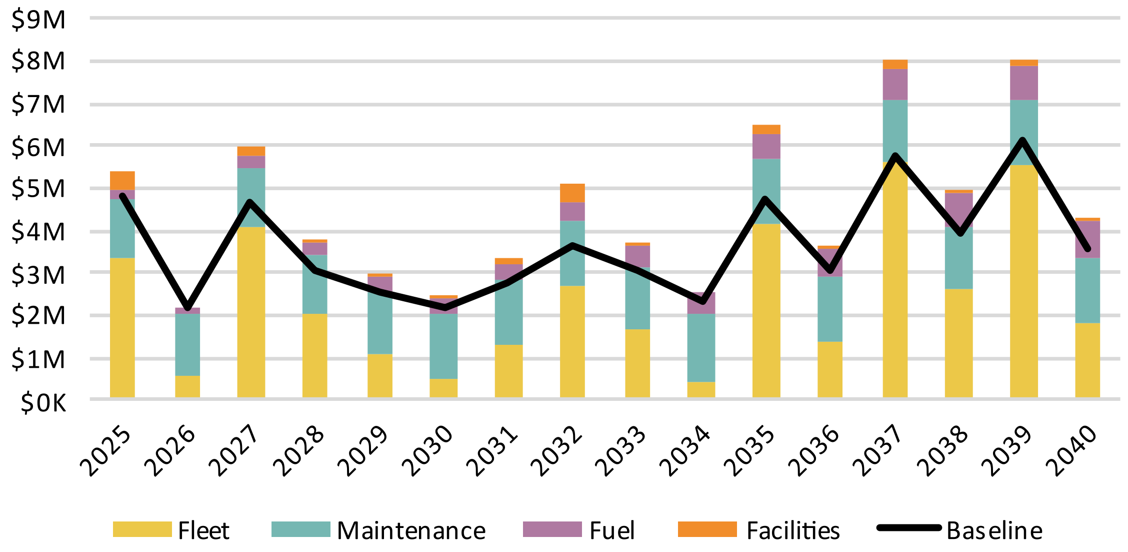

Figure C41: Public Works Yard Total Cost of Ownership

Civic Center Complex

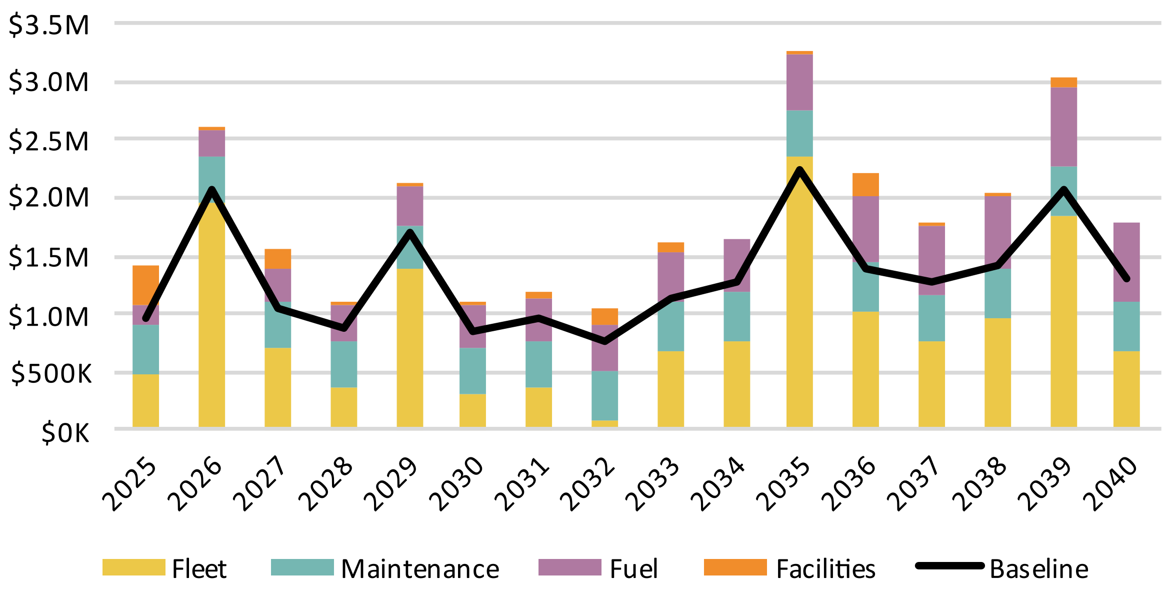

Figure C42: Civic Center Complex Total Cost of Ownership

Glendale Water & Power

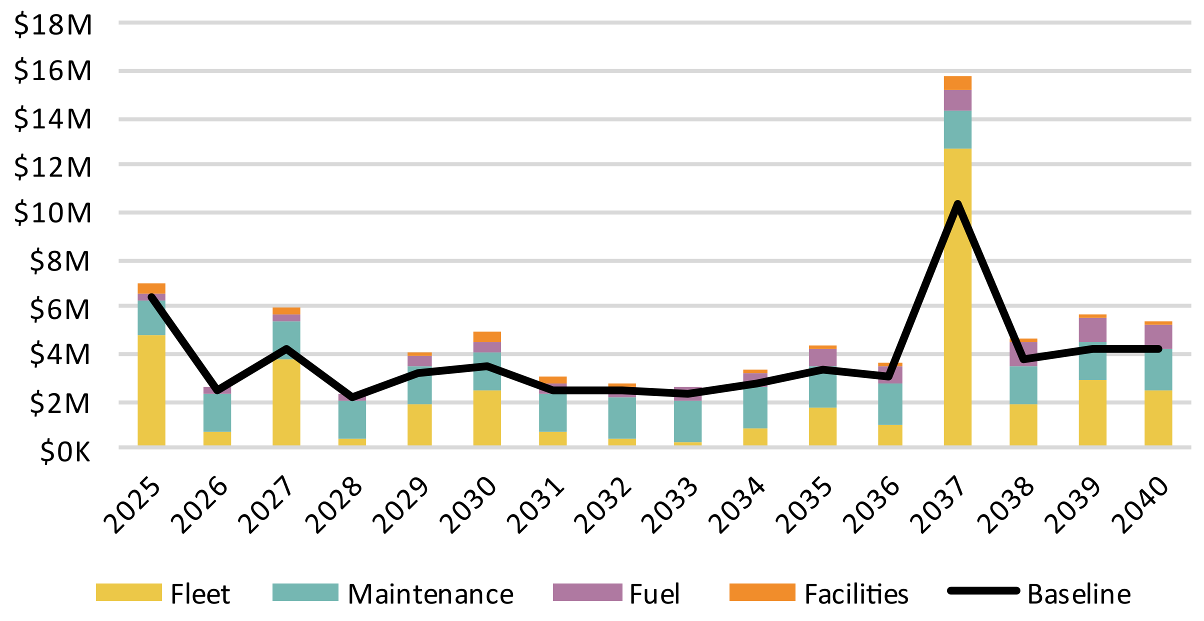

Figure C43: Glendale Water and Power Total Cost of Ownership

Integrated Waste Facility

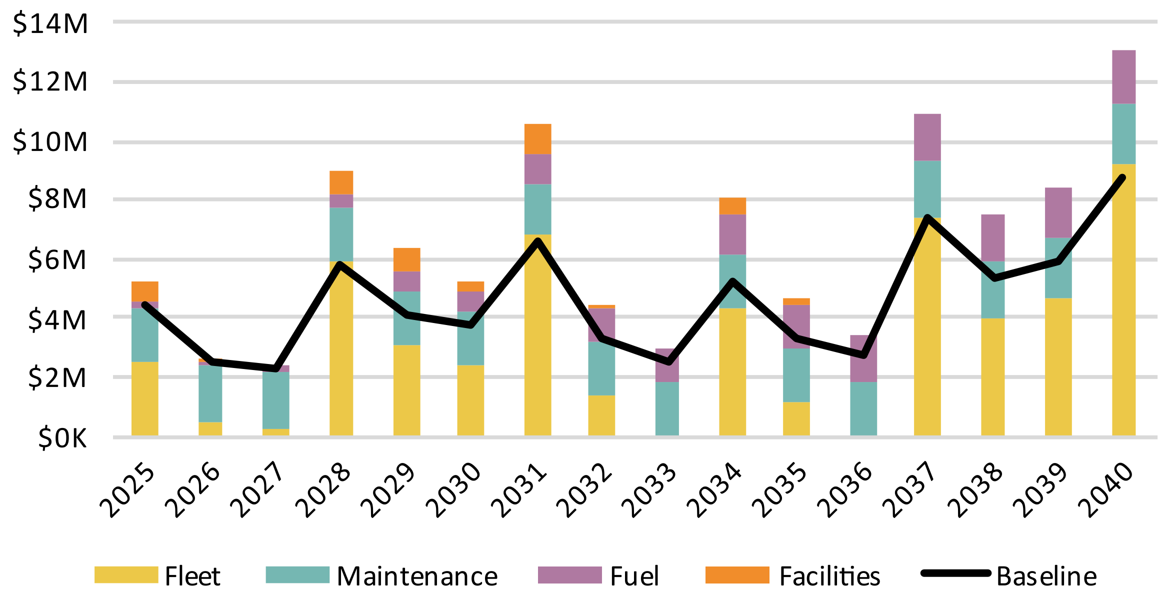

Figure C44: Integrated Waste Facility Total Cost of Ownership

Fire Station 21

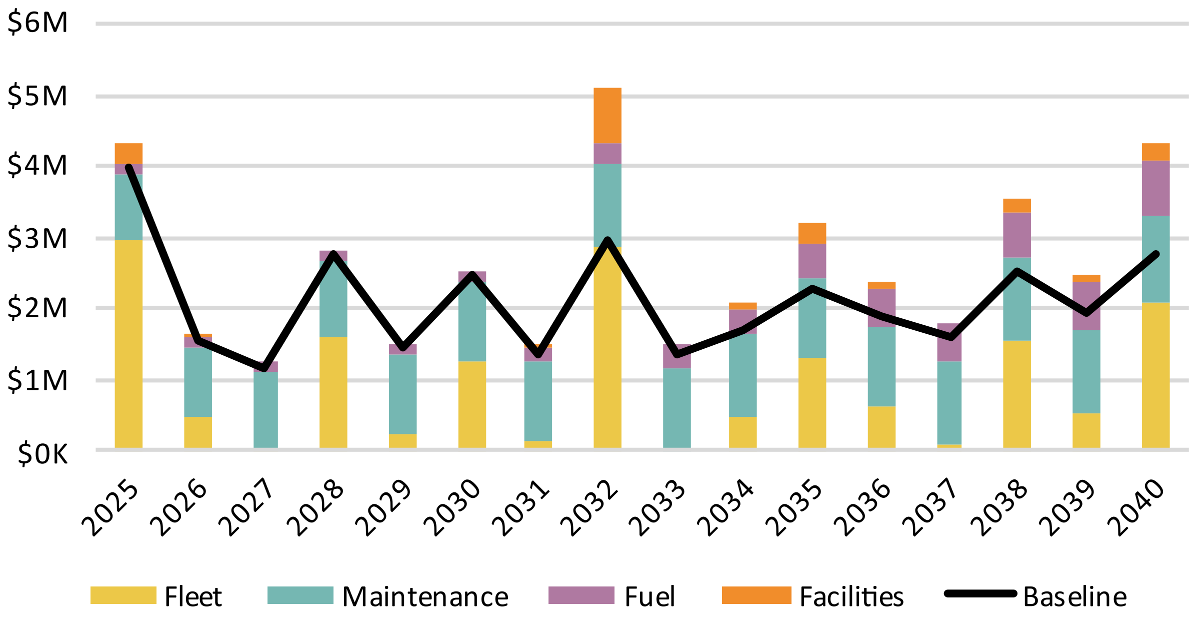

Figure C45: Fire Station 21 Total Cost of Ownership

Police Parking

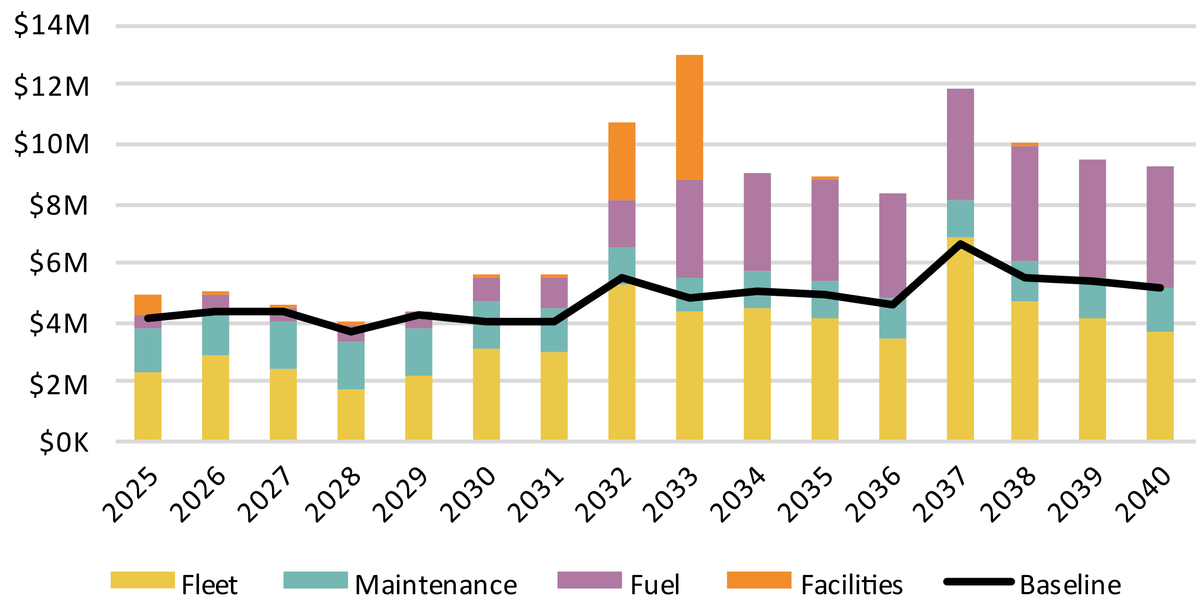

Figure C46: Police Parking Total Cost of Ownership