APS FLEET ADVISORY SERVICES PROGRAM

City of Flagstaff

Arizona Public Service (APS)

Fleet Electrification Assessment Report

Date: March 12, 2024

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1 EXECUTIVE SUMMARY

Arizona Public Service (APS) is working with qualified commercial customers to support their transportation electrification and decarbonization goals. As part of APS's vision to create a sustainable energy future for Arizona while serving its customers with clean, reliable, and affordable energy, the APS Fleet Advisory Services Program (the Program) is providing customers with no-cost assessments of the costs and benefits of converting their existing fossil fuel-powered fleets to all-electric fleets. In addition to supporting commercial customers with important aspects of fleet electrification planning, the Program serves as a tool to further enable APS and its customers to work collaboratively towards the successful integration of more EVs on the grid.

This assessment is built upon analysis conducted by DNV using their EV Fleet Analytics tool and related fleet market research. DNV is an independent third-party energy program implementer that APS has partnered with to provide fleet data analytics, market intelligence, and customized support for fleet electrification. The study uses customer-specific fleet data, including information on existing vehicles and current mileage requirements, to identify potential electric vehicle (EV) replacements for existing internal combustion engine (ICE) vehicles and estimate the total cost of ownership (TCO) savings and greenhouse gas (GHG) emissions reductions of transitioning to EVs. The study also provides customers with an EV Charging Infrastructure Buildout Strategy that includes estimates of the quantity and types of chargers required and the total installation cost.

The summary of activities included in this assessment is listed below:

- Data review that includes an evaluation of current fleet, vehicle operations, processes, and infrastructure.
- EV fleet analytics:
  - Summary of potential EV replacement options for existing ICE vehicles.
  - TCO comparison for EV and ICE fleet (capex,[1] maintenance, and fuel costs).
  - Assessment of GHG emissions reduction potential.
- EV charging infrastructure buildout strategy:
  - Evaluation of fleet charging needs based on identified near-term EV replacement potential.
  - Quantity and type of chargers recommended for selected facilities.
  - Infrastructure buildout costs (including electric service requirements and associated costs if applicable).
  - Estimated charging costs.
- Fleet electrification transition costs.
- Overall TCO (integrating vehicle and infrastructure analysis results).
- Summary of recommendations regarding vehicle electrification and infrastructure installation.

This report presents the fleet advisory study results for the City of Flagstaff's fleet. For brevity, we will refer to the City of Flagstaff as "Flagstaff" or the "City" throughout this report.

1.1 Recommendations for the City of Flagstaff

Through the analysis and research conducted for this study, DNV developed the following recommendations and considerations, classified as "fleetwide" and "targeted." For this report, "recommendations" are activities that the City should

[1] Capital expenditures, also known as vehicle purchase cost or upfront cost.

pursue in the near-term (or continue doing, in some cases), whereas "considerations" are items to keep in mind and/or discuss internally; considerations do not require near-term action.

1.1.1 Fleetwide Recommendations

The fleetwide recommendations are summarized below.

> Our analysis shows **potential fleetwide lifetime TCO savings** of over **$3.25M** for the light-duty non-patrol fleet, over **$700,000** for the light-duty patrol fleet, and over **$7.4M** for the medium- and heavy-duty fleet – for a total of $11.35M over an assumed vehicle lifetime.

- **Continue with plans to electrify City fleet** and build upon the steps taken so far given the clear potential for long-term, fleetwide TCO savings from electrification. Our analysis shows potential fleetwide lifetime TCO savings of over $3.25M for the light-duty non-patrol fleet, over $700,000 for the light-duty patrol fleet, and over $7.4M for the medium- and heavy-duty fleet (for a total of $11.35M over an assumed vehicle lifetime). Further, the potential fleetwide GHG emissions reduction is approximately 40,764 metric tons.
- **Pursue the strategic and integrated deployment of EV charging infrastructure** across City facilities, including considerations for EV Ready deployments to bring down the total installed infrastructure cost.
- **Prioritize electrifying vehicles with positive TCO savings** and install the recommended charging infrastructure in advance of vehicle acquisitions to ensure EVs have a place to charge once they join the fleet.
- When installing EV charging infrastructure at the selected facilities, **document lessons learned and best practices** to support long-term infrastructure deployment.
- **Seek to build strong partnerships** with APS, automakers, EV charging providers, internal stakeholders, and other municipalities pursuing electrification. These relationships will help the City collect critical data to support decision-making, ensure diverse perspectives are taken into account, and streamline electrification efforts. Key points:
  - When planning future infrastructure projects in particular, **engage with APS** early and often to gain a full understanding of available electric capacity, potential constraints, potential efficiencies, and opportunities to align future infrastructure planning with APS grid planning and expansion efforts.
  - Flagstaff should **engage with vehicle manufacturers in advance of planning to procure medium- and heavy-duty vehicles (MHDVs)** in order to collect up-to-date pricing and specification data, understand vehicle delivery timelines, and establish manufacturer relationships.
- **Track and evaluate EV and charger usage** to assess EV fleet vehicle performance and optimize future electrification efforts. This data can inform cost-effective future planning that takes into account EV usage, fleet performance, and associated infrastructure needs to balance overall cost with fleet operational performance and reliability. We recommend:
  - Implementing a vehicle telematics platform to support vehicle performance analysis. Note that a vehicle telematics platform should be deployed to both new EVs and existing ICEs and can provide Flagstaff with better data to inform future decision-making.
  - Collecting and analyzing charging data (available via a networking subscription) to understand charging behavior, charger performance, and any impacts on fleet operations; this data can also be leveraged to inform future infrastructure buildouts.

- **Leverage managed charging functionality** offered through networked chargers to maximize both energy cost savings and GHG emissions reductions. We recommend that the City enroll in APS's Level 2 EV charging rate rider to take advantage of lower energy costs when solar power is plentiful (9 a.m.–3 p.m.) and limit charging during APS's non-residential on-peak period (3 p.m.–8 p.m.), when energy is more expensive.

1.1.2 Targeted facility-level recommendations

The targeted, facility-specific recommendations are summarized below.

- City Hall:
  - Pursue electrification of 26 Administrative vehicles that demonstrate positive TCO savings.[2]
  - To charge these vehicles, install five dual-port (10 total ports) 40-A Level 2 chargers dedicated to City fleet only, with EV Ready infrastructure for a further five dual-port chargers (20 total ports including EV Ready work).[3]
- Police Department:
  - Pursue electrification of 10 administrative/detective vehicles that demonstrate positive TCO savings.[4]
  - To charge the administrative/detective vehicles, install six dual-port 40-A Level 2 chargers (12 total ports).
  - Initiate an internal stakeholder process to develop next steps regarding patrol fleet electrification, with the intent of collecting additional data and feedback to address current concerns regarding electrification of patrol vehicles.
    - When the City has enough information to move forward, we recommend that it begin its patrol fleet electrification efforts with up to four patrol vehicles and two 150 kW direct-current fast chargers (DCFC), plus EV Ready infrastructure for two more 150 kW DCFC fast chargers.
    - This project will likely require a capacity upgrade from APS and permission from Coconino County Sheriff's Department, so the City should engage with APS and the County early in the planning process.
- Thorpe Park:
  - Pursue electrification of 13 Parks department vehicles that demonstrate positive TCO savings.[5]
  - To charge these vehicles, install one dual-port 40-A Level 2 charger and one 100 kW DCFC fast charger.
- Public Works:
  - Pursue electrification of 46 vehicles that reside at the Public Works facility and demonstrate positive TCO savings.[6]
  - To charge these vehicles, install 10 DCFC fast chargers, each with a 100 kW power rating.
  - Consistent with our fleetwide recommendation to engage early with both MHDV manufacturers and APS, the City should develop a thoughtful and detailed electrification plan for Public Works that seeks to minimize the logistical challenges of a fleet transition while maximizing learnings that can be applied to streamline electrification efforts within the broader fleet. This process should involve careful consideration of the vehicle types to electrify first (from within the pool of vehicles that show positive TCO savings), the pace of electrification, and the broader consideration of current and future available electrical capacity.

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[2] The ages of the vehicles included in the City Hall electrification analysis ranged from 15 to 30 years.

[3] Note: all chargers recommended in this study are for fleet-dedicated usage (that is, they would not be publicly accessible).

[4] The ages of the vehicles included in the Police Department electrification analysis ranged from 13 to 18 years, with an average age of 15.6 years.

[5] The ages of the vehicles included in the Thorpe Park electrification analysis ranged from 18 to 27 years.

[6] The ages of the vehicles included in the Public Works electrification analysis ranged from 15 to 36 years.

1.2 Considerations for the City of Flagstaff

The considerations developed through this study are summarized below.

- Develop a policy around charging for take-home vehicles; we anticipate that this will be more of an administrative than a technical challenge.
- Consider pilot EV deployments, particularly for MHDVs; this approach will allow the City to collect critical performance data before committing to larger investments.
- Consider the costs and benefits of non-ownership (leasing) arrangements for EV charging infrastructure; note that the cost-benefit equation may change over time as the fleet scales and gains experience. Non-ownership and/or leasing arrangements may reduce the total installed cost of infrastructure by opening access to EV charging infrastructure tax credits.
- Consider the potential to charge vehicles from 9 a.m.–3 p.m. (all days of the week) to align with APS's lowest rates; this will depend on the extent to which vehicles are parked during this time across the City's facilities.
- As the electric fleet grows, maintenance needs will evolve, as will the skills required from Fleet Services staff. Flagstaff should continue providing education and training opportunities for staff to learn how to maintain EVs across all vehicle classes, working in conjunction with vehicle manufacturers and dealerships to ensure the training is current and aligns with Flagstaff's safety processes.
- EV maintenance, while broadly understood to be less expensive and less demanding than ICE vehicle maintenance, involves working with potentially unfamiliar and/or hazardous vehicle systems, including power electronics and batteries. Flagstaff should consider updates to its existing maintenance processes as well as the acquisition of appropriate safety equipment and tools. Beyond measures to improve safety through proper vehicle maintenance, the City should also be mindful of overall best practices surrounding fire mitigation and safety when responding to collisions involving EVs (both for fleet-owned EVs as well as for privately-owned EVs operating in Flagstaff).

2 FLAGSTAFF FLEET OVERVIEW

Flagstaff's fleet consists of several hundred vehicles spread across more than 30 City departments and a wide range of use cases. These vehicles – which are used for people, equipment, and materials transport around town; out-of-town travel; police patrol work; trash collection; and more – serve critical municipal functions and are domiciled across a number of facilities, including City Hall, the Police Department, Public Works, and Thorpe Park. Certain vehicles, such as garbage trucks and police patrol cars, serve dedicated functions and are typically domiciled at a single site when not in use, whereas others serve in more flexible roles. A subset of vehicles is also designated "take-home" vehicles; these vehicles are domiciled at the home of the City employee to which they are assigned.

In line with its Carbon Neutrality Plan and broader climate-related goals, Flagstaff is actively seeking opportunities to electrify its municipal fleet and develop the necessary charging infrastructure for reliable operation of an electric vehicle (EV) fleet. Discussions with the Fleet Manager and City Climate Analyst indicated that the city has an "EV First" policy, which prioritizes the purchase of EVs, then plug-in hybrids, and then conventional hybrids over internal combustion engine (ICE) vehicles and requires individuals who request a non-EV to justify why an ICE vehicle is necessary. The City has a robust process for handling and reviewing requests for new vehicles; this process is designed to proactively control costs as well as to align overall fleet size with the needs of individual departments.

Flagstaff procures gas and diesel fuel at market rates and conducts routine vehicle maintenance and repairs itself, though non-city technicians are used occasionally for maintenance and repair work. There are several EVs present in Flagstaff's fleet today, including three Chevy Bolts and four Ford F-150 Lightning pickup trucks; additional EVs are on order or pending receipt. Flagstaff has also installed fleet-dedicated EV charging to support these existing EVs, including two charge ports[7] at Public Works and four at the Police Station. The City also installed 18 EV charge ports across multiple city-owned locations through its participation in APS's Take Charge AZ program in recent years; however, these chargers are publicly available and were not designed to support dedicated fleet EV charging. As a result, the City is focusing on installing dedicated Level 2[8] and DCFC[9] fast charging infrastructure that will meet current and future charging needs.

DNV's fleet electrification assessment leveraged data on 361 vehicles[10] across 34 departments, which DNV consolidated into 10 department categories to streamline the presentation of results. For example, the Administrative category in Table 2-1 is comprised of 17 small departments, 15 of which have fewer than 10 vehicles each.

Table 2-1. Fleet breakdown by department

Fleet Department	Total Vehicles	Percent of Fleet
Administrative	62	17%
Airport	8	2%
Fire	29	8%
Fleet Services	12	3%
Police	64	18%
Street Maintenance	59	16%
Water Management/Utilities	46	13%

7 A charge "port" is synonymous with a "plug." Ports are connected to EV "chargers," which can contain one port ("single-port") or two ports ("dual-port"); chargers with more than two ports are relatively rare.

8 Level 2 charging uses a 240 V single-phase or 208 V three-phase AC electrical service and typically has a power rating between 6 kW and 19.2 kW. Level 2 charging stations deliver charging speeds faster than Level 1 chargers (which use a standard 120-V wall socket and charge at less than 1.8 kW) but slower than direct-current fast charging (DCFC), defined below. Level 2 charging can recharge most EVs overnight.

9 DCFC is the fastest type of commercially available EV charging. It typically features charging speeds of 50 kW to 350 kW and can restore approximately 80% of an EV's charge in 15-45 minutes; higher power levels result in lower charging times.

10 During initial data review, DNV removed the following vehicles from the analysis: motorcycles (7), trailers (8), existing EVs (6), vehicles that were missing make/model data (14), ineligible police vehicles (29), and high-mileage fire vehicles (12).

Fleet Department	Total Vehicles	Percent of Fleet
No dept. provided	8	2%
Solid Waste	44	12%
Parks and Recreation	29	8%
Total	**361**	**100%**

Table 2-2 summarizes this fleet breakdown by vehicle class and type.

Table 2-2. Fleet breakdown by vehicle class and type

Vehicle Class	Vehicle Type	Total Vehicles	Percent of Vehicles in Class
Light-duty	SUV/Hatchback	100	54%
	Pickup truck	68	37%
	Sedan	9	5%
	Van	7	4%
	Incomplete vehicle	0	0%
Light-duty subtotal		**184**	**100%**
Medium-duty	Incomplete vehicle	38	50%
	Pickup truck	33	43%
	Truck	5	7%
Medium-duty subtotal		**76**	**100%**
Heavy-duty	Truck	85	84%
	Fire vehicle	13	13%
	Incomplete vehicle	2	2%
	Bus	1	1%
Heavy-duty subtotal		**101**	**100%**
Total		**361**	

The majority (184, or 51%) of Flagstaff's vehicles are light-duty, with 101 heavy-duty (28%) and 76 medium-duty (21%). The most common vehicle type in the fleet is pickup trucks (101, 28%), with 68 light-duty pickups – predominantly Ford F-150s – and 33 medium-duty (these are heavier work trucks, like the Ford F-250 and F-350, which are classified as medium-duty in this analysis). SUVs and hatchbacks (100, 28%) are the next most common. Trucks (90, 25%) are the third most prevalent vehicle type and are dominated by heavy-duty vehicles that include garbage trucks, dump trucks, and firefighting vehicles as well as box and flatbed trucks.

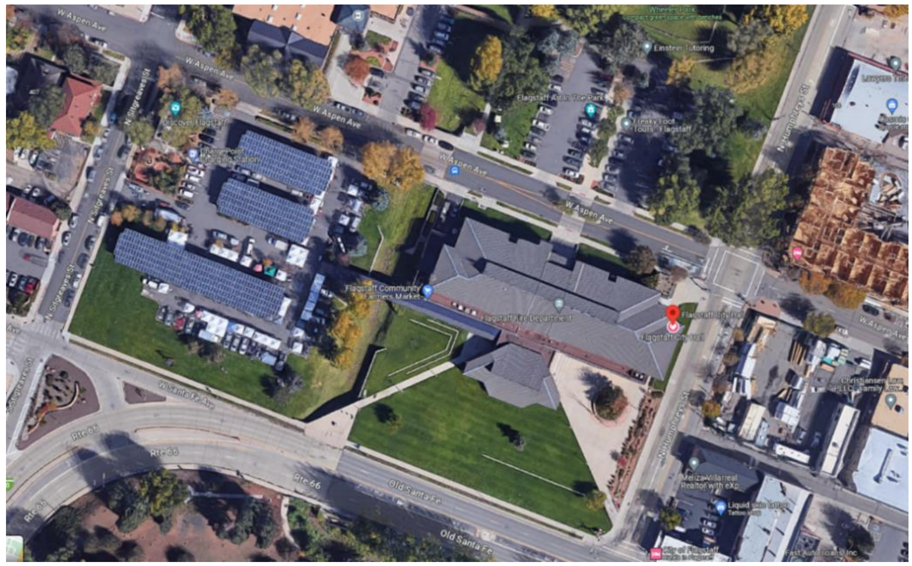
The "incomplete vehicle" category (40, 11%) is comprised of primarily medium-duty vehicles whose final configuration could not be ascertained. Based on the available make/model information, many of these vehicles are likely heavy pickup/work trucks, such as the Ford F-350 and F-450. However, because we could not determine whether these vehicles had been upfitted for an alternative use, we classified them as "incomplete," which is consistent with how they were identified based on their vehicle identification number (VIN).

3 SELECTED FLEET FACILITY OVERVIEW

Flagstaff selected four facilities for inclusion in this study that are described below.

3.1 Flagstaff City Hall

Figure 3-1. City Hall



Flagstaff City Hall is located at 211 W. Aspen Ave. and contains offices for multiple City departments, including administrative functions as well as traffic and fire department offices. The facility has 110-120 parking spaces, two publicly available dual-port Level 2 EV chargers (four total ports), and three solar carparks providing on-site renewable generation. Vehicles from Flagstaff's Administrative departments (62 vehicles included in this analysis) regularly park at City Hall, and it is likely that vehicles from other departments park on-site when visiting City Hall on official business. A subset of these 62 Administrative department vehicles form the basis of this facility's charging infrastructure scenario, described in greater detail in Section 6.2.

3.2 Flagstaff Police Department

Figure 3-2. Flagstaff Police Department

Flagstaff's Police Department is located at 911 E. Sawmill Rd. and is co-located with the Coconino County Sheriff Department, which is owned by Coconino County. The City has an arrangement with the County through which the City is able to direct the installation of EV charging infrastructure if it covers the costs. The facility contains offices for Police Department staff, including administrative, detective, and patrol functions. The facility has over 300 non-public parking spaces on the west and south sides of the property (left and bottom, respectively, in Figure 3-2), several solar carparks, and four non-networked Level 2 EV charge ports. The 64 police vehicles included in this analysis – including vehicles used by administrative staff and detectives as well as patrol cars – regularly park at the Police Department, with administrative and detective vehicles being "take-homes" and patrol cars operating daily with minimal downtime between shifts. A subset of these 64 vehicles form the basis of this facility's charging infrastructure scenario, described in greater detail in Section 6.3.

3.3 Parks and Recreation (Thorpe Park)

Thorpe Park is located at 600 N. Thorpe Rd. The park is home to the Thorpe Park Sports and Recreation Complex, athletic fields, tennis courts, and a parks maintenance facility with parking for fleet vehicles (this parking is unmarked and an exact number of spaces was not tallied). The 29 Parks and Recreation vehicles included in this analysis regularly park at Thorpe Park; a subset of these vehicles form the basis of this facility's charging infrastructure scenario, described in greater detail in Section 6.4.

Figure 3-3. Thorpe Park Fleet Facility

3.4 Public Works

Figure 3-4. Public Works Department Facility

The Flagstaff Public Works Department facility is located at 3200 W. Rte. 66. This facility houses several buildings, including (counterclockwise from top right in Figure 3-4): the Wash Rack, Fleet Services (Building #2, purple roof), Solid Waste (Building #3, grey roof), Streets (Building #5, pink roof), and Administrative staff (Building #6, white roof, bottom left).

Parking is located throughout the facility, with department-specific areas corresponding to each building. Vehicles from Flagstaff's Fleet Services, Solid Waste, and Streets departments (93 vehicles) regularly park at Public Works; a subset of these vehicles form the basis of this facility's charging infrastructure scenario, which is described further in Section 6.5.

4 ASSESSMENT METHODOLOGY

DNV worked with APS to develop this assessment of fleet electrification potential, costs, and benefits for the City of Flagstaff.

4.1 Study Scope

The scope of this study includes Flagstaff's on-road fleet vehicles (with the exception of motorcycles). Construction or miscellaneous equipment – including air compressors, generators, forklifts, and trailers – was excluded from the analysis during initial data review. Additionally, some specialized or high-mileage vehicles were excluded from the analysis based on discussions with Flagstaff team members: excluded vehicles in this category include the Police Department's bomb truck and special weapons and tactic (SWAT) vehicle as well as Fire Department vehicles that are occasionally called to travel out of state to assist in fighting wildfires. Finally, vehicles that did not contain any make/model information were also excluded since a suitable replacement EV could not be accurately identified.

4.2 Overview

Assessment performed and report prepared for:

Company/Organization: City of Flagstaff (Flagstaff)

Primary Contact: Danae Presler, Climate Analyst: City of Flagstaff Sustainability Office

Telephone: (928) 213-2141

Email: danae.presler@flagstaffaz.gov

As part of the assessment, DNV:

- Reviewed data provided by Flagstaff, including vehicle rosters, telematics[11] data, mileage logs, and maintenance and fuel cost records.
- Interviewed several Flagstaff employees to collect qualitative data describing the fleet's facilities, operations, vehicle purchase processes, and electrification efforts to-date.
- Deployed its EV Fleet Analytics tool to identify EV replacements and compare the costs and GHG emissions of ICE and EV fleets.
- Assessed charging infrastructure needs (types and quantities), charging energy requirements, and associated charging infrastructure equipment, installation, and operating costs (using data provided by APS where available).
- Synthesized the analysis results across the above activities to develop the findings, recommendations, and other considerations contained in this report.

Based on these activities, DNV has developed recommendations and other considerations that will help the Flagstaff team understand the costs and benefits of converting to an all-electric fleet and effectively plan for their continued electrification efforts.

[11] "Telematics" refers to any system of granular, remote data collection for a commercial fleet. Telematics systems typically collect high-resolution trip data and can include trip start and stop time and location; trip-level mileage, speed, fuel consumption, and fuel economy; and additional information used to manage and optimize fleet operations. Telematics data provides a more granular and accurate dataset than mileage logs, which may be updated less frequently and are more prone to data entry error. More information on fleet telematics can be found here: https://www.eroad.com/fleet-telematics-explained/

4.3 Detailed methodology and study approach

DNV's fleet assessment process consists of multiple steps and leverages a combination of analytical tools and market research[12] to provide robust, accurate, and customized insights to participating customers. The assessment contained the following steps:

- **Kickoff meeting:** This meeting, held between APS, Flagstaff, and DNV, marked the official start of the study. During this meeting, we introduced key members of the study team, reviewed the study scope and approach, shared data requirements, and discussed next steps. The kickoff was held in June 2023.
- **Data review:** Following initial receipt of Flagstaff's fleet data, DNV reviewed the data for completeness and worked with the Flagstaff team to identify and remove out-of-scope equipment, fill data gaps, and develop reasonable assumptions where needed. This activity extended from early August to early October 2023 and concluded once DNV had a suitable dataset with which to continue to the analysis.
- **Vehicle Analytics:** DNV loaded Flagstaff's fleet data into its EV Fleet Analytics tool. This tool leverages a data-driven approach to identify suitable EV replacements, quantify the total cost of ownership (TCO) of EVs and ICE vehicles, and estimate the GHG emissions of the existing and replacement vehicles.
  - **Replacement vehicle identification:** The tool uses information on the existing fleet – including vehicle type (e.g., sedan, SUV), peak daily mileage, and special requirements (e.g., all-wheel drive, local maintenance support) – to identify suitable EV replacements from within DNV's EV specifications database that match the existing vehicle type and provide sufficient range to meet existing mileage needs.
  - **Calculating TCO:** Once suitable replacement EVs have been identified, the tool integrates data on vehicle purchase costs, available EV tax credits, fuel costs, fuel economy, and maintenance costs to estimate and compare the TCO of ICE vehicles and EVs. Data on vehicle costs and other performance specifications is compiled from multiple sources to streamline the analysis.[13]
  - **Calculating GHG emissions:** The tool leverages the fuel economy and mileage data along with GHG intensity factors for gasoline, diesel, and APS grid power to estimate and compare the GHG emissions reductions of ICEs and EVs.
- **Charging Infrastructure Analysis:** Next, DNV assessed the charging infrastructure needs of Flagstaff's selected facilities and estimated the associated equipment, installation, and operating costs. This analysis was focused on the charging infrastructure needs of a subset of vehicles identified as primarily needing to refuel at one of the selected facilities. This narrowing of focus aligned with the scope of the Program-funded study and with the reality that Flagstaff will pursue a phased transition to EVs rather than transitioning all vehicles at once. As such, the infrastructure analysis is focused on near-term infrastructure needs, though it also includes recommendations and considerations for the long-term.
  - **Developing charging infrastructure scenarios.** For each of the selected facilities, DNV defined a set of vehicles for which to calculate the charging energy needs, forming the basis of the near-term charging needs assessment and cost analysis.
  - **Estimating charging infrastructure needs.** This analysis built upon outputs from the Vehicle Analytics task to determine the type of charger (Level 2 vs. DCFC and associated power level) required to serve the selected EVs.

[12] Note that the costs included in this report (including for vehicles, charging infrastructure, charger maintenance, etc.) are estimates. They are not firm quotes and are subject to change in response to a number of market and other factors.

[13] Note that while DNV's analysis (including the associated data deliverable) refers to specific make/models, these are intended to be "representative replacement options" rather than strict recommendations of a specific vehicle. The City is free to choose other models with similar price/performance that will meet Flagstaff's needs.

- Estimating charging infrastructure capex[14] and opex.[15] Following the above analysis, DNV applied representative per-charger cost factors to estimate the all-in cost of charger acquisition, installation, and operation.

- **Fleet Electrification Transition Cost Analysis:** Finally, DNV synthesized the analysis findings from the Vehicle Analytics and Charging Infrastructure Analysis to develop a holistic fleet electrification cost summary for Flagstaff's fleet. This activity also included a summary of recommendations and considerations regarding vehicle electrification and infrastructure installation.

4.3.1 Summary of data sources

This study drew upon multiple datasets from disparate sources, each of which is described briefly below.

City of Flagstaff

Flagstaff provided the following data to support this assessment:

- Four selected fleet facilities:
  - Flagstaff City Hall – 211 W. Aspen Ave.
  - Flagstaff Police Department – 911 E. Sawmill Rd.
  - Parks and Recreation Department – 600 N. Thorpe Rd.
  - Public Works Yard – 3200 W. Rte. 66
- Active vehicle roster across all departments
- Vehicle mileage data (combination of telematics and non-telematics/mileage logs)
- Vehicle maintenance data
- Vehicle dwell time estimates (based on vehicle activity logs from telematics data)
- Additional qualitative data collected via conversations with the Flagstaff team and staff from various City departments, including extensive discussions with the City Fleet Manager as well as interviews with the Police and Management Services Departments

APS

APS provided the following data to support this assessment:

- Summary of Arizona-specific average EV charger equipment, installation, and networking costs from the Take Charge AZ program
- Historical energy consumption data for the selected facilities
- APS commercial utility rates (accessed via web), including energy and demand charges
- Facility-level electric capacity data, including transformer sizes

DNV

DNV integrated data from the following sources to complete the study:

- EV Fleet Analytics Tool:
  - ICE and EV specifications, including vehicle type and class, vehicle make/model, fuel economy (miles per gallon and miles per kWh), GHG intensity (per mile), range, and battery size provided by the US EPA

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[14] Capital expenditures, also known as vehicle purchase cost or upfront cost.
[15] Operational expenditures, consisting of energy costs (kWh, kW), charger maintenance costs, and networking fees.

- ICE and EV price data (manufacturer suggested retail price, or MSRP) for 2023 vehicles, sourced from Wards Automotive data
- EV price and additional specification data, sourced from evadoption.com data

- Additional market and pricing data sourced from previous studies and/or web research.

4.3.2 Summary of key assumptions

Several assumptions were developed to facilitate this study. We summarize the key assumptions here, with additional assumptions included in Appendix A Additional Assumptions Used in the Analysis.

4.3.2.1 Vehicle analytics

- Based on conversations with the Flagstaff team regarding its vehicle acquisition policy, we assumed all acquisitions would be outright purchases of new vehicles (i.e., there is no leasing, no investigation of used vehicles, and no consideration for financing costs in this analysis).
- DNV modeled a 14-year non-patrol vehicle life and a 7-year patrol vehicle life to estimate lifetime TCO savings and GHG emissions reductions. These inputs were based on the provided data describing the age of the City's fleet vehicles; they differ slightly from the City's vehicle replacement policy (15 years for non-patrol and 6 years for patrol).[16]
- In estimating vehicle TCO comparisons, we assumed that Flagstaff would be choosing between a new ICE and a new EV. For example, for an existing Ford F-150, our analysis modeled the cost comparison between a new Ford F-150 (gasoline) and a new Ford F-150 Lightning (electric). In the vast majority of cases, we assumed a like-for-like vehicle type replacement (i.e., pickup for pickup, sedan for sedan).
- All EVs were assumed to be eligible for federal tax credits ($7,500 per vehicle for vehicles under 14,000-lb gross vehicle weight rating (GVWR) and $40,000 per vehicle for vehicles over 14,000 lb GVWR). The information available from the Internal Revenue Service (IRS) at the time of this study's completion suggests that Flagstaff, as a tax-exempt organization, would be able to claim the credit.[17] We encourage Flagstaff to follow updates to the Commercial Clean Vehicle Tax Credit as they continue to pursue fleet electrification.[18]
- We assumed that Flagstaff will be able to take advantage of Federal tax credits when available for all vehicles to reduce the upfront cost of purchased EVs. We acknowledge that the list of qualified manufacturers may change over time at the IRS's discretion.[19]
- There was no consideration of plug-in hybrid EVs (PHEVs) in this analysis. PHEVs present a significantly lower adoption barrier than all-electric EVs due to their ability to run on gasoline and their potential to be recharged using a Level 1 (wall socket) charger. Additionally, the modeling of PHEV usage, TCO savings, and emissions impacts requires more assumptions regarding driver charging and driving behavior.

4.3.2.2 Charging infrastructure buildout strategy

- We assumed no EV charger incentives or rebates would be available to offset upfront equipment and/or installation costs. This assumption reflects the recent closure of APS's Take Charge AZ program, the lack of incentives/rebates at the state-level, and IRS language suggesting tax-exempt organizations do not qualify for the federal government's Alternative Fuel Vehicle Refueling Property Credit.[20] This is a conservative assumption; it is possible that incentives

[16] There is a 2-3% positive impact on TCO savings for a 15-year vs. a 14-year vehicle life. This small discrepancy does not change the overall analysis results or findings contained within this study.

[17] Note that DNV and APS do not provide tax advisory guidance or support. The City should engage with internal and/or external tax advisors to fully understand tax credit eligibility, opportunities, and risks.

[18] https://www.irs.gov/credits-deductions/commercial-clean-vehicle-credit

[19] https://www.irs.gov/credits-deductions/manufacturers-for-qualified-commercial-clean-vehicle-credit

[20] https://www.irs.gov/credits-deductions/alternative-fuel-vehicle-refueling-property-credit

and/or rebates will become available in the future or that Flagstaff could pursue a non-purchase arrangement (e.g., leasing from an organization with tax liability) to gain access to such incentives.

- We developed per-charger cost estimates for charger equipment, installation, maintenance, and networking fees; these costs were then scaled by the number of recommended chargers. These cost factors pulled from a number of data sources, including APS's Take Charge AZ program, the California Electric Vehicle Infrastructure Project (CALeVIP) program, and web research.
- We integrated historical energy consumption data with the facility-level electric capacity data provided by APS to estimate available capacity to support new EV charging load. This analysis involved reasonable assumptions regarding the contributions to peak load of on-site renewable generation, power factor, and potential future increases to historical peak demand.

5 FLEETWIDE VEHICLE ANALYSIS

This section outlines the results of the Vehicle Analytics task. It begins by providing a high-level overview of the daily peak and average mileage estimates by vehicle type and department, followed by a fleetwide summary of total cost of ownership (TCO) savings and GHG emissions reductions.

The TCO cost savings and GHG emissions reductions results presented in this section are for all fleet vehicles that achieved positive TCO savings across the light-, medium-, and heavy-duty classes. In Section 6 – Charging Infrastructure Buildout Strategy – we present targeted charging infrastructure buildout scenarios for each of the four selected facilities, built around a smaller number of vehicles to be electrified, along with recommendations for each scenario.

5.1 Fleet mileage summary

To help identify suitable EV replacements for Flagstaff's existing fleet vehicles, we developed estimates of each vehicle's peak daily mileage requirement based on available mileage data from telematics and mileage logs as well as discussions with Flagstaff team members. The "peak daily mileage" represents the maximum mileage that would be required on 95% of travel days; it also guides the determination of the minimum EV range that would be suitable to meet Flagstaff's needs. This method was selected to meet Flagstaff's current operational requirements and to maximize the amount of charging that can be conducted on-site at Flagstaff facilities (thus minimizing the need for a "top up" at a public charging station). While this is a robust approach for selecting EVs, we encourage Flagstaff to evaluate mileage requirements when selecting EVs in the future and, where appropriate, to account for anticipated long-distance travel needs (e.g., traveling by car to a conference in Albuquerque).

RECOMMENDATION:
EVALUATE MILEAGE REQUIREMENTS WHEN SELECTING EVS IN THE FUTURE TO MAKE DATA-DRIVEN ELECTRIFICATION DECISIONS BASED ON REAL-WORLD NEEDS.

The average daily mileage was used to estimate the costs of vehicle operation. Maintenance costs were calculated using per-mile cost estimates, and fueling costs were calculated using average mileage, fuel economy (miles per gallon or miles per kWh), and average fuel costs for gasoline, diesel, and electricity.

5.1.1 Light-duty vehicles

Table 5-1 below, summarizes the **peak** daily mileage data summary for Flagstaff's light-duty vehicles; note that the values shown are averages from vehicles in the same department and of the same vehicle type.[21]

Table 5-1. Peak daily mileage by department and vehicle type – light-duty

Fleet department	Pickup truck	SUV/Hatchback	Sedan	Van
Administrative	147	156	138	107
Airport		150		
Fire		154		100

[21] Empty cells represent departments that do not have any vehicles of a given type.

Fleet department	Pickup truck	SUV/Hatchback	Sedan	Van
Fleet Services	150	150	160	
Parks and Recreation	94			150
Police	150	153	150	105
Solid Waste	150		150	
Street Maintenance	112	128		
Water Management/Utilities	137	150	150	

Table 5-2, below, summarizes the **average** daily mileage data for Flagstaff's light-duty vehicles; note that the values shown are averages from vehicles in the same department and of the same vehicle type.[22]

Table 5-2. Average daily mileage by department and vehicle type – light-duty

Fleet department	Pickup truck	SUV/Hatchback	Sedan	Van
Administrative	45	48	42	18
Airport		40		
Fire		50		60
Fleet Services	25	50	41	
Parks and Recreation	38			21
Police	21	35	21	26
Solid Waste	50		50	
Street Maintenance	44	46		
Water Management/Utilities	50	50	50	

5.1.2 Medium- and heavy-duty vehicles

Table 5-3, on the next page, summarizes the average daily mileage data summary for Flagstaff's medium- and heavy-duty vehicles (MHDVs); note that the values shown are averages from vehicles in the same department and of the same vehicle type. A peak mileage assessment was also completed for the MHDVs, which found that range was rarely a limiting factor for the vehicles in Flagstaff's fleet. Special attention was paid to the City's garbage trucks, which run long routes on a regular basis. Note, also, that 36 vehicles were excluded from the MHDV average daily mileage assessment due to limited mileage data, other missing data, or limited electrification potential. A majority of the city's MHDV fire vehicles were excluded due to a combination of missing mileage data and electrification potential, given the mission critical nature of this segment of the fleet as well as limited availability and high cost of electric fire vehicles.

[22] Empty cells represent departments that do not have any vehicles of a given type.

Table 5-3. Average daily mileage by department and vehicle type – medium- and heavy-duty

Fleet department	Bus	Fire vehicle*	Incomplete vehicle	Pickup truck	Truck	Van
Administrative	6		25	25		
Airport				25	25	
Fire			25	25	25	25
Fleet Services			22	25	35	
Parks and Recreation			28	35		25
Police			25	25	25	
Solid Waste		59*	34	25	77	
Street Maintenance			34	43	72	
Water Management/Utilities			33	25	25	

* The one "fire vehicle" included in Table 5-3 is part of the Solid Waste department; this vehicle was classified as a fire vehicle based on its VIN.

5.2 Fleetwide TCO savings summary

Using its EV Fleet Analytics Tool, the provided vehicle data, and the daily peak and average mileage data described above, DNV assessed the total cost of ownership (TCO) for Flagstaff's existing ICE fleet and the identified EV replacements and subtracted the EV TCO from the ICE TCO to determine the resulting savings, if any. Table 5-4 below, summarizes this comparison from a fleetwide perspective across all three classes.

Table 5-4. Fleetwide TCO savings summary[23]

	Light-duty (non-patrol)*	Light-duty (police patrol)*	Medium- and Heavy-Duty*
Vehicles assessed	143	41	177
Vehicles achieving positive TCO savings	120	41	151
Percent of vehicles with positive savings	84%	100%	85%
Average annual TCO savings (per-vehicle)	$1,946	$2,435	$3,490
Total annual TCO savings	$233,533	$99,847	$527,005
Total lifetime TCO savings	$3,269,457	$698,928	$7,378,070
Total energy required (annual kWh)	709,383	160,704	1,460,484

* The average vehicle life for non-patrol vehicles is 14 years (based on provided data). For this study, we reduced the average vehicle life for patrol vehicles to seven years, which is slightly higher than the average age suggested by Flagstaff's current patrol fleet but in line with broader market research.

Due to the unique operational challenges of a police patrol fleet and an acute vehicle shortage identified via interviews with Police Department staff, we analyzed the patrol fleet separately from the rest of Flagstaff's municipal fleet. Note that we provide additional context regarding these operational challenges in Section 6.3.

5.2.1 Light-duty non-patrol fleet

Within Flagstaff's non-patrol light-duty vehicle (LDV) fleet, 84% of the 143 vehicles demonstrate positive TCO savings based on the combination of upfront vehicle cost, maintenance costs, and fueling costs. The average per-vehicle annual savings is

[23] Note that all TCO savings values are in current (2023) dollars.

$1,946, which equates to $233,533 in annual savings if all 120 vehicles were electrified at once. Over an average 14-year vehicle life, Flagstaff could achieve over $3.25M in TCO savings by electrifying its non-patrol light-duty fleet, a significant cost savings opportunity.

Among the 120 vehicles with positive TCO savings, the average EV premium – that is, the ratio between the EV and ICE upfront costs – was 16% and the average daily mileage was 43.7 miles. This combination of factors worked together to result in positive annual and lifetime TCO savings, as lower EV maintenance and fueling costs, accrued over the vehicle's life, more than offset the added upfront cost of an EV. We recommend that Flagstaff prioritize electrifying this pool of vehicles over time and will provide more targeted recommendations in subsequent sections.

OPPORTUNITY:
FLAGSTAFF COULD ACHIEVE OVER $3.25M IN OPERATING COST SAVINGS BY ELECTRIFYING ITS NON-PATROL LIGHT-DUTY FLEET

A total of 23 vehicles did not show positive TCO savings through this analysis. This is a result of a combination of a high EV premium and relatively low mileage, which reduced the potential for these vehicles to make up the added upfront cost through lower operating costs. These vehicles showed an average EV premium of 51% and average daily mileage of between 20 and 25 miles. This result does not mean that these 23 vehicles cannot be electrified. In fact, there are many EVs that would be suitable matches based on vehicle type and electric range; however, we recommend that Flagstaff wait to electrify these low-priority vehicles until those with positive TCO savings have been electrified.

5.2.2 Patrol fleet

Flagstaff's patrol fleet currently consists of 41 vehicles, predominantly Ford Explorer SUVs that have been upfitted with emergency lights and auxiliary equipment. Due to the uniformity of this departmental fleet, our analysis found that 100% of these vehicles demonstrate positive TCO savings, with an average per-vehicle annual savings of $2,435. These savings equate to $99,847 in annual savings if all 41 vehicles were electrified at once and a lifetime savings of nearly $700,000 over an average 7-year modeled vehicle life. These savings are about 25% higher than the non-patrol fleet on a per-vehicle basis, which is primarily driven by two factors:

- **EV Premium.** The upfront cost of an EV patrol car is only 3.6% higher than a hybrid Ford Explorer after federal tax credits, as compared to an average premium of nearly 16% for the non-patrol fleet after tax credits.[24] As a result, EV patrol cars are very competitive on upfront cost compared to the baseline ICE vehicle Flagstaff currently uses in its fleet.[25]
- **Operational intensity.** Unlike the majority of the non-patrol vehicles, which were assumed to operate five days per week, the patrol vehicles were assumed to operate seven days per week, resulting in maintenance and fuel cost savings accruing more rapidly for patrol vehicles. This assumption reflects the fact that these are high-usage vehicles that are in constant rotation and "required to be operational 24/7," per our interview with Police Department staff.

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[24] DNV considered both the Tesla Model Y Long-range (330 miles EPA-rated) and the Ford Mustang Mach-E CA Route 1 Long-range (312 miles EPA-rated) as representative patrol EV candidates; both options have been deployed by police departments in the U.S.

[25] DNV assumed that the costs to upfit an ICE patrol car vs. an EV patrol car would roughly cancel out. To account for miscellaneous costs and a "learning curve" penalty for upfitters, we added a 20% cost multiplier to EV patrol cars in our analysis.

Even with the modeled positive savings shown above, there may be other barriers to electrification that the Police Department will need to work to overcome. These barriers and considerations are discussed in greater detail in Section 6.3.1.

RECOMMENDATION: CONTINUE IMPLEMENTATION OF "EV FIRST" VEHICLE PROCUREMENT POLICY AND PURSUE THE STRATEGIC DEPLOYMENT OF EV CHARGING INFRASTRUCTURE ACROSS THE SELECTED SITES.

5.2.3 Medium- and heavy-duty fleet

The majority of Flagstaff's medium- and heavy-duty vehicle (MHDV) fleet (85%) demonstrates positive TCO savings based on the combination of upfront vehicle cost, maintenance costs, and fueling costs. The average per-vehicle annual savings of $3,490 equates to $527,005 in annual savings if all 151 vehicles were electrified at once. Over an average 14-year vehicle life, Flagstaff could achieve over $7.4M in operating cost savings by electrifying these vehicles, or more than twice the potential TCO savings of the non-patrol light-duty fleet.

Operating cost savings drive these significant cost savings. This effect is amplified for MHDVs relative to LDVs due to the low fuel economy of heavier ICE vehicles and the greater efficiency of EVs. Further, our analysis found that MHDV EVs cost 39% less to maintain per year on average, which has a greater impact than for LDVs due to the more intense maintenance requirements of MHDVs. It's worth noting that the post-tax credit EV premium for MHDVs in our analysis averaged approximately 55%.

While the estimated per-vehicle cost savings for MHDVs are notably higher than for LDVs on average, we must note that the medium- and heavy-duty EV landscape is still nascent and evolving. Certain vehicle types – including garbage trucks and Class 4-6 straight trucks[26] – have several models on offer from established automakers, whereas the heavy pickup truck space (F-250 and larger) features several new market entrants as well as providers that offer electrified options built upon the frames of familiar ICE models. Given the fluid state of the MHDV space, we recommend that Flagstaff begin to engage with vehicle manufacturers in advance of planning to procure MHDVs in order to collect up-to-date pricing and specification data, understand vehicle delivery timelines, and establish manufacturer relationships.

RECOMMENDATION: BEGIN ENGAGING WITH MANUFACTURERS IN ADVANCE OF PROCURING MHDVS TO BUILD RELATIONSHIPS AND COLLECT PRICING AND PERFORMANCE DATA.

5.2.4 Fleetwide TCO savings takeaways

Across all vehicle classes (light-, medium, and heavy-duty), it is clear that there is significant potential for the City of Flagstaff to achieve TCO savings through the electrification of its fleet vehicles. Due to the fleet's relatively low average daily mileage requirements, there are few instances in which a vehicle cannot be electrified because an EV with sufficient range could not be identified. There are, indeed, some vehicles that do not achieve positive TCO savings due to a combination of a high EV premium and relatively low mileage, which hinders the ability to accrue operating cost savings over the life of the vehicle. However, the majority of vehicles do achieve positive TCO

[26] Straight trucks do not have a trailer hitch – they include box trucks and flatbed trucks.

savings. As such, we recommend that the City continue on the path it has been on through the implementation of its "EV First" vehicle procurement policy and pursue the strategic deployment of EV charging infrastructure across its properties (including EV Ready considerations where appropriate). More detail on the charging infrastructure buildout strategy for the four selected fleet facilities for this study is provided in Section 6.

5.3 Fleetwide GHG emissions reduction summary

DNV's EV Fleet Analytics Tool also quantified the GHG emissions reductions that can be achieved by electrifying Flagstaff's fleet. Table 5-5, below, summarizes the results from a fleetwide perspective.

Table 5-5. Fleet GHG emission reduction summary

	Light-duty (non-police patrol)*	Light-duty (police patrol)*	Medium- and Heavy-Duty*
Total annual emissions reduction (metric tons)	597	189	2,220
Total lifetime emissions reduction (metric tons)	8,360	1,324	31,080
Lifetime emissions reduction equivalency	1,860 gasoline-powered passenger vehicles driven for one year 940,700 gallons of gasoline consumed	295 gasoline-powered passenger vehicles driven for one year 148,982 gallons of gasoline consumed	6,916 gasoline-powered passenger vehicles driven for one year 3,497,243 gallons of gasoline consumed

* The average vehicle life for non-patrol vehicles is 14 years (based on provided data). For this study, we reduced the average vehicle life for patrol vehicles to seven years, which is slightly higher than the average age suggested by Flagstaff's current patrol fleet but in line with broader market research.

Across all classes, Flagstaff's projected lifetime GHG emissions reduction from electrifying the 312 vehicles with positive TCO savings is 40,764 metric tons, or the equivalent of the CO_2 sequestration potential of nearly 9,071 gasoline-powered passenger vehicles driven for one year.[27] There are several points worth noting about these results:

- The GHG emissions reductions presented in Table 5-5 account for Flagstaff's participation in APS's Green Power Partners (GPP) Program Green Connect option, which allows Flagstaff to claim the use of 100% renewable energy for their electricity consumption (Flagstaff pays a per-kWh adder as part of the program). That is, these results assume the electricity used for EV charging has a GHG intensity of 0 kg of CO_2 per kWh.
- The emissions reduction potential shown above is higher than if Flagstaff were not part of GPP, in which case a GHG intensity of 0.372 kg of CO_2 per kWh would have been used.[28]

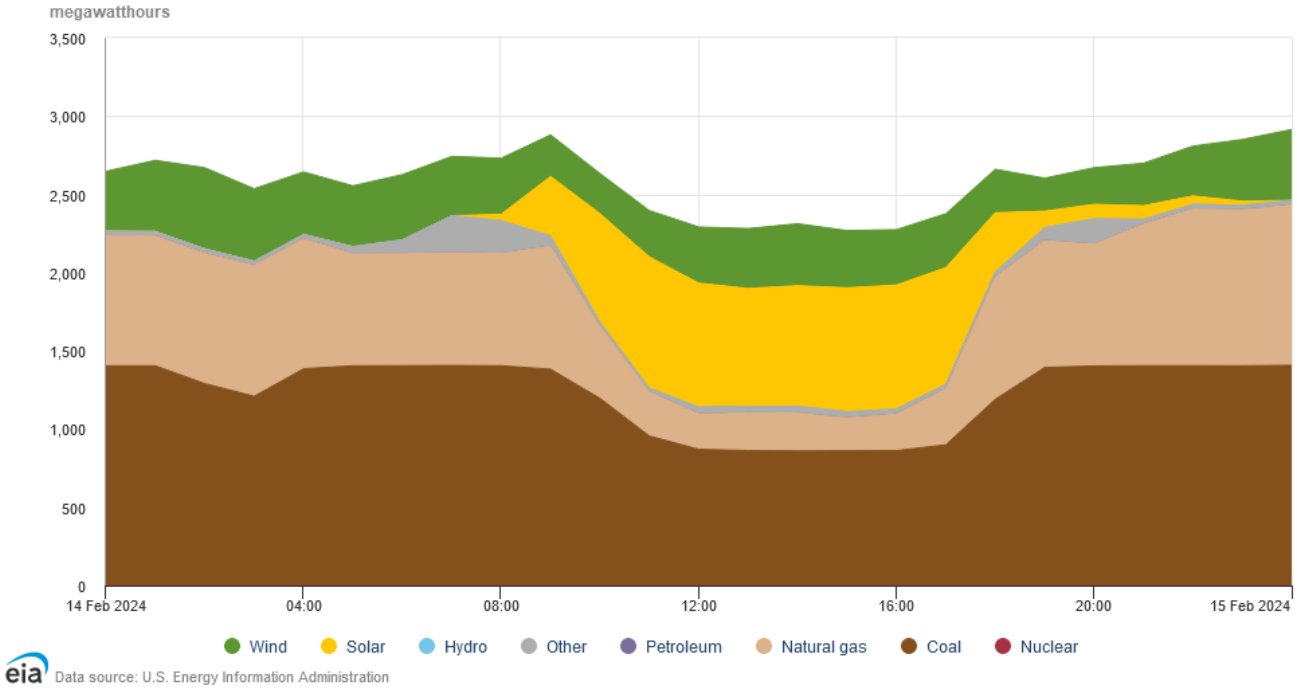
5.3.1 Managed charging and GHG emissions reductions

It is critical to note that a static GHG intensity factor, while valuable for this analysis, does not tell the full story of the grid's carbon intensity. The carbon intensity of grid power varies throughout the day as well as seasonally in response to changing demand patterns, the evolving mix of power generation, and other factors. This means that it is possible to align EV charging with certain times of the day to consume renewable power in real-time. In Arizona, the largest concentration of carbon-free renewable power is generated during the day from solar power, as shown in Figure 5-1.

[27] These equivalencies were determined using the EPA's Greenhouse Gas Equivalencies Calculator, available here: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

[28] This intensity comes from the EPA's eGRID dataset for the Arizona-New Mexico region, available here: https://www.epa.gov/egrid/summary-data

Figure 5-1. Electricity generation (MWh) by fuel source, 2/14/24 - 2/14/24[29]



These same seasonal and intraday variations within the electric grid also affect the price of the power that APS procures on behalf of its customers. To reflect these changing prices (which often, but not always, coincide with higher renewable power generation and thus lower emissions) and to incentivize EV charging off-peak, APS offers a rate rider for separately metered or submetered Level 2 EV charging (Rate Rider GS-EV) that is structured as follows:

29 Accessed on 2/22/24 via the EIA's Hourly Electric Grid Monitor: https://www.eia.gov/electricity/gridmonitor/dashboard/electric_overview/balancing_authority/AZPS

- **Off-peak kWh Credit.** For Level 2 charging conducted between 9 a.m. and 3 p.m., Monday to Sunday, customers receive a credit proportional to the amount of energy charged during this period.
  - For the Time-of-Use (TOU)[30] Extra Small and TOU Small rate plans, the credit is $0.04223 per kWh.
  - For the TOU Medium and TOU Large rate plans, the credit is $0.01766 per kWh.
- **On-peak kWh Premium.** For Level 2 charging conducted between 3 p.m. and 8 p.m., Monday to Friday, customers pay a premium proportional to the amount of energy charged during this period.
  - For the TOU Extra Small and TOU Small rate plans, the premium is $0.04223 per kWh.
  - For the TOU Medium and TOU Large rate plans, the premium is $0.01766 per kWh.

The selected facilities are currently on a mix of APS's Extra Small, Small, and Medium rate plans; none are currently on a TOU rate. It is likely that several facilities will be pushed into larger rate-plan classes as EVs are adopted due to the resulting increase in both electricity consumption (kWh) and demand (kW) from EV charging.

Per APS, the rate rider requires a separate meter or submeter to accurately quantify the time of day when charging occurs. Additional detail on these two options is provided below:

- **Submetering:** this option would require Flagstaff to switch its facility's rate to TOU, which could have an impact on the overall energy costs for the City (and may require additional efforts to manage overall energy consumption and cost) depending on when each facility consumes electricity. The benefit to submetering is that Flagstaff would not need to open a new account/service with APS to serve EV charging.
- **Separate metering:** this option would require Flagstaff to open a dedicated electrical service for EV charging but would allow the City's facilities to remain on their current utility rates. Per APS, the amount of time needed to set up a new service will depend on site conditions, the location of the incoming electric service, and the location of the chargers relative to existing on-site electrical equipment.

RECOMMENDATION: ENROLL IN APS'S EV RATE RIDER AND REDUCE CHARGING COSTS BY MINIMIZING ON-PEAK CHARGING AND INCREASING OFF-PEAK CHARGING.

We recommend that Flagstaff do the following to minimize energy costs and maximize GHG emissions reductions:

- Enroll in APS's Level 2 EV charging rate rider – and determine whether separate metering or submetering is preferred – to take advantage of potential lower costs for charging during the off-peak period.
  - Note that if the City pursues submetering and moves its facilities to TOU rates, it is possible that energy costs will increase depending on when energy is consumed at individual facilities. It may also be possible for the City to lower overall energy costs compared to a non-TOU case; however, this analysis is outside the scope of this study.

[30] TOU utility rates charge different prices for energy consumed or produced at different times. They provide a price signal to customers to help align energy consumption with periods of lower wholesale energy costs or lower grid carbon-intensity.

- Minimize EV charging from 3 p.m. to 8 p.m., Monday-Friday. This can be facilitated through a combination of charging schedules, user access controls, and staff training.
- Increase EV charging during the 9 a.m. to 3 p.m. window where possible. Given the fact that many vehicles are in use during this time, this may require setting charging schedules to maximize weekend charging, when vehicles are less likely to be in use.

5.4 High-level implementation checklist

Table 5-6, below, contains an overview of the ordered steps that Flagstaff should follow as it continues along its electrification journey. Several of these steps will be familiar to Flagstaff, given that the City has already adopted several EVs and deployed early Level 2 charging infrastructure.

Table 5-6. High-level EV and charging infrastructure implementation checklist

Category	Checklist
Vehicle Planning	• Review list of recommended EV replacements at each selected facility. • Refine and prioritize as needed based on combination of vehicle age, total mileage, projected TCO savings, current vehicle wear and tear, budget availability, and other factors. • Initiate discussions with manufacturers/dealers to refine pricing and delivery time estimates.
Charging Infrastructure Planning	• Review infrastructure recommendations and determine appropriate number and types of chargers to deploy for each facility (in tandem with the above EV adoption planning). • Reach out to qualified EV charging vendors and contractors for price quotes and installation timelines. • Consider viability of pursuing alternative infrastructure ownership and/or leasing arrangements that may reduce total installed costs by opening access to EV charging infrastructure tax credits.
Utility Engagement	• Work with APS to verify available site electrical capacity, particularly to inform long-term plans and EV Ready installation planning.
Infrastructure Installation	• Purchase and install EV charging infrastructure at selected facilities.
Vehicle Acquisition	• Purchase EVs. • Schedule acquisitions to align with or slightly follow infrastructure installation.
Vehicle Operation and Evaluation	• Operate EVs and evaluate their performance. This may include analysis of vehicle telematics and/or charger utilization data to understand usage patterns, charging behavior, EV performance, and achieved cost savings. • Incorporate learnings into future planning.

Addressing Long-term Considerations	• Assess the need for – and, if needed, develop – a charging infrastructure policy for take-home vehicles.
	• Initiate a robust process involving the appropriate stakeholders to develop next steps regarding patrol fleet electrification. Steps to this process may include:
	  • Work with APS to assess the additional capacity required to support multiple DCFC charge ports, including potential capacity expansion costs.
	  • Initiate conversations with automakers and police vehicle upfitters to begin collecting the data needed to inform budget development and vehicle capability assessment.
	  • Collect input from additional stakeholders to understand potential fleet readiness perception concerns; stakeholders may include police offers.
	  • Develop a robust plan for collecting the vehicle performance data needed to inform decisions regarding ongoing electrification. Include both EV charging infrastructure and vehicle considerations in future planning.

6 CHARGING INFRASTRUCTURE BUILDOUT STRATEGY

This section outlines the results of the EV Charging Infrastructure Buildout Strategy task. It begins with results at the facility level and closes with an overview of the findings for all four in-scope facilities. The results briefly restate the facility description, summarize the vehicles included in the targeted infrastructure buildout scenario, and then highlight the recommended charger deployment approach. We then summarize the costs of the proposed scenario and close by identifying any electric capacity constraints, if applicable.

6.1 Approach

As shown in Section 5, a significant portion of Flagstaff's fleet demonstrates positive TCO savings and thus represents an electrification opportunity. The number of vehicles with electrification potential is much higher than could be reasonably electrified in the near-term, due to the high upfront cost of vehicle acquisition, the need to plan charging infrastructure ahead of vehicle deployments, potential limited EV availability, and operational challenges. To address this challenge and provide actionable insights, DNV developed one charging infrastructure buildout scenario per selected fleet facility. This approach was designed to allow Flagstaff to focus its efforts on a manageable number of vehicles, resulting in infrastructure buildout recommendations that are more targeted and can be addressed in the near-term while providing a basis for longer-term planning.

To develop each scenario, DNV completed the following steps:

- Built upon the results of the Vehicle Analytics task described in Section 5 and mapped the vehicles with electrification potential to one of the selected facilities, with assistance from the Flagstaff team.
- Identified a subset of vehicles likely to park at the facility, which was used to determine the required number and type of EV chargers; we assumed that the oldest vehicles would be replaced first.
- Worked with Flagstaff and APS to compile historical energy consumption and electrical equipment sizing for each facility.
- Integrated charger equipment, installation, maintenance, and networking cost data.
- Analyzed the total infrastructure buildout costs.

The following subsections provide additional detail on EV-related concepts that factored into our analysis.

6.1.1 EV-ready infrastructure planning

For some of the selected facilities, DNV included a recommendation for the development of "EV Ready" infrastructure. EV readiness is generally defined as the practice of building parking spaces that "include electrical infrastructure at the time of construction that enables future EV charging."[31] In this study, we included the following under EV Ready development (also referred to as "futureproofing"):

- Digging/trenching to extend electrical infrastructure to additional parking spaces in the future.
- Running electrical conduit to accommodate additional EV charging infrastructure.
- Installation of additional electrical equipment, including panels, to serve future charging needs.

Planning EV Ready, or future-proofed, charging infrastructure can result in significant installation cost savings. For example, if a project only needed 50 ft of trenching to support an initial charger buildout but expected to need 50 ft more in the future, it would be more cost-effective to dig 100 ft during a single project than digging 50 ft per project across two projects. While it can be difficult to look too far into the future when planning fleet electrification efforts, our recommendations are designed to

[31] https://www.cleanenergy.org/blog/ev-readiness-and-why-we-need-it-now/

accommodate both first and second “waves” of electrification, looking beyond the initial set of recommended EVs. To calculate future-proofed installation costs, we added an assumed 20% economy of scale cost savings factor to our standard per-charger installation cost estimate and multiplied this estimate by the number of recommended EV Ready chargers.

6.1.2 Networked EV chargers

Note that all recommendations are for *networked chargers.* Networked EV chargers offer wireless connectivity through Wi-Fi, cellular, or other connections and provide the following functionality:

- Store and transmit charger usage data, including plug-in/plug-out time, energy consumption, energy costs, charging session duration, and more.
- Ability to schedule charging (e.g., to begin at 10 p.m. even if the vehicle is plugged in at 5 p.m.).
- Ability to set prices and/or control charger access to specified sets of users (e.g., from a single department).

EV charging vendors typically charge a networking fee for access to this functionality; for this study we assumed a fee of $120 per year per charger. These fees and the available functionality will differ across different charging hardware and software providers. Many EV charging vendors offer the ability to manage EV charging through advanced scheduling that is easily programmed via a web-based dashboard, which then communicates over-the-air with the charger.

6.1.3 EV charger maintenance

As with any piece of equipment, EV chargers require regular maintenance to ensure they operate reliably and safely over their useful life. Many EV charging vendors offer proactive maintenance packages. When installing EV charging infrastructure, it is critical to establish responsibility for maintenance costs and determine the responsible party for repairs, whether Flagstaff, the charging network/vendor, or the installer. The Department of Energy further recommends that “charger maintenance contracts should include a response time, time for a given repair, and an overall uptime requirement” (also known as a service-level agreement or SLA) to ensure charger reliability and to provide clarity on expected performance and anticipated costs.

Proactive charger maintenance can include the following activities:

- Regularly cleaning and inspecting the charger itself, charging cables and, if applicable, interactive screens.
- Repairing damaged charging cables.
- Cleaning ventilation grates.
- Ensuring software and firmware are up to date.

For this analysis, we assumed an annual per-charger maintenance cost of $398 for Level 2 chargers and $800 for DCFC.

6.1.4 Cost of energy for EV charging

To estimate the cost of charging the recommended replacement vehicles, DNV reviewed APS’s rate tariff and analyzed increased electricity consumption from EV charging. There are multiple variables that impact the cost of electricity, including the following:

- Pace of EV replacements in Flagstaff’s fleet.
- Timing of EV charging compared to when a facility’s demand currently peaks.
- Magnitude of EV charging peak load, which may increase as more EVs join the fleet but can be managed through smart scheduling and other strategies.
- Cost of energy, including the potential for facilities to change rate-plan classes as their overall energy consumption increases as well as the ability for Flagstaff to take advantage of time-of-use charging rates that incentivize or disincentivize charging during specific periods of the day.

To account for uncertainty in the variables listed above, DNV utilized an all-in per-kWh cost of $0.15/kWh when analyzing the cost to charge EVs in our analysis. This figure is based on the General Service Medium rate plan published by APS and accounts for the adder Flagstaff pays under the GPP Connect program, as well as an adder to account for uncertain demand charge impacts. Although this does not provide a specific breakdown between the cost of energy and demand, it is intended to provide a conservatively high cost of "fueling" the proposed EV fleet.

The following sections outline the results for each fleet facility.

6.2 City Hall

Flagstaff City Hall is located at 211 W Aspen Ave and contains offices for multiple City departments, including administrative functions as well as traffic and fire department offices. The facility has 110-120 parking spaces, two publicly available dual-port Level 2 EV chargers, and three solar carparks providing on-site renewable generation.

A total of 62 vehicles from Flagstaff's Administrative departments were assumed to regularly park at City Hall; 26 of these vehicles were included in this scenario due to their above-average age and annual mileage (i.e., we assumed that these vehicles would be prioritized for replacement based on wear and tear). The total acquisition cost for these 26 vehicles is estimated to be $1.42M while producing an annualized cost savings of approximately $49,000.

Based on discussions with City staff, which indicated that a large one-time charger deployment would prove challenging for a number of reasons,[32] we modeled a scenario involving five dual-port Level 2 chargers (10 total ports) with EV Ready futureproofing for an additional 10 ports.[33] The following tables present the analysis results for this scenario.

Table 6-1. City Hall charging infrastructure buildout – charger recommendation

	Level 2	DCFC
Vehicles modeled in scenario	26	
Number of chargers	5	0
Charger type	40A L2	n/a
Port configuration	Dual-port	n/a
Total ports	10	n/a
Per-unit charger power (kW)	9.6	n/a
Total nameplate power (kW)	96	n/a
Amps per unit (breaker rating)	50	n/a
Total amps (before EV Ready)	500	n/a
Additional chargers modeled for EV Ready installation	*5*	*n/a*
Total amps (including EV Ready)	*1,000*	*n/a*

[32] The Flagstaff team indicated that converting more than 10 parking spots to EV charging in an initial buildout would be difficult. Additionally, Flagstaff City Hall hosts a farmer's market on weekends, during which cars must be removed.

[33] All recommended dual-port chargers were assumed to support simultaneous charging, or the ability to charge two EVs at the same time at a single charger. A dual-port 40 A charger would be able to deliver 40 A to each port.

Table 6-2 shows that the recommended five dual-port 40-A Level 2 chargers would support simultaneous charging at 9.6 kW per port for 10 EVs, for a total connected charging load of 96 kW. Serving this load would require 500 A of capacity. Further, the additional five dual-port chargers recommended for EV Ready installation would, when installed and energized, draw up to an additional 96 kW and require an additional 500 A of capacity. No DCFC chargers are recommended for City Hall due to the low daily charging energy requirements of the vehicles parking at this facility.

Table 6-2. City Hall charging infrastructure buildout – cost summary

	Level 2	DCFC	Total
Equipment costs (one-time)	$25,000	n/a	$25,000
Installation costs (one-time)	$30,000	n/a	$30,000
Maintenance costs (lifetime)*	$27,846	n/a	$27,846
Networking fees (lifetime)*	$8,400	n/a	$8,400
Maintenance costs (annual)	$1,989	n/a	$1,989
Networking fees (annual)	$600	n/a	$600
Year 1 cost	**$57,589**	**n/a**	**$57,589**
Recurring annual cost	**$2,589**	**n/a**	**$2,589**
Total lifetime cost*	**$91,246**	**n/a**	**$91,246**
Future-proofing installation cost (one-time)	*$24,000*	n/a	*$24,000*
Total lifetime cost with future-proofing	***$115,246***	*n/a*	***$115,246***

*Note that the average life of an EV charger was modeled at 14 years.

Table 6-3 shows that the recommended infrastructure would cost $25,000 for the chargers themselves and $30,000 for installation. Ongoing costs for proactive charger maintenance and networking fees add $2,589 per year and a total of $36,246 over the modeled 14-year life of the chargers.

There is also a one-time cost of $24,000 for the additional planning/design, trenching, conduit, and electrical equipment needed to support the recommended five EV Ready dual-port chargers. To reach our estimate of $24,000, we assumed an initial $30,000 installation cost and applied the aforementioned 20% savings factor to account for economies of scale in planning/design, trenching, and conduit, as well as the charger installation labor that would not be required.

Table 6-3. City Hall charging infrastructure buildout – electric capacity assessment

	Level 2	DCFC
Existing spare electrical capacity (kW)	435	
Recommended new charging load (kW)	96	n/a
Future-proofed chargers load addition (kW)	96	n/a
Remaining electrical capacity (after recommended chargers installed)	339	n/a
Remaining electrical capacity (after EV Ready chargers energized)	243	n/a

Table 6-3 shows that Flagstaff's City Hall currently has approximately 435 kW of spare electric capacity after accounting for existing grid infrastructure and current electricity demand. The recommended charging infrastructure would add up to 192 kW of new load to the site (including the EV Ready ports), leaving approximately 243 kW of spare capacity that could be used for additional future EV charging without needing to pursue a capacity upgrade with APS.

It is worth noting that in this scenario, we have recommended a total number of charge ports (10 at first and 20 over time) that is less than the total number of vehicles we recommended be prioritized for electrification at City Hall (26). Our analysis indicates that the average daily charging requirement, based on daily mileage requirements and EV efficiencies, will be 27 kWh, meaning that the majority of EVs will not need to recharge every day/night. Further, the average recharge time will be around three hours, which will make it possible to recharge at least two EVs per port during a single eight-hour workday when EVs are parked at City Hall during working hours. These statistics suggest that an EV-to-charger ratio of greater than one is acceptable; that is, the City does not need to install a dedicated charger for every EV it acquires.

The appropriate long-term ratio of EVs to chargers is difficult to determine until Flagstaff has acquired more EVs, gained experience incorporating them into fleet operations at scale, and documented any challenges that arise. In the early days of the fleetwide transition, a lower EV-to-charger ratio is sensible to prioritize reliability; over time, however, the City may gain confidence in its ability to charge EVs less often (for example, every second or third night instead of nightly) without impacting fleet readiness, in which case it may be possible to reduce future EV charging infrastructure costs as the fleet continues electrifying. We recommend that Flagstaff implement a system for tracking charger and EV usage (with the support of networked charging data and a robust vehicle telematics system) to develop an optimal charging strategy as the number of EVs in the fleet grows. Implementing this data-driven approach will help the City proactively identify any issues with charger availability and, over time, determine an appropriate EV-to-charger ratio that balances overall infrastructure costs with fleet readiness and reliability.

RECOMMENDATION:
IMPLEMENT A SYSTEM FOR TRACKING EV USAGE AND CHARGING BEHAVIOR USING NETWORKED CHARGING DATA AND TELEMATICS TO CREATE AN OPTIMAL CHARGING STRATEGY AS THE EV FLEET GROWS.

6.3 Police Department

Flagstaff's Police Department is located at 911 E Sawmill Rd and is co-located with the Coconino County Sheriff Department, which is owned by Coconino County. The facility contains offices for Police Department staff, including administrative, detective, and patrol functions; it has over 300 non-public parking spaces, several solar carparks, and four non-networked Level 2 EV charge ports.

A total of 22 vehicles belonging to administrative staff and detectives, plus 41 patrol vehicles, regularly park at the Police Department; of these, 10 administrative/detective vehicles were included in this scenario, along with four patrol vehicles. The total acquisition cost for these 14 vehicles is estimated to be $650,000 while producing an annualized cost savings of approximately $26,000. Based on discussions with City staff, we modeled a scenario involving the following charging infrastructure:

- **Level 2:** Six dual-port Level 2 chargers (12 total ports)

- **DCFC:** Two single-port 150 kW DC fast chargers for rapid refueling of patrol vehicles with EV Ready futureproofing for an additional two DCFC ports.

The tables below present the analysis results for this scenario.

Table 6-4. Police Department charging infrastructure buildout – charger recommendation

	Level 2	DCFC
Vehicles modeled in scenario	14	
Number of chargers	6	2
Charger type	40A L2	150 kW DCFC
Port configuration	Dual-port	Single-port
Total ports	12	2
Per-unit charger power (kW)	9.6	150
Total nameplate power (kW)	115	300
Amps per unit (breaker rating)	50	264
Total amps (before EV Ready)	600	528
Additional chargers modeled for future-proofing installation	*0*	*2*
Total amps (including EV Ready)	*0*	*1,055*

Table 6-5. Police Department charging infrastructure buildout – cost summary

	Level 2	DCFC	Total
Equipment costs (one-time)	$30,000	$211,558	$241,558
Installation costs (one-time)	$36,000	$175,524	$211,524
Maintenance costs (lifetime)	$33,415	$22,400	$55,815
Networking fees (lifetime)	$10,080	$3,360	$13,440
Maintenance costs (annual)	$2,387	$1,600	$3,987
Networking fees (annual)	$720	$240	$960
Year 1 Cost	**$69,107**	**$388,922**	**$458,029**
Recurring Annual Cost	**$3,107**	**$1,840**	**$4,947**
Total lifetime cost	**$109,495**	**$412,842**	**$522,337**
Future-proofing installation cost (one-time)	*$0*	$140,419	*$140,419*
Total lifetime cost with future-proofing	***$109,495***	*$553,261*	***$662,757***

Table 6-6. Police Department charging infrastructure buildout – electric capacity assessment

	Level 2	DCFC
Existing spare electrical capacity (kW)	205	Insufficient existing capacity for DCFC installation
Recommended new charging load (kW)	115	300
Future-proofed chargers load addition (kW)	0	300
Remaining electrical capacity (after recommended chargers installed)	90	Insufficient existing capacity for DCFC installation
Remaining electrical capacity (after EV Ready chargers energized)	90	Insufficient existing capacity for DCFC installation

Note the following points of consideration regarding this scenario:

- The recommended Level 2 chargers would primarily be used by the administrative/detective vehicles, which have a relatively low daily mileage requirement and are unlikely to require frequent fast charging; the Level 2 chargers could also be used by the patrol vehicles.
- While any fleet vehicle could use the fast chargers, they are primarily intended to provide rapid recharging for patrol vehicles, which often have unpredictable (and potentially high) mileage needs as well as short shift breaks.
- Despite the noted challenges with electrifying patrol vehicles (see Section 6.3.1) and the uncertainty associated with when the City might acquire one, we included a future-proofed DCFC build-out for this scenario to capture efficiencies associated with such a large infrastructure project.
- There is significant uncertainty in the true amount of available electrical capacity due to the extensive on-site solar. Based on our analysis of the available data, there is insufficient capacity to support the installation of DCFC chargers here without a capacity upgrade provided by APS. There appears to be capacity available for at least 12 40 A Level 2 charge ports.
  - As capacity is built out to support DCFC chargers, the City should consider treating the Police Department as a fast-charging “hub” that can be used by other departments when patrol cars are not charging; this will extend the value of the DCFC investment and reduce the need to install potentially duplicative infrastructure at other facilities.

6.3.1 Police Department considerations

Stemming from our interview with Police Department staff, a number of unique operational considerations for Police vehicles were identified and discussed. We summarize these considerations below, along with implications for fleet electrification and infrastructure deployment as well as strategies Flagstaff can take to navigate and mitigate these concerns.

6.3.1.1 Patrol Vehicles

A number of challenges have been identified by Police Department staff, including the following:

- **Mission critical operations.** Flagstaff’s patrol fleet provides a critical municipal function. The department recognizes that electrification efforts must take into account the ability of patrol EVs to respond to emergency situations and perform effectively given the unique demands of patrol work as well as Flagstaff’s climate.
- **Range, downtime, and charging.** The 41-vehicle patrol fleet currently operates under a “Hot Cars” structure in which the vehicles often run 24/7, with limited if any downtime between shifts; this is the result of a vehicle limitation that the department plans to address over time. This is a challenging operational mode for ICE vehicles and would pose additional challenges for EVs due to the lack of sufficient time to charge between shifts.

- **Upfront vehicle cost and upfitting complexity.** Flagstaff identified concerns about the upfront EV cost premium as well as potential costs and complexity associated with upfitting EVs with the necessary communications systems, lighting, sirens, and additional auxiliary systems.
- **Public and officer perception.** Department staff indicated that "some members of the public and law enforcement officers themselves may have reservations or concerns about the adoption of EVs for police work, potentially impacting morale and community perception."

These challenges stem from well-founded concerns regarding how the department's readiness may be impacted or perceived to be impacted. DNV's near-term recommendations address these concerns in the following ways:

- A measured introduction of EVs into the patrol fleet will allow the department to collect data and gain real-world experience before considering additional steps. This approach is prudent and will inform effective long-term planning while also allowing the City to address the concerns of officers and the public.
- The installation of DCFC infrastructure will address concerns around short shift breaks and EV range, since DCFC charging can charge a vehicle from 10% to 80% state of charge in 30-45 minutes.

RECOMMENDATION:
INITIATE A ROBUST INTERNAL STAKEHOLDER PROCESS TO IDENTIFY THE DATA, FEEDBACK, AND INFORMATION NEEDED TO INFORM NEXT STEPS FOR PATROL FLEET ELECTRIFICATION.

We further note that a number of cities around the country have begun adopting EVs and have documented both strong performance and realized operating cost savings, indicating that these concerns can be addressed and that EVs can perform well in a patrol context. That being said, given the concerns raised by Police Department staff, Flagstaff should initiate an internal stakeholder process to identify the data, feedback, and other information needed to develop next steps regarding patrol fleet electrification.

6.3.1.2 Take-home vehicles

We learned through this study that a large number of administrative and detective vehicles are taken home by their drivers. We did not address considerations around take-home charging in this study due to scope limitations. We do note, however, that the admin/detective vehicles recommended for replacement would be able to charge at the Police Department during the day, thus mitigating the near-term concern about providing at-home charging for City employees. Longer term, the City should evaluate the potential fleetwide need for at-home EV charging and develop a policy to guide the deployment and management of this infrastructure if installed at employee's homes in future. Several considerations for this policy are outlined below:

- Who pays for EV charging, and what are the payment options in this scenario? If employees pay, would the City reimburse them for this expense, and if so, how?
- Which party would be responsible for charger maintenance?
- What happens when a City employee with a home charger ends their employment with Flagstaff?

6.4 Thorpe Park

Thorpe Park is located in northwest Flagstaff; it encompasses a number of address locations and APS accounts. This analysis was specifically focused on the park's maintenance shed located at 600 N Thorpe Rd. This maintenance shed is located toward the northern end of the sports and recreation complex with entry from the public parking area.

The team identified 28 vehicles that belong to the Parks department that may visit this site on a regular basis and may sometimes be parked here overnight. Of these, 22 are medium- or heavy-duty. DNV identified 13 vehicles as prime targets for electrification – three light-duty pickup trucks and 10 medium-duty. Each of these vehicles demonstrates positive TCO savings and is nearing the end of its useful life. The total acquisition cost for these 13 vehicles is estimated to be $1.45M while producing an annualized cost savings of approximately $26,000.

Based on the available electric service capacity and nature of the Parks Department vehicle usage, the team modeled a limited infrastructure scenario primarily designed as a top-off station rather than one that can serve all 13 vehicles simultaneously. The proposed charging infrastructure for Thorpe Park includes:

- **Level 2.** One dual-port Level 2 charger (2 total ports), primarily for overnight charging.
- **DCFC.** One single-port 100 kW DC fast charger for rapid refueling of vehicles that stop here to complete needed work.

The tables below outline the proposed charging infrastructure, site electrical load impacts, and associated infrastructure buildout costs for the proposed EV replacement scenario.

Table 6-7. Thorpe Park charging infrastructure buildout – charger recommendation

	Level 2	DCFC
Vehicles modeled in scenario	13	
Number of chargers	1	1
Charger type	40A L2	100 kW DCFC
Port configuration	Dual-port	Single-port
Total ports	2	1
Per-unit charger power (kW)	9.6	100
Total nameplate power (kW)	19	100
Amps per unit (breaker rating)	50	176
Total amps (before EV Ready)	100	176
Additional chargers modeled for future-proofing installation	*0*	*0*
Total amps (including EV Ready)	*100*	*176*

Table 6-8. Thorpe Park charging infrastructure buildout – cost summary

	Level 2	DCFC	Total
Equipment costs (one-time)	$5,000	$70,519	$75,519
Installation costs (one-time)	$6,000	$58,508	$64,508
Maintenance costs (lifetime)	$5,569	$11,200	$16,769
Networking fees (lifetime)	$1,680	$1,680	$3,360
Maintenance costs (annual)	$398	$800	$1,198
Networking fees (annual)	$120	$120	$240
Year 1 cost	**$11,518**	**$129,947**	**$141,465**
Recurring annual cost	**$518**	**$920**	**$1,438**
Total lifetime cost	**$18,249**	**$141,907**	**$160,157**
Future-proofing installation cost (one-time)	*$0*	$0	$0
Total lifetime cost with future-proofing	***$18,249***	*$141,907*	*$160,157*

Table 6-9. Thorpe Park charging infrastructure buildout – electric capacity assessment

	Level 2	DCFC
Existing spare electrical capacity (kW)	505	
Recommended new charging load (kW)	19	100
Future-proofed chargers load addition (kW)	0	0
Remaining electrical capacity (after 1x dual-port Level 2 charger)	486	
Remaining electrical capacity (after 1x single-port DCFC charger)	386	

6.5 Public Works

The Flagstaff Public Works facility is located on the western edge of the city at 3200 W. Rte. 66. The facility is made up of five buildings, including an administrative building, facilities garage, and solid waste department. The vehicles parked at this facility are diverse, ranging from passenger cars to specialized, heavy-duty trucks. Although the facility is served by two sizeable electric services, the electric capacity required to electrify the full fleet of 107 vehicles that were identified as being domiciled here would require considerable increases in electric line capacity. As such, DNV recommends that Flagstaff follow the near-term recommendations outlined in this section while also beginning discussions with APS to ensure that this facility is included in planned grid buildouts for APS as the City's electrification efforts scale up.

RECOMMENDATION:
ENGAGE WITH APS TO ENSURE THE PUBLIC WORKS FACILITY IS INCLUDED IN ELECTRIC GRID PLANNING.

For the near-term, our analysis showed 46 vehicles nearing the end of their useful life that demonstrate positive TCO savings. Of these vehicles, 40 are medium- or heavy-duty. The total acquisition cost for these 46 vehicles is estimated to be $14.3M while producing an annualized cost savings of approximately $140,000 compared to equivalent ICE replacements.

Based on the high available electrical service capacity and number of vehicles domiciled at Public Works, this facility is a strong candidate for further electrification. DNV modeled charging infrastructure to support the recommended initial uptake of EVs, but we note that this leaves available service capacity for future EV charger buildout to support broader electrification of the vehicles here. The proposed charging infrastructure for the Public Works facility includes:

- **Level 2.** No additional Level 2 chargers (there are two ports already installed here for fleet and employee use, and the City is in the process of installing 12 more ports)
- **DCFC.** Ten single-port 100 kW DCFC.

The team's assessment has determined that no additional Level 2 chargers are required for near-term fleet electrification needs, but Flagstaff may opt to install additional units to support employee charging needs. DNV recommends that Flagstaff focus its resources on electrifying medium/heavy-duty vehicles at this facility, which would require the installation of DCFC infrastructure.

The tables below outline the proposed charging infrastructure, site electrical load impacts, and associated infrastructure buildout costs for the proposed EV replacement scenario.

Table 6-10. Public Works charging infrastructure buildout – charger recommendation

	Level 2	DCFC
Vehicles modeled in scenario	46	
Number of chargers	0	10
Charger type	n/a	100 kW DCFC
Port configuration	n/a	Single-port
Total ports	n/a	10
Per-unit charger power (kW)	n/a	100
Total nameplate power (kW)	n/a	1,000
Amps per unit (breaker rating)	n/a	176
Total amps	n/a	1,758
Additional chargers modeled for future-proofing installation	*n/a*	*0*
Total amps (including EV Ready)	*n/a*	*1,758*

Table 6-11. Public Works charging infrastructure buildout – cost summary

	Level 2	DCFC	Total
Equipment costs (one-time)	n/a	$705,192	$705,192
Installation costs (one-time)	n/a	$585,081	$585,081
Maintenance costs (lifetime)	n/a	$112,000	$112,000
Networking fees (lifetime)	n/a	$16,800	$16,800
Maintenance costs (annual)	n/a	$8,000	$8,000
Networking fees (annual)	n/a	$1,200	$1,200
Year 1 cost	**n/a**	**$1,299,473**	**$1,299,473**
Recurring annual cost	**n/a**	**$9,200**	**$9,200**
Total lifetime cost	**n/a**	**$1,419,073**	**$1,419,073**
Future-proofing installation cost (one-time)	*n/a*	*0*	*0*
Total lifetime cost with future-proofing	*n/a*	*1,419,073*	*1,419,073*

Table 6-12. Public Works charging infrastructure buildout – electric capacity assessment

Public Works	Level 2	DCFC
Existing spare electrical capacity (kW)	2,536	
Recommended new charging load (kW)	0	1,000
Future-proofed chargers load addition (kW)	0	0
Remaining electrical capacity (after 10x DCFC chargers)	0	1,536

6.5.1 Public Works facility considerations

The Public Works facility is large and houses multiple departments' fleets. DNV recommends that as part of its fleet electrification efforts, Flagstaff should develop a thoughtful and detailed electrification plan that seeks to minimize the logistical challenges of a fleet transition while maximizing learnings that can be applied to other vehicles and facilities in Flagstaff's fleet. This planning process should be informed by the analysis summarized in this study and focus on the vehicles that demonstrate positive TCO savings at this facility. Flagstaff should consider the following:

- Focus on electrifying a single vehicle type at a time (e.g., work trucks, garbage trucks). This will streamline the vehicle acquisition process and allow the affected department to gain experience operating and charging the new EVs while allowing time for performance analysis and documentation of learnings. Focusing on a single vehicle type at a time may also aid the process of drivers acclimating to and receiving any necessary training to operate the new vehicles.
- Within the above framework, consider piloting one or two vehicles of the selected vehicle type for a period of 6-12 months to collect the necessary performance data and staff feedback prior to placing a larger order. This measured approach will also allow time for charging infrastructure to be deployed in advance of vehicle procurement.
- Consistent with our fleetwide recommendation to implement a vehicle telematics platform, tracking and evaluating EV and charger usage from early deployments will provide valuable data to help inform longer-term planning.

RECOMMENDATION:
DEVELOP A THOUGHTFUL ELECTRIFICATION PLAN THAT SEEKS TO MINIMIZE THE LOGISTICAL CHALLENGES OF A FLEET TRANSITION WHILE MAXIMIZING LEARNINGS THAT CAN BE APPLIED ELSEWHERE

The effort to electrify the Public Works fleet is expected to span a number of years due to the high cost of specialized MHDV EV options as well as the age of the existing fleet. A number of Public Works vehicles were purchased in the last five years and should not be replaced immediately, but instead phased out once they reach the end of their useful life.

The Public Works facility has a large incoming electric service, with approximately 1.5 MW (1,500 kW) of available capacity remaining after the recommended installation of 10 single-port 100 kW DCFC. This remaining available capacity will allow the City to install additional chargers – both DCFC and Level 2 – at Public Works, and we recommend that the City further expand the charging infrastructure at this facility over time. However, we did not recommend a specific number of additional chargers (or EV Ready infrastructure development) due to uncertainty in the following areas:

- **Types of vehicles that will be electrified first.** Given the diversity of vehicles domiciled at Public Works and DNV's recommendation that Flagstaff engage early with manufacturers of MHDVs, we cannot determine which vehicles will be using the recommended initial wave of charging infrastructure. While the 10 recommended DCFC chargers will support charging across diverse vehicle types and classes – from high-mileage garbage trucks to lower-mileage work trucks – the direction that Flagstaff takes beyond this initial wave will depend on the vehicle types being electrified, their specific operations and mileage requirements, and other factors.
- **Pace of electrification.** Given our recommendation that the City focus on a single vehicle type and deploy EVs in a pilot capacity during early electrification efforts, we anticipate that 10 DCFC chargers will provide sufficient charging

capacity for the foreseeable future. As electrification planning evolves, the City should take a longer-term view and consider the potential for Public Works to serve as a fast-charging "hub" across the City's fleet to increase utilization.

- **Potential feeder-level capacity constraints upstream of this facility.** While the facility has available capacity today, it is likely that a larger grid-level project would be needed to provide the significant additional capacity that will be required to electrify the 100+ vehicles at this facility. As such, DNV recommends engaging with APS to identify potential future capacity availability and/or constraints relative to the City's longer-term electrification plans at this site, working in tandem to ensure that APS is aware of the City's plans while also ensuring that the City's plans take into account the capacity APS is able to provide.

7 TOTAL COST OF OWNERSHIP ANALYSIS RESULTS

This section outlines the results of the Total Cost of Ownership Analysis task for each facility. It begins with a summary of the TCO results at the facility level, across both recommended EV replacements and the recommended infrastructure, and concludes with a discussion on managed charging for Flagstaff's fleet. The TCO savings are calculated by subtracting the estimated lifetime cost of the recommended charging infrastructure from the estimated lifetime TCO savings of the recommended vehicles.

7.1 City Hall

The TCO savings from electrifying the 26 Administrative vehicles that park at City Hall, including the cost of the recommended charging infrastructure, is summarized in Table 7-1.

Table 7-1. City Hall all-in total cost of ownership summary

City Hall	
Vehicles	26
Chargers	Level 2: 5 dual-port 40-amp
Annual vehicle TCO savings	$48,997
Lifetime vehicle TCO savings	$685,953
Lifetime charging infrastructure cost	$91,246
All-in TCO savings	$594,707

7.2 Police Department

The TCO savings from electrifying the 10 take-home administrative/detective vehicles and four patrol vehicles at the Police Department, including the cost of the recommended charging infrastructure, is summarized in Table 7-2.

Table 7-2. Police Department all-in total cost of ownership summary

Police Department	
Vehicles	14
Chargers	Level 2: 6 dual-port 40-amp DCFC: 2 single-port 150 kW
Annual vehicle TCO savings	$25,731
Lifetime vehicle TCO savings	$292,047
Lifetime charging infrastructure cost	$522,337
All-in TCO savings	-$230,290

While the all-in TCO savings are negative for this facility, this is a result of our recommendation to install two 150 kW DCFC ports to serve four patrol cars – with EV Ready infrastructure for two more. These combined four charge ports represent an investment in Flagstaff's future electrification plans and were recommended for near-term action because of the potentially long planning and installation timeline for DC fast charging infrastructure. While this would incur a significant upfront cost, this infrastructure would be able to charge many more than four patrol cars in the future as well as vehicles from other departments that need to top-up throughout the day.

7.3 Thorpe Park

The TCO savings from electrifying the 13 Parks vehicles, including the cost of the recommended charging infrastructure, is summarized in Table 7-3.

Table 7-3. Thorpe Park all-in total cost of ownership summary

Thorpe Park	
Vehicles	13
Chargers	Level 2: 1 dual-port 40-amp DCFC: 1 single-port 100 kW
Annual vehicle TCO savings	$25,545
Lifetime vehicle TCO savings	$357,629
Lifetime charging infrastructure cost	$160,157
All-in TCO savings	$197,472

7.4 Public Works

The TCO savings from electrifying the 46 Public Works-domiciled vehicles, including the cost of the recommended charging infrastructure, is summarized in Table 7-4.

Table 7-4. Public Works all-in total cost of ownership summary

Public Works	
Vehicles	46
Chargers	Level 2: n/a DCFC: 10 single-port 100 kW
Annual vehicle TCO savings	$140,858
Lifetime vehicle TCO savings	$1,972,017
Lifetime charging infrastructure cost	$1,419,073
All-in TCO savings	$552,943

7.5 Takeaways

As this section shows, three of the selected facilities – City Hall, Thorpe Park, and Public Works – show positive TCO savings over the life of the recommended EVs and associated charging infrastructure as compared to a business-as-usual continuation of ICE procurements. The facility that does not show positive TCO savings – the Police Department – is a unique case because of its need for a front-loaded DCFC buildout to ensure patrol fleet readiness and the small number of patrol cars recommended for electrification at this time. We anticipate that as the City electrifies the Police fleet over time DCFC charging infrastructure development will be right-sized to balance upfront costs against the need for rapid charging and high fleet readiness. Further, we recommend that the City consider treating the Police Department as a fast-charging “hub” that can be used by other departments when patrol cars are not charging; this will extend the value of the DCFC investment and reduce the need to install potentially duplicative infrastructure at other facilities.

7.6 Managed charging

Managed charging is defined as any effort to influence or regulate the timing and/or quantity of EV charging. The objective of managed charging is typically to minimize or control the costs of EV charging; this can be achieved, for example, by capping EV charging demand or by shifting EV charging from a more expensive time of day to a less expensive one. Managed charging for fleet EVs can be undertaken by individual organizations using several different technologies designed to give fleet operators control over the timing and volume of charging. Managed charging is further augmented with staff training (and associated organizational policies) that teaches employees both the importance of managed charging and how to use the available tools to ensure it is consistently and properly implemented.

Given Flagstaff's interest in deploying networked EV chargers and the fact that many providers of networked chargers also provide managed charging tools, we recommend that Flagstaff start its managed charging journey using these available tools. When paired with proper staff education, training, and an oversight plan, these tools can be effective in controlling when EVs charge to avoid on-peak periods (which, for APS, may impact the price of energy) while ensuring that EVs are fully charged by the time they need to be. As the electric fleet grows and the City gains experience integrating EVs into existing operations, the City may want to consider investigating other third-party managed charging solutions as well, which will differ in price and available functionality.

RECOMMENDATION:
USE MANAGED CHARGING TOOLS AVAILABLE THROUGH NETWORKED CHARGERS, PLUS STAFF EDUCATION, TO AVOID ON-PEAK PERIODS AND REDUCE DEMAND IMPACTS.

The following basic aspects of managed charging are likely to be available as part of networking plans offered by EV charging providers (and may be further supported by options available in the vehicle itself):

- Scheduled charging – the ability to, for example, program a car that is plugged in at 5 p.m. to delay charging until the off-peak period or later (after 8 p.m. for APS).
  - Note that some vehicles may offer the option to program a "departure time" and will support managed charging while ensuring the vehicle has the desired charge by the specified time.
- Controlling charger power levels to output less than nameplate power to minimize demand impacts.
- Pricing control – the ability to set customizable prices based on multiple factors, including driver type and time of day.
  - Flagstaff has also expressed interest in having the ability to allocate charging fees to the appropriate department when sharing infrastructure; available pricing control tools will likely provide this functionality.

More advanced managed charging functionality – while not yet recommended for Flagstaff – may include the following:

- Smart charging optimization that can automatically optimize charging across multiple vehicles according to a pre-set objective. Objectives might include:
  - Prioritizing preferred vehicles (e.g., patrol vehicles) when multiple EVs are plugged in simultaneously at a bank of chargers.
  - Charging vehicles with the lowest state of charge first.
  - Ensuring all vehicles reach the necessary state of charge prior to a programmed departure time while not exceeding a pre-set demand limit for the facility.
- Charging optimization to minimize costs or take advantage of renewable energy production

DNV recommends that Flagstaff review the above capabilities of smart charging and the needs of its facilities depending on which vehicle/department combinations are selected for replacement. The need for and value of managed charging will depend on the facility and vehicles being electrified and the typical dwell time of the vehicles (that is, how long and when they are parked). For instance, managed charging may be advisable at the Public Works facility if refuse trucks are targeted for replacement as the first cohort of vehicles, as they are primarily in the field during the day and would be plugged in upon their return in the afternoon or evening (potentially during APS's on-peak period). In this scenario, Flagstaff might opt for a simple managed charging solution that delays the actual charging time until after 8 p.m., the end of the APS "on-peak premium" rate period, to manage charging costs. Further staggering of overnight charging schedules – to avoid multiple trucks all drawing power simultaneously – could help manage demand charges as well. City Hall and the Police Department, on the other hand, may be able to support charging during APS's 9 a.m. to 3 p.m. off-peak period, in which case it would be beneficial to provide education and other communications to City employees encouraging them to charge during these hours at these facilities.

The above examples are intended to illustrate how managed charging can be used differently depending on the City's objectives as well as the facility, vehicles, and use case in question. Due to uncertainty regarding the order in which Flagstaff will be able to electrify vehicles and deploy charging infrastructure, DNV cannot provide exact recommendations on when and how managed charging should be implemented across Flagstaff's facilities. Instead, we encourage the City to take advantage of the basic tools available from many charging providers, collect data to document the experience during early electrification phases, and reassess whether a more advanced solution is appropriate over time.

APPENDIX A. ADDITIONAL ASSUMPTIONS USED IN THE ANALYSIS

This Appendix summarizes additional assumptions that were used to complete this analysis.

- Maintenance cost factors ($/mile) were developed by vehicle type. This data was sourced from AAA for light-duty vehicles[34] (LDV) and from multiple data sources for medium- and heavy-duty vehicles[35] (MHDV).
- Gas and diesel prices were based on historical data from the Energy Information Administration (EIA) and regional AAA data paired with a near-term forecast of gas prices by 2030. These costs account for price increases through 2030 only (after which forecasts are rarely available) and are thus likely on the low side of estimates over a 14-year vehicle life. Gas was assumed to cost $4.69/gal and diesel was assumed to cost $4.99/gal.
- A price of $0.15/kWh was used for the cost of EV charging, based on APS's Business rates. We assumed that the level of charging would be consistent throughout the year, which justified the use of a simple average between APS's winter and summer electric rates (which are each in effect for half of the year). This estimate also encompasses some escalation moving out to 2030 and beyond based on the life of these vehicles.
- We assumed an electric grid GHG emissions intensity factor of 0 kg CO_2 per kWh because the City of Flagstaff participates in APS's Green Power Partners Program Connect option, which provides APS customers the opportunity to claim the use of 100% renewable energy for their electricity consumption. We provide further discussion on the topic of emissions intensity factors in Section 5.3.
- We assumed any necessary vehicle upfit costs would cancel out for an ICE and EV – i.e., we assumed that the estimated cost to upfit, for example, a police detective vehicle with the necessary lights and auxiliary equipment would be roughly equal for EVs and ICEs.
- We used the same annual depreciation rates for EVs and ICEs because while there is fairly well-established research regarding ICE depreciation rates, the body of research for EVs is limited at this time.
- We assumed that any end-of-life disposal costs for EVs (including battery recycling) would be offset by the potential value of selling or repurposing used batteries for use in second life battery applications.[36]

Charging Infrastructure Buildout Strategy:

- The effective useful life of EV chargers was modeled as 14 years to align with the average life of vehicles in Flagstaff's fleet.

[34] Light-duty vehicles, or LDVs, are classified by the federal Highway Administration as having a gross vehicle weight rating (GVWR) of less than 10,000 lb. LDVs include sedans, SUVs, crossovers/hatchbacks, and most pickup trucks; the vast majority of personal vehicles fall into this category.

[35] Medium- and heavy-duty vehicles, or MHDVs, are classified as having a gross vehicle weight rating (GVWR) of more than 10,000 lb. MHDVs include a wide range of vehicles, from heavy pickup trucks and cargo/shuttle vans to delivery and flatbed trucks. Heavy and specialized vehicles, including garbage trucks, school and transit buses, and Class 8 tractors are also in this category.

[36] Second life battery applications involve the reuse of used EV batteries in a stationary application – these stationary batteries can then be used to provide resiliency, minimize energy costs, and/or increase the consumption of variable renewable power at Flagstaff's municipal properties.

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