Colorado State Fleet Opportunity Assessment

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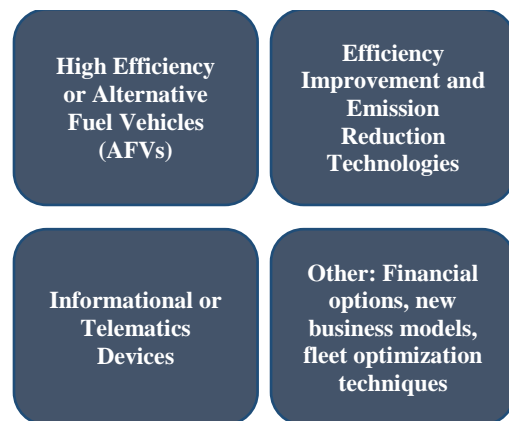
March 2015

Table of Contents

Executive Summary

The objective of the Colorado State Fleet Opportunity Assessment is to outline near-term, cost-effective opportunities for the State to work toward its petroleum reduction and air quality goals. The study team, led by Vision Fleet, Inc., worked closely with the Colorado Energy Office (CEO), State Fleet Management (SFM) in the Department of Personnel and Administration (DPA), and the Colorado Department of Transportation (CDOT) to design and conduct the study. The approach combined quantitative and qualitative factors related to the fleet's operations, including extensive fleet data analysis and conversations with multiple agency staff to evaluate the State fleet's current operations. The report's findings and recommendations highlight opportunities to cost-effectively deploy alternative fuel vehicles (AFV) and other petroleum reduction technologies, as well as strategies to address some of the inherent barriers to achieving the State's fleet goals.

Methodology

The study team assessed several fleet optimization opportunities, including a broad range of potential emission, fuel, and cost-reduction opportunities. These opportunities fell into four categories, as shown in Figure ES-1. The team analyzed each of the State's two fleets. The light-duty "white" fleet is owned and managed by SFM, which leases those vehicles to each State agency. The "orange" fleet is owned and managed by CDOT; it includes the State's medium- and heavy-duty vehicles and equipment. Each fleet represents roughly half of the State's annual petroleum consumption.
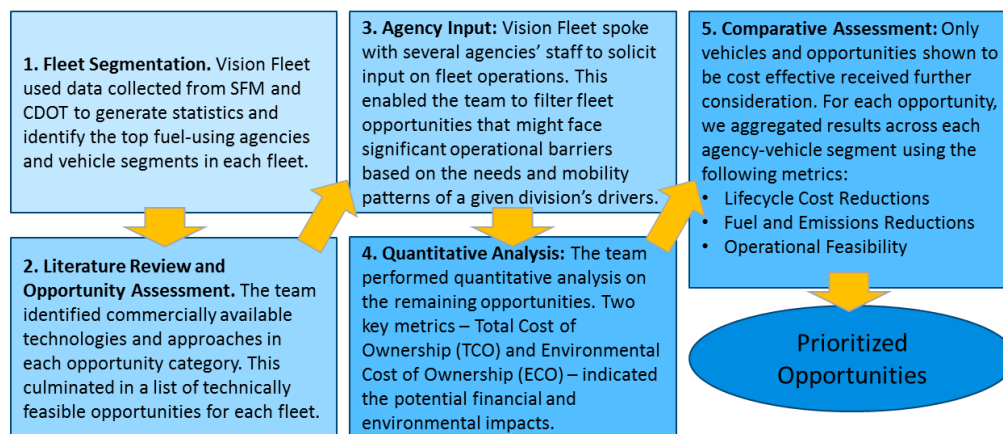
Figure ES-1. Fleet Opportunity Categories

| High Efficiency or Alternative Fuel Vehicles (AFVs) | Efficiency Improvement and Emission Reduction Technologies |
| Informational or Telematics Devices | Other: Financial options, new business models, fleet optimization techniques |

Source: Vision Fleet

Vision Fleet took a structured approach to creating a list of prioritized fleet opportunities based on lifecycle cost reduction potential, fuel and emissions reduction potential, and operational feasibility. The key steps in the team's approach are summarized in Figure ES-2.

Figure ES-2. Study Methodology Overview

1. Fleet Segmentation. Vision Fleet used data collected from SFM and CDOT to generate statistics and identify the top fuel-using agencies and vehicle segments in each fleet.

2. Literature Review and Opportunity Assessment. The team identified commercially available technologies and approaches in each opportunity category. This culminated in a list of technically feasible opportunities for each fleet.

3. Agency Input: Vision Fleet spoke with several agencies' staff to solicit input on fleet operations. This enabled the team to filter fleet opportunities that might face significant operational barriers based on the needs and mobility patterns of a given division's drivers.

4. Quantitative Analysis: The team performed quantitative analysis on the remaining opportunities. Two key metrics – Total Cost of Ownership (TCO) and Environmental Cost of Ownership (ECO) – indicated the potential financial and environmental impacts.

5. Comparative Assessment: Only vehicles and opportunities shown to be cost effective received further consideration. For each opportunity, we aggregated results across each agency-vehicle segment using the following metrics:
- Lifecycle Cost Reductions
- Fuel and Emissions Reductions
- Operational Feasibility

Prioritized Opportunities

Source: Vision Fleet

Vision Fleet narrowed its findings to a set of high-priority, technology-related and crosscutting opportunities. The team then provided overarching recommendations for addressing potential barriers to the State pursuing these types of fleet efficiency improvements.

Light-duty (White) Fleet Findings

The analysis revealed that the majority of the white fleet comprises pickup trucks, sport utility vehicles (SUVs), and both patrol and non-patrol sedans. Seven vehicle segments account for about 85% of white fleet fuel consumption; similarly, four agencies account for approximately 75% of fuel consumption: The Department of Natural Resources (DNR), Colorado Department of Public Safety (CDPS), the Department of Corrections (DOC), and CDOT.

Primary Technology Opportunities

The white fleet technology assessment considered more than 170 specific combinations of agencies, vehicle segments, and AFV or efficiency technologies. Table ES-1 summarizes findings for each major vehicle category.

Table ES-1. Summary of White Fleet Technology-related Opportunities

Vehicle Segment	Technology-Related Opportunities
Pickup Trucks (≥ 3/4 ton)	The low fuel efficiency of these heavier pickups creates some cost-effective opportunities for bi-fuel CNG replacement vehicles. However, these vehicles should be located in enough proximity to CNG fueling stations to achieve at least a 67% share of miles driven on CNG. Idle reduction solutions are another potentially strong opportunity, particularly for DNR pickups.
Pickup Trucks (≤1/2 Ton)	The CNG replacement opportunity for lighter pickups is less promising than for those above, though some cost-effective opportunities exist. For both CDOT and DNR pickups, however, telematics and idle reduction solutions appear well suited to provide cost-effective fuel and emissions reductions. For some CDOT pickup trucks, replacement with hybrid SUVs can also provide significant savings.
Sport Utility Vehicles (SUVs)	Fewer AFV options are available for SUVs, but some options exist where a driver could reasonably down-size into an AFV sedan. The greatest opportunities existed for replacement with a battery electric vehicle (BEV), plug-in hybrid electric vehicle (PHEV), or bi-fuel CNG sedan. The first of these options, however, is subject to range-related restrictions (about 80-90 miles roundtrip without charging). Where an AFV sedan is not practical, replacement with a hybrid SUV can still provide a strong savings for some vehicles.
Sedans	Electric vehicles and dedicated CNG sedans scored well in terms of average reductions in TCO. In either of these cases, trip routing, range and fueling/charging access are key considerations in the decision to convert a particular vehicle or group of vehicles. In situations where range or fueling issues prevent adoption of a full AFV option, both PHEVs and hybrids provide ECO improvements and potential cost savings.
Colorado Department of Public Safety (CDPS)	Given the prevalence of law enforcement vehicles and their associated use requirements, the team assessed specific opportunities for CDPS's leading vehicle segments. For non-pursuit SUVs, similar opportunities exist as for the general SUV category (switching to an AFV sedan where possible). The use case for CDPS pursuit sedans (i.e., high utilization and frequent idling) suggests strong opportunities for savings from idle reduction and telematics.

Source: Vision Fleet analysis

Primary Crosscutting Opportunities

In addition to the above technology-specific opportunities, the team assessed a broader set of crosscutting opportunities with potential fleet management benefits. Table ES-2 describes three such opportunities that could create financial and environmental efficiencies for the white fleet.

Table ES-2. White Fleet Crosscutting Opportunities

Opportunity	Description
Telematics	A targeted and well-managed telematics solution that transmits data such as location or diagnostic trouble and doesn't require manual tracking of vehicle usage would allow fleet coordinators and SFM to better understand trip routing and idling across their respective fleet vehicles. This data could subsequently inform the accurate assessment and ongoing evaluation of appropriate AFV and idle reduction opportunities. In the longer term, these same solutions can provide operating efficiencies via improved driving habits, better management of preventative vehicle maintenance, enhanced law enforcement safety and response coordination, and the automation of timely vehicle trip logging and monthly utilization reporting. A recently started CDOT telematics pilot deployment could provide an opportunity to consider expanding the program to other agencies' white fleet vehicles.
Carsharing and Motor Pool Management Solutions	Twenty percent of SFM vehicles are assigned to agency motor pools. Some agencies are already sharing their assigned motor pool vehicles with other co-located agencies, as those borrowing agencies' periodic vehicle needs may not justify a full-time vehicle allocation. Given the prevalence of such cross-agency sharing, there may be opportunities to reduce costs and administrative burdens by partnering with a private carsharing or motor pool management provider. Benefits include freeing vehicle coordinators from manually tracking pool vehicle usage and costs, drivers having improved access to a range of use-appropriate vehicles, and telematics reporting that improves tracking of scheduled preventative maintenance.
AFV Leasing and Shared Savings Deployments	Third-party solutions can facilitate or expedite the deployment of AFVs within a fleet through various leasing arrangements. In these cases, an agency or fleet outsources the ownership and management of a set of vehicles, avoiding the large periodic capital costs and maintenance requirements of those vehicles. Instead, the agency pays some combination of a fixed and variable rate that bundles those costs together, much like SFM's arrangement with individual agencies. The advantages lie in the broader selection of vehicles, decreased administrative burdens, and various value-added services provided by the third party (including the carsharing or motor pool management solutions discussed above). For AFVs, the leasing company may leverage available tax credits to pass lower costs on to the fleet, while also taking on much of the risk associated with deployment planning, charging infrastructure, and vehicle's future residual value onto the third party.

Source: Vision Fleet analysis

Medium- and Heavy-Duty (Orange) Fleet Findings

The orange fleet includes more than 3,000 pieces of equipment, more than 1,600 of which are medium- and heavy-duty trucks. The remainder comprises a mix of on-road and off-road equipment. Snow plows comprise nearly half of orange fleet fuel consumption, while non-plow trucks consume an additional 40%. Construction equipment (e.g., loaders and motor graders) represent about 8%. The orange fleet relies primarily on diesel fuel (95% of fuel consumed).

Primary Technology Opportunities

The team's analysis led to the high-potential technical opportunities summarized in Table ES-3.

Table ES-3. Summary of Orange Fleet Technology-related Opportunities

Equipment Segment	Technology-Related Opportunities
Snow Plows	Despite the potential for significant petroleum and cost savings from converting some snow plows to a CNG platform, this is not likely a near-term opportunity. Heavy-duty CNG engines still have relatively uncertain and untested performance in the demanding and highly variable snow plow application, which is a mission-critical role during winter storms. As such, the team recommends that CDOT work to reduce the uncertainty around CNG plows for its specific needs, potentially including its own pilot test. In the meantime, there likely are fuel and cost savings available from idle reduction technologies, which CDOT's current telematics deployment can help to better assess on a vehicle-specific basis.
Non-Plow Trucks	Analysis identified more than 90 trucks that were potential candidates for a dedicated CNG replacement based on TCO criteria. On average, each replacement would offset an estimated 2,800 to 4,600 gallons of diesel fuel annually and reduce the truck's per-mile lifetime costs by 4-8%. Modeling also showed reasonably attractive petroleum savings from replacing certain medium-duty work trucks with hybrid-electric drive trucks, which avoid barriers associated with fueling infrastructure availability.
Construction Equipment	Based on assumptions about front loader idling practices and the costs of reliable idle reduction technologies, idle reduction retrofits are likely to provide substantial petroleum and cost savings. Given the number of loaders in the fleet, this could result in substantial aggregate savings if widely deployed. CDOT can use its current telematics deployment to provide asset-specific idling data to more accurately assess the potential savings.

Source: Vision Fleet analysis

Primary Crosscutting Opportunities

At the time of this reports' writing, CDOT was in the early stages of deploying a fleet-wide telematics program. With proper management and data analysis, a program at that scale will allow CDOT to more accurately assess and implement additional fleet efficiency opportunities, including AFV and idle reduction solutions. Given CDOT's current focus on such a large program, the team identified only one additional crosscutting opportunity: retrofitting maintenance facilities to accommodate natural gas vehicles (NGVs).

The costs for up-fitting vehicle maintenance and (to a lesser degree) storage facilities is significant and can present a substantial barrier to NGV adoption. This is particularly true for small deployments where the per-vehicle share of that incremental cost is greater. Those costs' magnitude depends on the characteristics of an individual facility and the types of repairs the facility is expected to handle. As an alternative to facility upgrades, at least during initial demonstration efforts, CDOT could consider outsourcing major maintenance of heavy-duty NGVs. In the meantime, CEO and CDOT could take action to better understand potential options and costs for up-fitting one or more facilities by contracting with a professional engineering firm.

Recommendations

Table ES-4 outlines the study team's final recommendations for the State to enhance the economic and environmental efficiency of its fleet composition and operations.

Table ES-4. Summary of Vision Fleet Recommendations

Recommendation	Description and Strategies
1. Pursue focused deployment of a broader set of AFV technologies across the white fleet, including CNG, PHEV and BEVs.	**Flexibility in Identifying AFV Opportunities:** Be willing to replace vehicles early if they are good AFV candidates. Develop policies and procedures to facilitate reassignment of current vehicles in order to prioritize the placement of AFVs into appropriate use cases. Use temporary telematics to identify AFV opportunities.
	Targeted AFV Deployments: Create replicable, agency-focused examples of large AFV deployments. Develop best practices to facilitate future deployments in other agencies and locations.
	AFV-specific Education, Training, and Incentives: Educate, train, and incentivize drivers to help meet the State's AFV goals. Improve understanding of AFV options and policies, dispel myths about AFV limitations, and encourage feedback about persistent barriers to AFV adoption.
	Alternative Options to AFV Deployment and Management: Consider third-party leasing or carsharing services that can expedite the transition to AFVs and provide operational support to ensure success.
2. Where there isn't a case for an AFV, prioritize hybrids for replacement vehicles where supported by TCO analysis.	In many cases, a hybrid-electric vehicle will provide substantial lifetime petroleum and operational cost savings. Future State bids should specify hybrid-drive options on all vehicle classes where such options exist.
3. Build upon CDOT's experience with its recent telematics pilot to consider similar opportunities in other agencies.	The best practices and lessons learned by the CDOT team can jumpstart similar efforts elsewhere in the white fleet, particularly in agencies with similar vehicles and use cases (e.g., DNR's pickup trucks). Explore opportunities to leverage CDOT's experience and contract for additional deployments.
4. Break down the first-cost and technology risk barriers that prevent adoption of AFV, idle reduction, and other efficiency technologies.	**Modify Whole-cost Accounting and TCO Analysis:** Develop standard procedures and formulas for modeling (and monitoring) potential AFV and fuel reduction efforts that better link acquisition and operations budgets.
	Expand the Annual Bid beyond Vehicles: Include idle reduction technologies and telematics solutions in the State bid and budgeting process. This will provide agencies with added flexibility, especially in how they allocate vehicle replacement budgets.
	Pilot Deployment Funding: Create an annual fund for agency-led demonstrations of large AFV deployments and other fuel reduction solutions. Prioritize scalable projects that will provide case studies for other agencies.
	Data and Information: Provide agency staff with enhanced access to fleet data and periodic training and forums where coordinators can learn best practices for using data to improve fleet efficiency.
5. Improve collaboration and participation in the State Bid Process.	Enhance SFM's approach to collecting input from fleet coordinators (and participating municipalities) in the bid specification process. Consider not only what agencies would like to procure, but also how past vehicles have fallen short of their needs. Develop an online fleet coordinators' forum where agency staff can exchange fleet management ideas, best practices, and requests.
6. Begin an effort to test medium- and heavy-duty CNG truck capabilities in the CDOT orange fleet.	CDOT should identify vehicles that provide suitable use cases for CNG replacements and that operate near existing or planned CNG fueling infrastructure. For those locations, the State should conduct a professional assessment of facility-specific costs to store or maintain those vehicles. Reach out to engine manufacturers, fuel station owners, and CNG service providers about a potential public-private partnership to facilitate and lower the costs of such a demonstration.

Section 1: Introduction

The State of Colorado owns, operates, and maintains a large and diverse fleet of vehicles and equipment that is essential to the many agencies serving its citizens. Various centralized and agency-specific fleet, vehicle, and equipment coordinators are tasked with understanding the needs of their staff and providing cost effective mobility and equipment options. At the same time, they look for opportunities to reduce petroleum use and associated air quality impacts. This study, completed by Vision Fleet, Inc. under contract to the Colorado Energy Office (CEO), seeks to identify and assess new opportunities to enhance these efforts. This introductory section provides important information about the purpose and goals of this study, the study team's guiding principles, the general scope of the project, and the organization of this final report.

Purpose of this Study

Most states have substantial opportunities to better utilize fleet assets to generate financial and environmental savings. To help Colorado achieve these goals for a clean and economical fleet, Vision Fleet took a data-driven, collaborative approach. The objective of the Colorado State Fleet Opportunity Assessment is to outline opportunities that the State can implement in the near term to work toward its petroleum reduction and air quality goals. Realizing these goals would simultaneously reduce fleet costs.

The study team worked closely with CEO, State Fleet Management (SFM), and the Colorado Department of Transportation (CDOT) to design and conduct the study. The resulting approach combined quantitative data and qualitative factors related to the fleet's operations. This included extensive fleet data analysis and conversations with multiple agency staff to evaluate current operations and equipment usage. The report's findings and recommendations highlight opportunities to cost-effectively deploy alternative fuel vehicles (AFV) and other petroleum reduction technologies. It also presents strategies to address some of the inherent barriers to achieving the State's fleet goals.

Project Goals

The three primary goals of this study focus on the technical, operational, behavioral, and financial opportunities that could make the State's transportation fleet cleaner, more cost effective, and more efficient. They include the following:

- **Goal 1:** Identify actionable strategies to reduce air emissions and petroleum consumption in the State fleet. Include input from various fleet and agency stakeholders about their employees' specific needs and vehicle usage to ensure the accuracy and usefulness of these strategies.

- **Goal 2:** Prioritize opportunities that can be addressed within the fleet's current operating framework and budgets. Emphasize those that can further decrease overall fleet lifecycle costs (i.e., via savings on fuel and maintenance).

- **Goal 3:** Identify barriers to, and practical solutions for, incorporating clean, cost-saving technologies. Any large-scale deployment of AFVs, emission reduction technologies, or

other efficiency improvements will encounter some obstacles and risks. The study team considered these challenges throughout the project, particularly in conversations with agency fleet staff.

Guiding Principles

At the outset of this project, the study team (including Vision Fleet, CEO, SFM, and CDOT) agreed to five guiding principles to steer their efforts. These principles include the following identified attributes:

- **Forward-focused.** The emphasis of this assessment is on next-level emissions, fuel, and cost-saving opportunities.
- **Systematic and Objective.** As an independent third-party, Vision Fleet provides an unbiased and structured approach to assessing potential opportunities.
- **Data-driven and Defensible.** Methodologies and assumptions align with current industry standards and include thorough documentation.
- **Collaborative.** Participation and input from various fleet and department stakeholders was essential to the accuracy and usefulness of the study's findings.
- **Concise and Clear.** This final report includes high-level findings in an accessible format, with additional detail available for those who seek it.

These guiding principles were considered at each stage of the project to ensure a forward-thinking, objective, data rich, collaborative, and concise report.

Project Scope

The project analyzed each of the State's two distinct fleets:
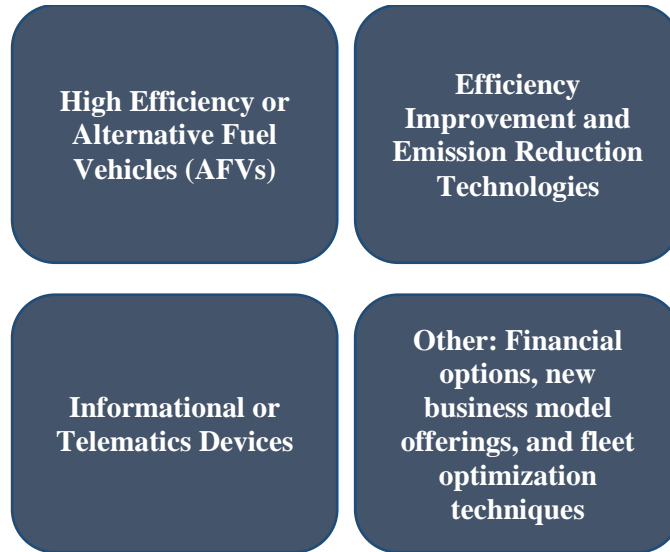
- **White Fleet:** State Fleet Management, within the Division of Central Services (DCS), owns and manages the majority of light-duty passenger, cargo, and work vehicles across the State fleet. These white fleet vehicles are operated by various State agencies. With the exception of some specific agency divisions and the State's largest universities, these vehicles are acquired and owned by SFM and are leased to each agency. This study included all white fleet vehicles leased by SFM, as well as those procured directly by agencies (who report those vehicles' usage data to SFM).[1] It excludes, however, those vehicles procured directly by the large universities.[2]
- **Orange Fleet:** The second fleet is CDOT's orange fleet, which comprises the State's heavy-duty on-road and off-road (e.g., construction) equipment. Unlike the white fleet, CDOT procures, owns, and manages the orange fleet independent from SFM.

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[1] Only a few State agency divisions procure and manage vehicles outside of the SFM process. The Department of Corrections, for example, independently procures some medium- and heavy duty vehicles (e.g., buses and large cargo trucks) as these vehicles are not typically included on SFM's annual vehicle bid.

[2] Colorado law allows institutions of higher education to exempt themselves from the State fleet program. The State's three largest universities (the University of Colorado, Colorado State University, and Colorado School of Mines) are exempt, having chosen to independently procure and manage their respective fleets. Given the unique needs and operational aspects of each university's fleet, they were excluded from the scope of this study.

The study team assessed several fleet optimization opportunities across the two State fleets, including a broad range of potential emission, fuel, and cost-reduction opportunities. These opportunities fell into four categories, as shown in Figure 1. The following subsections describe the types of opportunities in each category.

Figure 1. Fleet Opportunity Categories

High Efficiency or Alternative Fuel Vehicles (AFVs)	**Efficiency Improvement and Emission Reduction Technologies**
Informational or Telematics Devices	**Other: Financial options, new business model offerings, and fleet optimization techniques**

Source: Vision Fleet

High Efficiency or Alternative Fuel Vehicles

Each year, the diversity of more efficient conventional (internal combustion engine) and AFV options increases in the market. This includes vehicles that can run on compressed or liquefied natural gas (CNG and LNG), propane, electricity, and blends of biodiesel or ethanol. In general, these vehicles' enhanced fuel economy or use of alternative fuels provides opportunities to achieve some combination of reduced operating costs, petroleum consumption, or greenhouse gas (GHG) emissions. In most cases, however, these operational savings come at a higher upfront purchase price, with the savings accruing over the life of the vehicle.

As a result of this dynamic as well as other factors, replacing old vehicles with new vehicles that incorporate alternative fuel technologies is not a straight-forward decision. Specific use cases of the fleet's current vehicles need to be carefully considered in order to identify AFV replacements that can provide savings while delivering consistent and reliable operations. In addition, the fueling (or charging) infrastructure needs and functional requirements of the vehicle must be judiciously observed and weighed against projected emission and cost savings.

Despite these challenges, several public fleets provide recent examples of large-scale AFV deployments. For example, the State of Oklahoma, which joined with Colorado in a Memorandum of Understanding to encourage incorporation of CNG vehicles into public fleets, has made "slow but steady" progress in adopting the vehicles (Wertz 2014, Krehbiel 2014). Public fleets are also showing increased adoption of heavy-duty AFVs. Dane County (Wisconsin), for example, deployed its first CNG-powered snowplow in early 2014.

Several municipal governments have shown a willingness to pursue large electric vehicle (EV) and plug-in hybrid electric vehicle (PHEV) deployments. In the San Francisco Bay Area, for example, 10 municipal governments collaborated to purchase a combined 90 EVs across their respective fleets. Participants expect $500,000 in operational savings over the first five years (Government Fleet 2014a). The City of Indianapolis is similarly pursuing a large-scale deployment of 425 EV and plug-in hybrid electric vehicles (PHEVs) over a two-year period in an effort to reduce its petroleum consumption (Grass 2014).[3]

Efficiency Improvement and Emission Reduction Technologies

Rather than replacing an existing vehicle with a more efficient or alternative model, opportunities also exist to improve efficiency or emissions performance through various equipment enhancements. The study included a high-level analysis of several types of these technologies by comparing the relative costs, benefits, and barriers to their application.

Regenerative Braking Retrofits

Regenerative braking systems work by capturing and temporarily storing a portion of a vehicle's kinetic energy during braking events. That stored energy is then released during acceleration to supplement the power provided by the vehicle's primary engine. These systems can utilize both hybrid electric and hydraulic hybrid configurations. To date, the most economic use cases for this opportunity include heavier, higher-mileage vehicles with frequent start-stop usage (e.g., garbage trucks or delivery vehicles) (Gross 2014, Piellisch 2014). While such cases are especially prevalent in private fleets, public fleets have been adopting the technology as well. In late 2014, the City of Boston converted four of its 160 cargo and passenger vans to include an electric hybrid drive train, with plans to adopt more in the future (BusinessWire 2014). The vehicle platforms for which vendors provide retrofits, however, continue to increase.

Auxiliary Load Management (ALM)

Auxiliary Load Management technologies comprise a variety of related idle reduction solutions. In general, ALM solutions reduce a vehicle's fuel consumption and emissions related to unnecessary idling. At their most basic, ALM solutions can automatically shut off an engine after a pre-determined duration of idling, with the engine restarting upon an action by the driver (e.g., depressing the brake pedal). More advanced solutions monitor the various auxiliary energy requirements of the vehicle (e.g., signal lights or a laptop) against the vehicle battery's charge. Then the engine automatically restarts as needed to maintain a certain minimum charge (Government Fleet 2014b).

Auxiliary Power Systems (APS)

Like ALM solutions, Auxiliary Power Systems seek to reduce the need for an engine to idle in order to power various energy-using equipment. Unlike ALM, APS solutions include a secondary power source, often an additional battery or a small combustion engine, that provides power for auxiliary equipment while the vehicle is stationary. Such systems are well suited to work vehicles (e.g., utility trucks) that spend long periods of time in a particular location with equipment in use (Brauer 2013).

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[3] Vision Fleet, which authored this study, is the prime contractor for the City of Indianapolis EV program.

Diesel Emission Retrofit

Emissions retrofits focus primarily on diesel engines, which have been subject to increasingly stringent federal requirements over the past decade. Diesel Oxidation Catalysts and Diesel Particulate Filters are the most common and cost effective technologies currently in use (Clean Air Fleets 2015, Environmental Protection Agency [EPA] 2014). Most newer diesel-powered vehicles will have requisite emissions controls installed as standard equipment. Many fleets, however, own and operate heavy-duty diesel equipment for more than 15 or 20 years. This provides ample opportunity to improve emissions from older engines that do not meet current standards. Some municipal governments, including Chicago, are implementing programs to retrofit the majority of their diesel fleets. Such efforts, however, may be subject to funding availability. The retrofits, themselves, do not provide any operational cost savings to offset the cost of the technology (City of Chicago 2015).

Informational or Telematics Devices

These devices generally involve a system that collects, transmits, and logs vehicle data, including vehicle locational data, powertrain statistics, and other operational characteristics. Fleet and vehicle managers can use this data to improve their fleet's operations via more efficient routing, enhanced maintenance, and driver behavior programs. The key advantages of these solutions arise from their automated (and often real-time) data collection, data processing, and reporting features. Without telematics, fleet managers and vehicle coordinators still can glean a lot of useful information about a vehicle's operation. For example, they can manually download powertrain data from a vehicle's on-board computer system. Similarly, most organizations maintain some sort of trip log or utilization records to understand how and where vehicles are being driven. However, the data provided through a well-designed telematics solution provides more granular and accurate data to inform key decisions, and in a more timely manner than manual data collection and reporting.

Gathering rich and accurate data on an existing fleet is also an important step in analyzing suitable AFV or efficiency improvement opportunities for various fleet use cases. Once AFVs or efficiency improvement technologies are implemented, continued use of telematics devices provide for accurate measurement of the efficiency, ongoing operations, and real-time savings of the vehicles. They can also be used to inform the need for additional fueling infrastructure. This assessment considered cases where the addition of telematics devices would be significantly beneficial to the Colorado fleets.

In California, the State's department of transportation (Caltrans) is implementing a fleet-wide telematics deployment across its approximately 7,500 sedans, trucks and snow plows. With an upfront cost of $2.5M and an annual data reporting cost of $1.5M, the program is expected to save at least $500,000 each year by replacing the manual vehicle logging process and an additional 16% savings on fuel costs (Government Fleet 2014c).

Other Crosscutting Opportunities

Finally, this assessment also considered a broad set of crosscutting opportunities to improve the State fleet's environmental and lifecycle costs. This includes alternative vehicle procurement options and innovative leasing models that the State could employ to unlock greater savings in the implementation of AFVs or efficiency improvement technologies. The Bay Area's multi-

government procurement of EVs (see above section on High Efficiency or Alternative Fuel Vehicles) is a recent example of an aggregated or collaborative purchasing approach. In this case, Alameda County coordinated with the other agencies to aggregate EV demand across multiple government entities and secure grant funding for the incremental cost of the vehicles (Government Fleet 2014a).

As an alternative to owning AFVs, public fleets are also employing third-party-supported approaches to transitioning their fleets toward more efficient options. The Indianapolis "Freedom Fleet" EV program is one example. The city effectively leases EVs and PHEVs on a cost-per-mile basis through a contract with guaranteed and shared savings features. The approach allowed the city to shift many of the perceived risks of a large-scale AFV transition (e.g., candidate vehicle identification and fuel price volatility) to its third-party provider (Grass 2014).[4] In other cases, city fleets are working with third-party-providers to transition and manage motor pools of mostly EV, PHEV and hybrid-electric vehicles (LeSage 2012). In both of these examples, the third party provides previously developed data analytics and operational capabilities that would take substantial time and resources for fleet organization to develop on its own.

Finally, the team also examined various best-practice fleet management strategies for improving efficiency. This included fleet-wide rightsizing, carsharing, vehicle substitution options (e.g., telecommuting or subsidized public transit), and driver outreach, engagement, and training efforts.

The assessment utilized a strategic approach of identifying the most cost-effective and applicable opportunities from these categories by considering the current demographics, operational characteristics, and costs incurred by the Colorado fleet.

Organization of Report

This report is organized to provide a logical and data-driven path for the State's fleet management stakeholders to utilize when making decisions on how to strategically work toward a cleaner and more economical fleet. It includes the following sections:

- **Section 1: Introduction.** This section provides an overview of the study's purpose, goals, and scope.

- **Section 2: Methodology**. This section describes the overall data collection and analysis approach the team used in the analysis, including both quantitative and qualitative components.

- **Section 3: Fleet Segmentation Findings.** This section outlines the team's initial quantitative findings from its review of white and orange fleet data. It highlights key fleet statistics, including breakdowns by agency and vehicle type.

- **Section 4: White Fleet Key Findings.** This section describes important qualitative insights gained during agency interviews; results from the team's subsequent quantitative

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[4] Vision Fleet, which authored this study, is the prime contractor for the City of Indianapolis EV program.

analysis; and the most promising near-term opportunities for achieving reductions in cost, petroleum, and emissions for the light-duty white fleet.

- **Section 5: Orange Fleet Key Findings.** This section describes important qualitative insights gained during agency interviews; results from the team's subsequent quantitative analysis; and the most promising near-term opportunities for achieving reductions in cost, petroleum, and emissions for the heavy-duty orange fleet.

- **Section 6: Recommendations.** Based on the analysis and findings, this section describes the key opportunities and next steps that Vision Fleet recommends as the State pursues a more efficient and more economical fleet.

- **Appendix A: Telematics Pilot Case.** This appendix provides an overview and findings from a telematics-enabled assessment the team conducted to evaluate AFV opportunities for a particular subset of State fleet vehicles.

- **Appendix B: Summary Output Tables.** This appendix provides output tables for the qualified opportunity assessment analysis for each priority agency and vehicle segment.

Section 2: Methodology

Vision Fleet took a structured approach to creating a list of prioritized fleet opportunities based on lifecycle cost reduction potential, fuel and emissions reduction potential, and operational feasibility. The resulting recommendations focus on opportunities that address multiple fleet improvement goals while highlighting potential barriers to implementation. Figure 2 illustrates the key steps in the team's approach.

Figure 2. Illustrated Summary of the Study Methodology
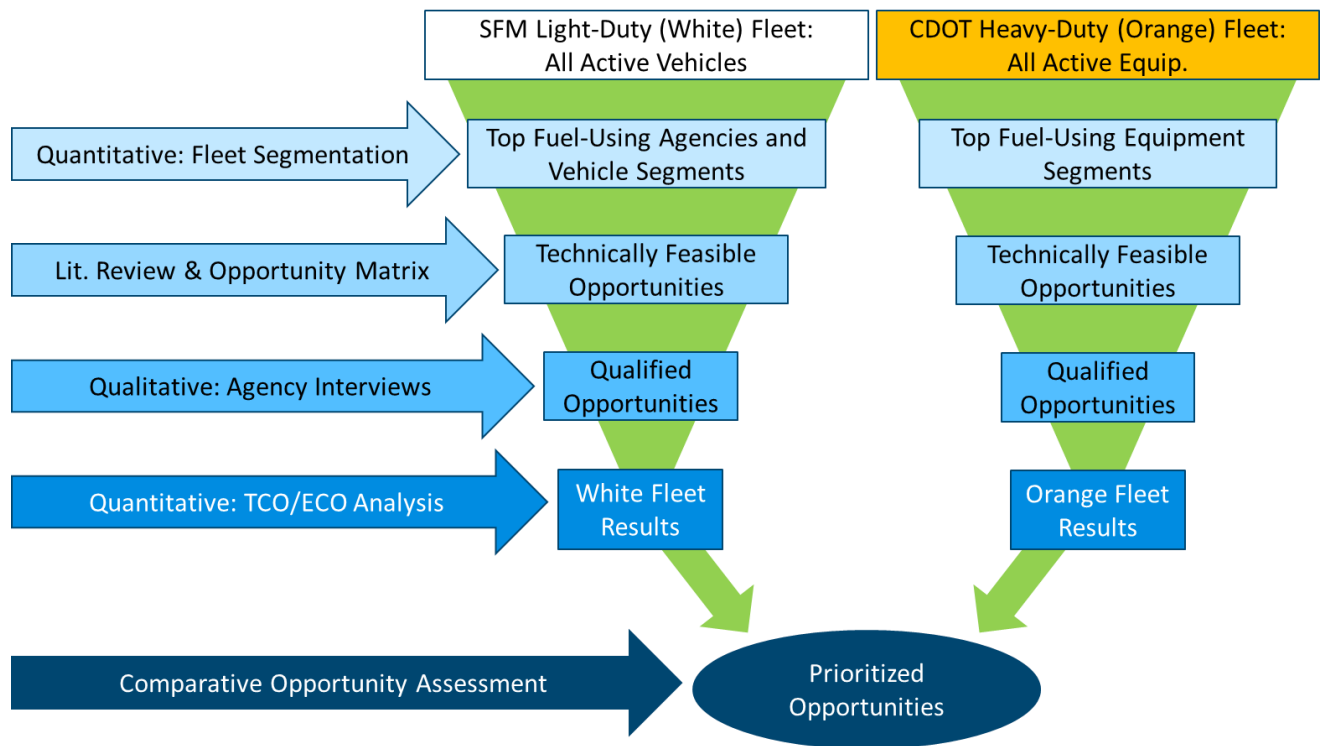
Source: Vision Fleet

The key steps in the team's approach included the following:

- **Fleet Segmentation.** Vision Fleet worked with SFM and CDOT to collect key vehicle data on the white and orange fleets, respectively. The team then used this data to generate key statistics and metrics and to identify the top fuel-using agencies, equipment segments, and vehicle segments.

- **Literature Review and Opportunity Assessment.** The team conducted an extensive literature review to identify and qualify commercially available technologies and approaches in each opportunity category. This step culminated in a list of technically feasible opportunities for the white and orange fleets, organized in an "opportunity matrix" across a prioritized list of high-fuel-use agencies and vehicle segments.

- **Agency Input:** Vision Fleet then spoke with fleet and vehicle management staff from 20 agencies, divisions, and regions. These discussions focused on each division's vehicle user service requirements and objectives, as well as past experiences and best practices related to petroleum and cost reduction strategies. This work enabled the team to filter fleet opportunities that, while technically feasible, might face significant operational barriers based on the needs and mobility patterns of a given division's drivers. The result of this work was a revised opportunity matrix that included a narrowed set of qualified opportunities in the white and orange fleets for further quantitative analysis.

- **Quantitative Analysis:** Finally, the team performed detailed quantitative analysis on the qualified opportunities, with a focus on two key metrics: Total Cost of Ownership (TCO) and Environmental Cost of Ownership (ECO). This TCO/ECO analysis helped determine the potential financial and environmental impacts of implementing each opportunity within the prioritized agency and vehicle segments identified. The team then conducted a comparative opportunity assessment on these results, in the context of its earlier qualitative findings, to generate a final list of prioritized opportunities for consideration by the State's fleet stakeholders.

The remainder of this section provides additional detail on specific components of the methodology.

TCO / ECO Analysis Approach

For the qualified opportunities remaining following the agency interviews, the team ran a detailed quantitative analysis on the anticipated lifecycle costs and savings and anticipated environmental benefits. For AFV, efficiency, idle reduction, and telematics opportunities, this approach used detailed assumptions about the incremental costs and savings (monetary and environmental) for each technology. For other crosscutting opportunities (financing, fleet management), the team used more generalized cost-benefit assumptions based on case studies and experiences from other fleets and the potential relative opportunity with the State fleet.

For the quantitative analysis of opportunities, the team's evaluation focused on two key metrics – Total Cost of Ownership (TCO) and Environmental Cost of Ownership (ECO). The following provides a high-level overview of each of these metrics.

Total Cost of Ownership

The TCO metric is an industry-standard approach to assessing the overall cost and efficiency of a fleet's operations based on the full lifecycle cost accounting of each vehicle. In addition to the upfront purchase cost of each vehicle, it considers the annual and lifetime costs of fuel, maintenance and eventually residual value upon disposition of that vehicle. All of these costs are then divided by the appropriate mileage (either annual or lifetime) to assess the levelized cost per mile ($/mile) for the fleet to own and operate that vehicle. An illustrative example of the basic historical TCO formula used in this assessment appears in Figure 3.

Source: Vision Fleet

Figure 3. Historical TCO calculation.

$$TCO_H = \frac{To-date\ Fuel\ \$ + To-date\ Maintenance\ \$}{Current\ Lifetime\ VMT} + \frac{Purchase\ \$ - Anticipated\ Salvage\ \$}{Average\ VMT\ at\ Time\ of\ Sale}$$

This historical TCO calculation provides a starting point to develop each vehicle's forward-looking "business-as-usual" TCO (TCO_{BAU}). This metric uses key assumptions about how long a particular vehicle will stay in the fleet, how many miles it will ultimately drive, and the types of costs it will accrue over that time period. The result is a baseline value for how much it will cost (per mile) for the fleet to continue to operate that vehicle until the end of its expected useful life. While various assumptions must be used to forecast future costs in each of these categories (especially fuel costs), a wealth of historical data from both the State's fleet and other fleets provided a reasonable range for conducting the type of opportunity assessment envisioned for this study.

The TCO_{BAU} then becomes the point of comparison for assessing alternative opportunities, including AFVs or other options for decreasing fuel use, costs, or emissions. This "opportunity" TCO (TCO_n) is similarly based on assumptions about the upfront cost, fuel efficiency and costs, and maintenance costs associated with an AFV or efficiency technology within the same operating context as the current vehicle.

Given the breadth of potential AFV and efficiency technology opportunities considered for this study, the Vision Fleet team used a simplified approach to its TCO analysis. A key simplifying assumption was that any replacement vehicle (conventional or AFV) or efficiency technology would be financed and owned by the state in the same manner as the current fleet. This allowed the team to omit operational costs for things like insurance, warranty management, data tracking and other overhead-related aspects of managing the fleet. As such, the TCO figures in this report are not fully representative of the comprehensive costs the state incurs for owning and operating its fleet, and they should not be relied upon for making comparisons to fleet outsourcing opportunities (e.g., leasing) or other similar alternatives.

Environmental Cost of Ownership

The Environmental Cost of Ownership (ECO) for a particular vehicle or vehicle segment can be measured in much the same way as TCO. By quantifying the incremental fuel use (or savings) and associated emissions of different alternative fuel platforms, emissions retrofits and other efficiency technologies, a reasonable assumption can be generated for the amount of petroleum saved or greenhouse gases (GHGs) that will be avoided over the expected lifetime of a particular vehicle.

For petroleum reduction estimates, the team assumed that an AFV or vehicle with an efficiency technology would travel the same number of average annual and lifetime miles as the baseline vehicle. For each AFV opportunity, we first calculated the average annual alternative fuel consumption (and petroleum consumption for bi-fuel options) by combining assumptions about the share of miles traveled on the alternative fuel with each vehicle's estimated gasoline- or diesel-gallon-equivalent (GGE or DGE, respectively) fuel economy.[5] The result for each vehicle was an estimate of gallon-per-year consumption for each fuel (petroleum and alternative fuel)

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[5] The team ran two scenarios for each bi-fuel AFV opportunity to evaluate results sensitivities to "low AF use" versus "high AF use" situations. For example, for bi-fuel CNG, the team modeled the opportunity assuming each of 67% and 90% of miles traveled on CNG. Across all bi-fuel opportunities (including CNG and PHEVs), the results showed little material effect on the number of vehicles that would meet the TCO criteria for that opportunity.

that we compared to the baseline vehicle's petroleum consumption to estimate net petroleum savings. For efficiency opportunities, the calculation used a more straightforward assumption about the estimated percent reduction in fuel consumption based on the technologies' application.

For its assessment of GHG reductions, the Vision Fleet team relied primarily on assumptions and metrics developed by the team at Argonne National Laboratories for the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model and the Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) tool.[6,7] These robust models consider the full lifecycle ("Well-to-Wheels" or WTW) emissions associated with various alternative fuel platforms, from the initial extraction and production of those fuels to their eventual use in a vehicle to transport its occupants.

Using the AFLEET model and assumptions, we developed a factor for each fuel's carbon dioxide-equivalent (CO2e) GHG emissions per gasoline- or diesel-equivalent gallon consumed. We then applied this factor (tons of CO2e GHGs / gasoline gallon equivalent) to the estimated annual consumption of each fuel based on the above petroleum reduction calculations. The result was a net change in GHG emissions on a tons/year basis.

Comparative Opportunity Assessment

The team used the results of the TCO and ECO analyses to generate our preliminary quantitative results. These results, along with qualitative considerations surrounding each opportunity, led to a prioritized set of opportunities recommended for consideration and potential implementation by SFM and CEO and other agencies. The comparative assessment followed three key steps, which are outlined in Figure 4.

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[6] https://greet.es.anl.gov/
[7] https://greet.es.anl.gov/afleet

Figure 4. Opportunity Assessment Minimum Criteria and Comparative Metrics
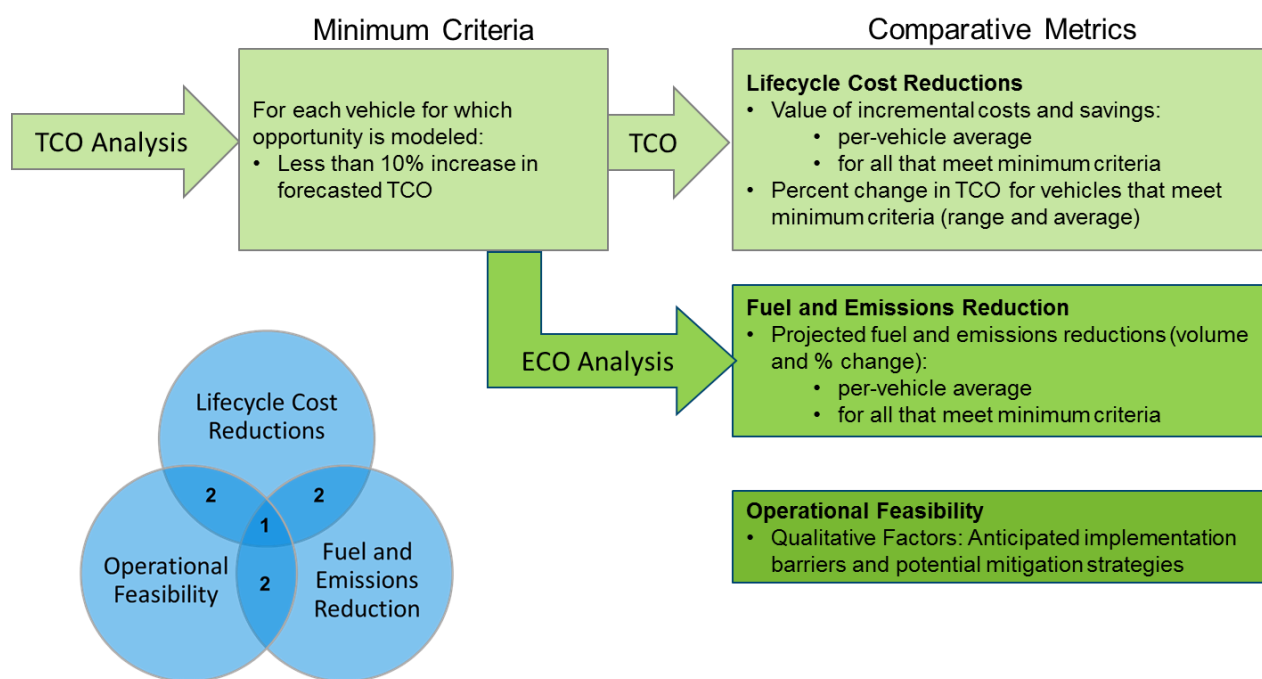
Source: Vision Fleet

As shown in Figure 4, for each agency-vehicle segment and applicable opportunity, the team first calculated the TCO and ECO for each individual vehicle in that segment. Only those vehicles for which the modeled change in TCO was less than a 10% increase were considered to be cost-effective and warranted further consideration. This minimum criteria threshold aligns with the State's procurement guidelines for preferential purchase of AFVs (Colorado Revised Statutes [CRS] 24-30-1104).

For each opportunity, we then aggregated the results across each agency-vehicle segment to provide a basis for comparison to other opportunities and other segments. For each opportunity analyzed, the team quantified the expected results (only for vehicles meeting the TCO threshold) across several key metrics:

- Lifecycle Cost Reductions: average per-vehicle cost savings on a TCO basis
- Fuel and Emissions Reductions: average per-vehicle petroleum reductions (gallons/year) and GHG reductions (tons/year) and aggregate annual reductions if opportunity was applied to all cost-effective vehicles.
- Operational Feasibility: qualitative factors (e.g., potential barriers to adoption or facilitation strategies) for each opportunity, primarily based on interviews findings.

Using these comparative metrics and qualitative factors, the team then narrowed the list of beneficial opportunities to a list of high-priority, technology-related recommendations for consideration by CEO and the State's fleet management teams. These high-priority opportunities are presented in each of Sections 4 and 5 for the white fleet and orange fleet, respectively. Section 6 includes additional overarching recommendations that seek to address some of the potential barriers that the State might encounter in trying to implement these technology-specific opportunities.

Section 3: Fleet Segmentation Findings

The fleet segmentation findings stem from analysis of the current fleet of State vehicles in Colorado. The quantitative analysis was bolstered by qualitative interviews and surveys with more than 20 agency or division fleet coordinators. The quantitative portion of the analysis began with a collection of pertinent data on the fleet from the State's asset management data systems. Data points such as vehicle make, model, year, fuel economy, fuel type, annual fuel consumption and cost, maintenance patterns, vehicle usage, and vehicle mileage were utilized to perform a comprehensive segmentation and cost analysis of the fleet. Fleet costs were then forecasted and calculated on a TCO and ECO basis to assess the financial and environmental impacts of the vehicles should they continue to operate within the State fleet.

The fleet segmentation analysis was conducted separately for each of the State's orange and white fleets. As shown in Table 1, the combined fleets consumed over 7.7 million gallons of fuel in 2014. With the white fleet consuming about eight percent more fuel on average than the orange fleet, there are significant opportunities to reduce fuel consumption across both fleets.

Table 1. Statewide Fleet: Combined Fuel Use for Fiscal Year 2014 (FY14)

Fleet	FY14 Fuel (gallons)	FY14 Fuel (%)
Orange Fleet (incl. bulk fuel)	3,577,151	46%
White Fleet	4,173,960	54%
Total	**7,751,112**	**100%**

Note: Sum of fleet values does not equal Total due to rounding.
Source: Vision Fleet analysis of SFM FY14 Data and CDOT FY14 Data

SFM White Fleet Segmentation

As shown in Table 2, the white fleet comprises more than 6,000 active units across 19 departments.[8] With an average fuel economy of 17.2 mpg and more than 65.6 million total miles traveled in FY14, there are likely to be several opportunities for efficiency improvements across the white fleet. The challenge for fleet coordinators is to identify opportunities that are achievable within the budgetary and operational constraints of their respective agencies and divisions. Additionally, several fleet coordinators demonstrated that they already are taking efforts to improve fleet efficiency and reduce fuel consumption, particularly through vehicle selection and rightsizing initiatives.

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[8] The analysis focused on vehicles that were still listed in an "Active" status at the end of FY14. Inactive vehicles included those in the dataset that had been sold sometime in FY14 or that were slated for retirement and were not currently being driven.

Table 2. White Fleet Summary Statistics: FY14

Metric	FY14 (All Vehicles)	FY14 (Active Only)
# of Units	6,967	6,141
Average Age (years)	7.1	6.7
Total Vehicle Miles Traveled	71,802,951	65,601,000
Average VMT	10,306	10,682
Fuel Consumption (gallons)	4,562,204	4,173,960
Average Fuel Economy (MPG)	17.2	17.2
Individual Agencies	19	19

Note: Excludes vehicles sold or pending sale. Summary data excluded those vehicles missing data in at least one relevant data field (e.g., mileage or fuel).
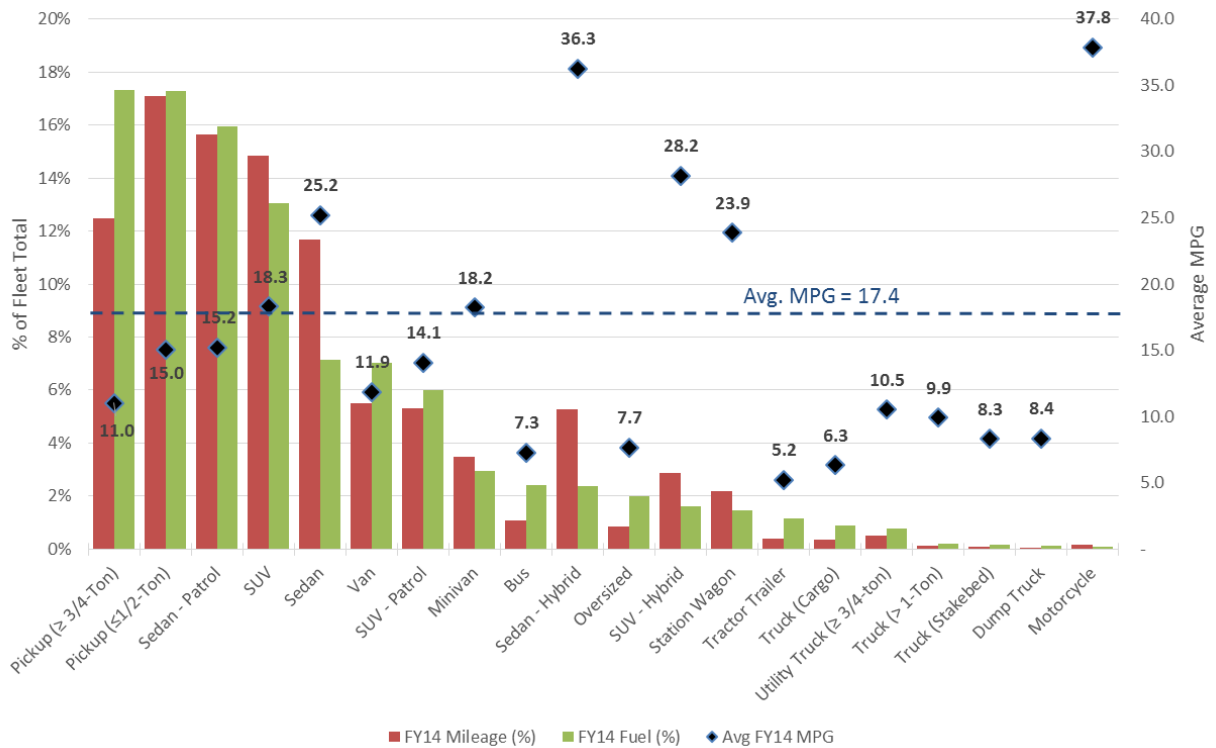*Source: Vision Fleet analysis of SFM FY14 data*

The following subsections provide additional high-level characterization of the white fleet, including key statistics across vehicle segments and agencies.

SFM Fleet Segmentation: Vehicle Type

Figure 5 shows the breakdown of white fleet fuel consumption and mileage by vehicle type for FY14. The analysis revealed that the majority of the white fleet comprises pickup trucks, sport utility vehicles (SUVs), and both patrol and non-patrol sedans. Notably, the vehicle segments with the largest share of miles are also those with lower relative fuel efficiencies. Small percentage gains in fuel economy across a vehicle segment with low efficiency and a large number of miles driven can add up to substantial savings in a relatively short time.

Figure 5. White Fleet Share of FY14 Fuel and Mileage by Vehicle Type

Note: Excludes vehicles sold or pending sale. Summary data excluded those vehicles missing data in at least one relevant data field (e.g., mileage or fuel).
Source: Vision Fleet analysis of SFM FY14 data

As shown in Figure 5, the top seven fuel-consuming vehicle segments account for about 85% of the white fleet's fuel consumption and mileage. Pickup trucks alone represent about 35% of each metric's total, which may signal opportunities not only for AFVs, but for idle reduction technologies as well. Patrol sedans also comprise a large share of fuel and could yield substantial results from similar improvements. While non-pursuit sedans are relatively more efficient than pickups and SUVs, they may also hold potential to shift to more efficient hybrid-electric, electric, or natural gas vehicle options.

SFM Fleet Segmentation: Agency
Figure 6 segments the white fleet across each of the 19 agencies that comprise the SFM fleet.

Figure 6. White Fleet Share of FY14 Fuel and Mileage by Agency

Note: Excludes vehicles sold or pending sale. Summary data excluded those vehicles missing data in at least
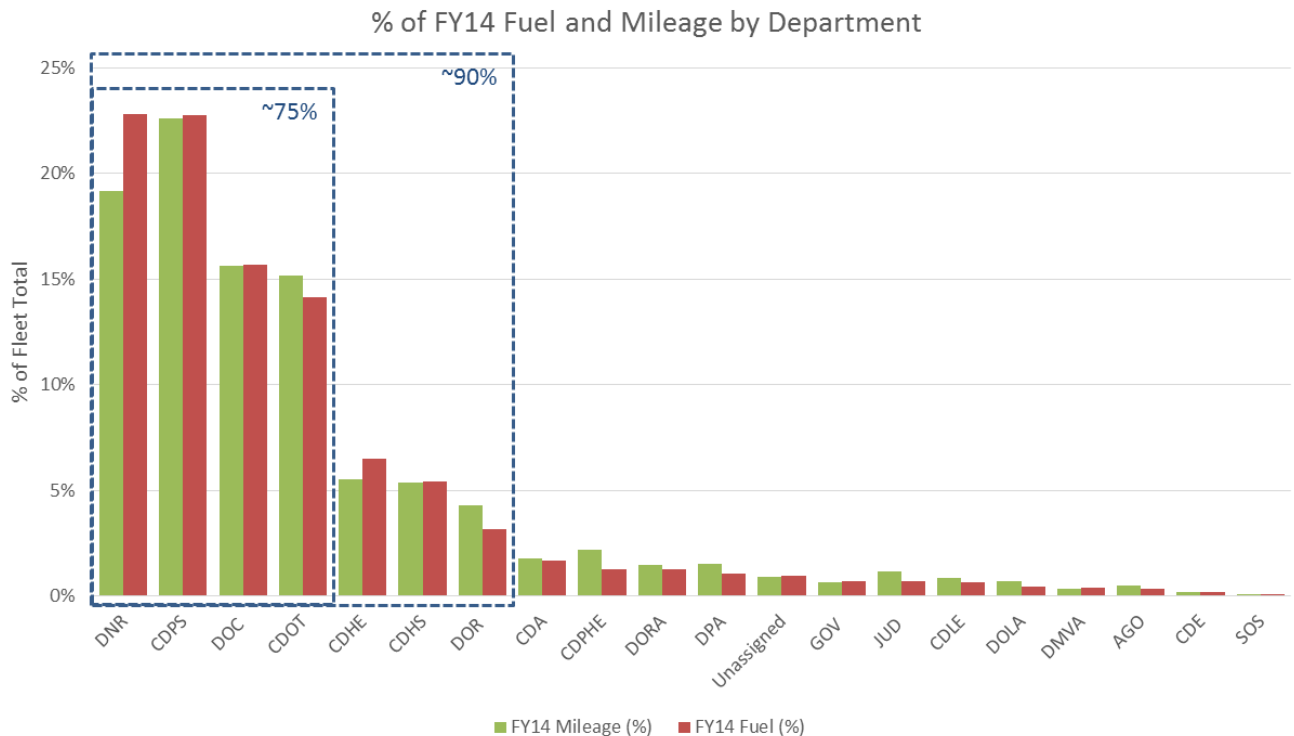one relevant data field (e.g., mileage or fuel).
Source: Vision Fleet analysis of SFM FY14 data

As shown, four agencies account for approximately 75% of white fleet mileage and fuel
consumption: The Department of Natural Resources (DNR), Colorado Department of Public
Safety (CDPS), the Department of Corrections (DOC), and CDOT. Three more departments (the
Colorado Department of Higher Education, the Colorado Department of Human Services, and
the Department of Revenue) bring that total share of white fleet mileage and fuel consumption to
about 90%. The twelve remaining departments account for a combined 10% of the fleet's
mileage and fuel. This concentration of usage reiterates the opportunity to identify focused,
scalable improvements that can be replicated across an agency.

SFM Fleet Segmentation: Top 20 Fuel-using Agency/Vehicle Segments

As discussed in Section 2, the study team sought opportunities to narrow the scope of this
assessment and prioritize these types of scalable opportunities. This included an effort to focus
on those agency and vehicle segments that account for the greatest shares of fuel consumption
across the white fleet. Table 4 lists each of the Top 20 fuel-using agency and vehicle segments,
which span only seven departments and represent 60% of the white fleet's total assets, 67% of
annual miles traveled, and 70% of its annual fuel consumption.

Table 3. Top 20 White Fleet Agency-Vehicle Segments by FY14 Fuel Consumption

| Dept.	Vehicle Type	# of Assets (Clean)	Avg FY14 Mileage	Avg FY14 MPG	% of Assets	FY14 Mileage (%)	FY14 Fuel (%)	Summary	
CDPS	Sedan - Patrol	421	21,581	15.8	7%	14%	14%	Top 10 48% units 56% VMT 58% fuel	Top 20 60% units 67% VMT 70% fuel
DNR	Pickup (≥ 3/4-Ton)	451	12,666	11.6	8%	9%	12%		
CDOT	Pickup (≤1/2-Ton)	346	13,991	16.3	6%	7%	7%		
DNR	Pickup (≤1/2-Ton)	310	12,016	15.4	5%	6%	6%		
CDPS	SUV - Patrol	153	19,198	14.3	3%	4%	5%		
CDOT	SUV	301	9,913	18.5	5%	5%	4%		
DNR	SUV	181	11,407	17.9	3%	3%	3%		
DOC	Sedan	272	10,280	24.4	5%	4%	3%		
DOC	Van	171	7,147	11.2	3%	2%	2%		
DOC	SUV	134	11,484	16.8	2%	2%	2%		
CDOT	Pickup (≥ 3/4-Ton)	51	16,564	12.2	0.9%	1.3%	1.7%	Next 10 12% units 10% VMT 12% fuel	
CDHE	Van	128	6,897	12.4	2.2%	1.3%	1.6%		
CDHS	Van	91	6,866	11.0	1.6%	1.0%	1.3%		
DOC	Sedan - Hybrid	140	11,806	30.9	2.4%	2.5%	1.3%		
DOC	Pickup (≥ 3/4-Ton)	98	4,546	9.3	1.7%	0.7%	1.2%		
CDPS	SUV	59	13,894	18.6	1.0%	1.2%	1.1%		
DORA	Pickup (≤1/2-Ton)	35	21,402	17.9	0.6%	1.1%	1.0%		
DOC	Bus	22	10,322	6.4	0.4%	0.3%	1.0%		
DOC	Tractor Trailer	17	12,635	5.3	0.3%	0.3%	1.0%		
CDHE	Sedan - Patrol	75	5,574	10.7	1.3%	0.6%	0.9%		

Note: Excludes vehicles sold or pending sale. Summary data excluded those vehicles missing data in at least one relevant data field (e.g., mileage or fuel). Color-coding for averages indicates higher (green) and lower (orange/red) values for per-vehicle average mileage and fuel economy. Color coding for percentage shares of mileage and fuel indicates relative shares of the total (darker red = greater share). Source: Vision Fleet analysis of SFM FY14 data

SFM Fleet Segmentation: Alternative-Fuel Capability

Figure 7 illustrates the share of active white fleet vehicles equipped to utilize each conventional or alternative fuel as of June 2014. As shown, the white fleet has previously deployed a significant share of FlexFuel (E85) vehicles, which represent nearly 27% of its vehicles. Hybrid, diesel, CNG, propane, and electric vehicles all have been deployed on a relatively smaller scale throughout the fleet. However, SFM continues to work with agencies to grow the share of vehicles running on CNG.

Figure 7. Share of Active Vehicles Deployed by Fuel Type – June 2014
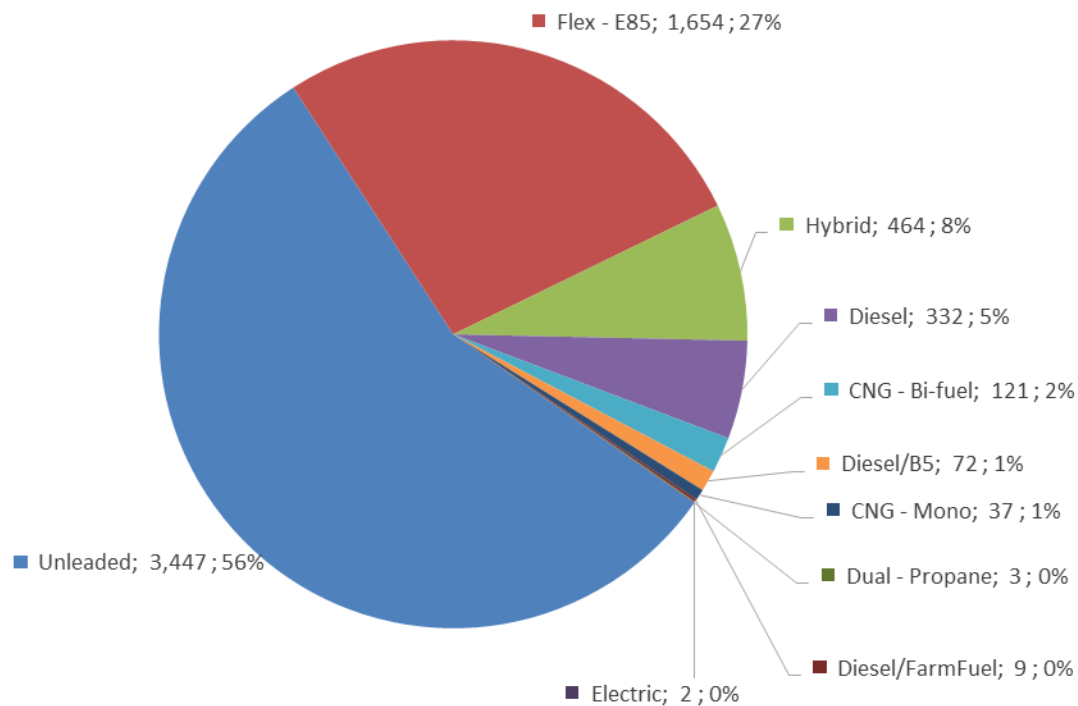
Note: Excludes vehicles sold or pending sale.
Source: Vision Fleet analysis of SFM FY14 data

CDOT Orange Fleet Segmentation

The orange fleet includes more than 3,000 pieces of equipment. As shown in Table 4, more than 1,600 of these assets are on-road equipment with distance-based odometers. The remainder comprises a mix of on-road and (mostly) off-road equipment with hourly meters (e.g., construction and small powered equipment).

Table 4. Orange Fleet Summary Statistics: FY14

| Metric	Distance	Hours	Total
Number of Units	1,632	1,487	**3,119**
Average Age (years)	10.3	12.1	
FY14 Total Usage (Miles or Hours)	17,821,182	992,440	
FY14 Average Usage (Miles or Hours)	12,274	578	
FY14 Fuel Consumption (Gallons)	3,106,896	468,750	**3,575,645**
FY14 Average Fuel Economy (MPG or HPG)	6.8	1.3	

Note: Summary data excluded those vehicles missing data in at least one relevant data field (e.g., mileage or fuel).
Source: Vision Fleet analysis of CDOT FY14 data

Notably, the on-road equipment uses about 87% of the orange fleet's fuel. An average fuel economy (for distance-metered units) of under 7 mpg, and the orange fleet's reliance on diesel fuel (95% of fuel consumed), suggests that opportunities may exist for improving efficiency and emissions through replacement or retrofits of older equipment. This could include AFVs or emission or idle reduction focused technologies.

Orange Fleet Segmentation: Equipment Type

As shown in Figure 8, the top four equipment types in the orange fleet – snow plows, light-, medium-, and heavy-duty trucks, and construction equipment – consume the majority of the fleet's fuel.

Figure 8. Orange Fleet Share of FY14 Assets and Fuel Consumption by Vehicle Type
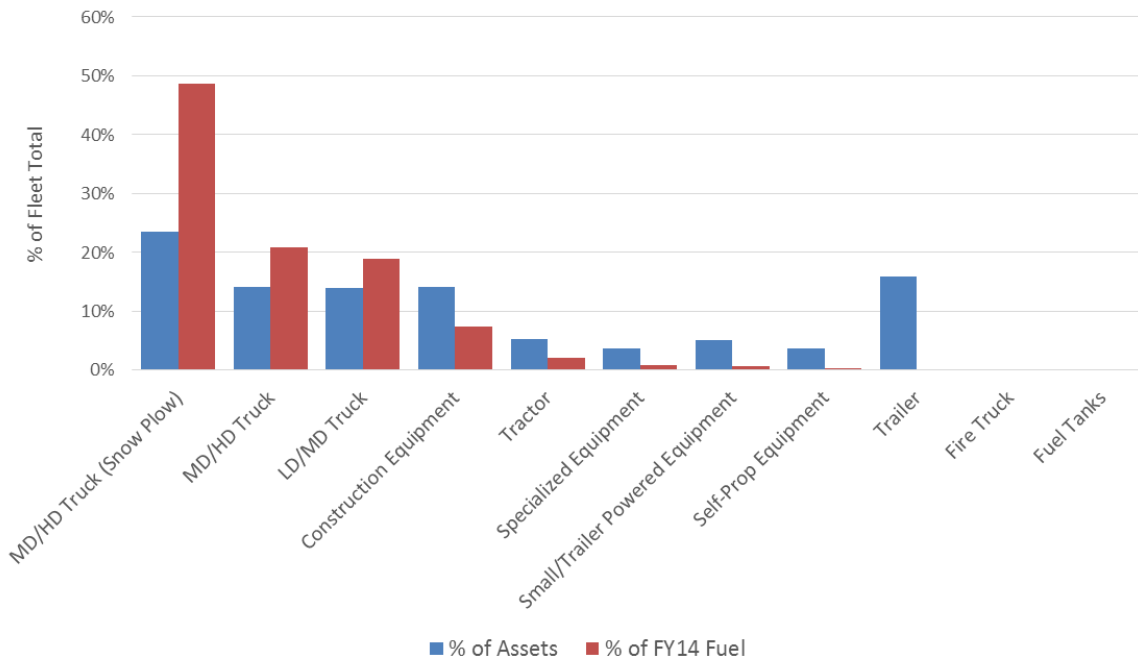
Note: Fuel statistics exclude those vehicles missing with missing or suspect fuel data.
Source: Vision Fleet analysis of CDOT FY14 data

Medium- and heavy-duty (MD/HD) trucks in the two primary snow plow classes (658 & 756) comprise nearly half of orange fleet fuel consumption.[9] Other non-plow MD/HD trucks (those of at least 2-ton capacity) and LD/MD trucks (under 2-ton capacity) each consume an additional 20% of the fleet's fuel. Construction equipment (e.g., loaders and motor graders) represent about 8%. Together, these categories comprise 96% of orange fleet fuel consumption. Other equipment, mostly smaller, self-propelled and other specialized equipment, collectively represent <5% of fuel consumption. Given this concentration of fuel consumption among the top four equipment types, the team focused its orange fleet efforts on opportunities in those categories.

Orange Fleet Segmentation: Trucks ≥ 2 Tons (MD/HD Trucks)

Table 5 provides an overview of the key statistics for the orange fleet's heavy-duty truck segment.

Table 5. Orange Fleet FY14 Summary Statistics for MD/HD Trucks (Distance-Metered Only)

Vehicle Type	# of Assets	Average FY14 Mileage	Average FY14 MPG	% of MD/HD Assets	% of MD/HD FY14 Fuel	FY14 Fuel (cum%)
Snowplow Class Codes (658 & 756)	**734**	**11,527**	**6.6**	**69%**	**72%**	
Truck - Tandem: Dump (Snow Plow)	437	12,626	5.4	41%	50%	50%
Truck (≥2 Ton): Dump (Snow Plow)	296	9,611	5.9	28%	22%	71%
Truck - Tandem: Snow Work (Snow Plow)	1	13,777	3.9	0%	0%	72%
All Other MD/HD Trucks	**335**	**11,581**	**16.2**	**31%**	**28%**	
Truck (≥5 Ton): 4x4	52	10,541	3.8	5%	6%	78%
Truck - Tandem: Tractor	40	15,201	4.9	4%	5%	83%
Truck - Tandem: Snow Work	23	12,273	3.4	2%	4%	86%
Truck (≥2 Ton): Dump	40	16,682	8.7	4%	3%	90%
Truck (≥2 Ton): Attenuator	59	6,763	5.7	6%	3%	92%
Truck (≥2 Ton): Mechanic/Crane	44	8,875	7.1	4%	2%	95%
Truck (≥2 Ton): Aerial	21	12,388	6.0	2%	2%	96%
Truck (≥2 Ton): Utility/Stake Bed	21	9,556	6.5	2%	1%	97%
Truck (≥2 Ton): Debris	4	27,534	6.5	0.4%	0.4%	98%
Truck (≥2 Ton): Digger Derrick	4	11,366	5.7	0.4%	0.4%	98%
Truck - Tandem: Stake Bed	7	9,439	6.0	0.7%	0.4%	99%
Truck (2.5 Ton) Hook Lift	5	8,329	5.5	0.5%	0.4%	99%
Truck (≥2 Ton): 4x4	6	11,688	5.6	0.6%	0.4%	99%
Truck (≥2 Ton)	3	13,018	5.4	0.3%	0.3%	100%
Truck - Tandem: Tanker	2	3,254	6.2	0.2%	0.0%	100%
Refuse Truck	1	4,263	5.0	0.1%	0.0%	100%
Truck (≥2 Ton): Cargo Van	1	4,175	6.9	0.1%	0.0%	100%
Road Oil Distributor	1		3.2	0.1%	0.0%	100%
Truck - Tandem	1	N/A	N/A	0.1%	N/A	N/A
Total for MD/HD Trucks	**1,069**	**11,544**	**9.6**			

Note: Summary data excluded those vehicles missing data in at least one relevant data field (e.g., mileage or fuel).
Source: Vision Fleet analysis of CDOT FY14 data

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[9] CDOT has agency-specific equipment category (class) codes to help track the primary uses of each piece of equipment. While other class codes may include trucks and equipment that also support snow removal activities, the majority of the orange fleet's dedicated snowplows fall in these two class codes.

As shown in Table 5, of the top four vehicle types, snow plows consume the majority of orange fleet fuel. Their mission-critical status and adverse operating conditions make them a more difficult candidate for AFV and petroleum reduction opportunities, as there is limited room for additional equipment and potentially high consequences if any operational issues arise due to AFV or efficiency-oriented equipment. However, other fleets in the United States are working to demonstrate that such opportunities can be implemented safely and reliably in their respective regions. Any strategies involving snow removal equipment with the State's orange fleet must emphasize continued reliability and performance. As such, in addition to available CNG options, this study included other opportunities such as idle reduction technology (e.g., APUs or ALM) and telematics.

Other MD/HD trucks span a wide range of configurations and usages, making it difficult to recommend a standardized approach to petroleum reduction that will work in all use cases. Where the location, usage patterns, and configuration of the vehicles allows, some of these large work trucks may provide cost-effective opportunities for AFV replacements. In addition, many of these trucks are used in construction or road maintenance activities where high idle times are common. Where AFVs are less feasible, idle reduction technologies may provide worthwhile fuel savings.

Orange Fleet Segmentation: Trucks < 2 Tons (LD/MD Trucks)

Figure 9 summarizes the share of various use cases of LD/MD trucks (those less than 2 ton) by number of assets and fuel consumption.

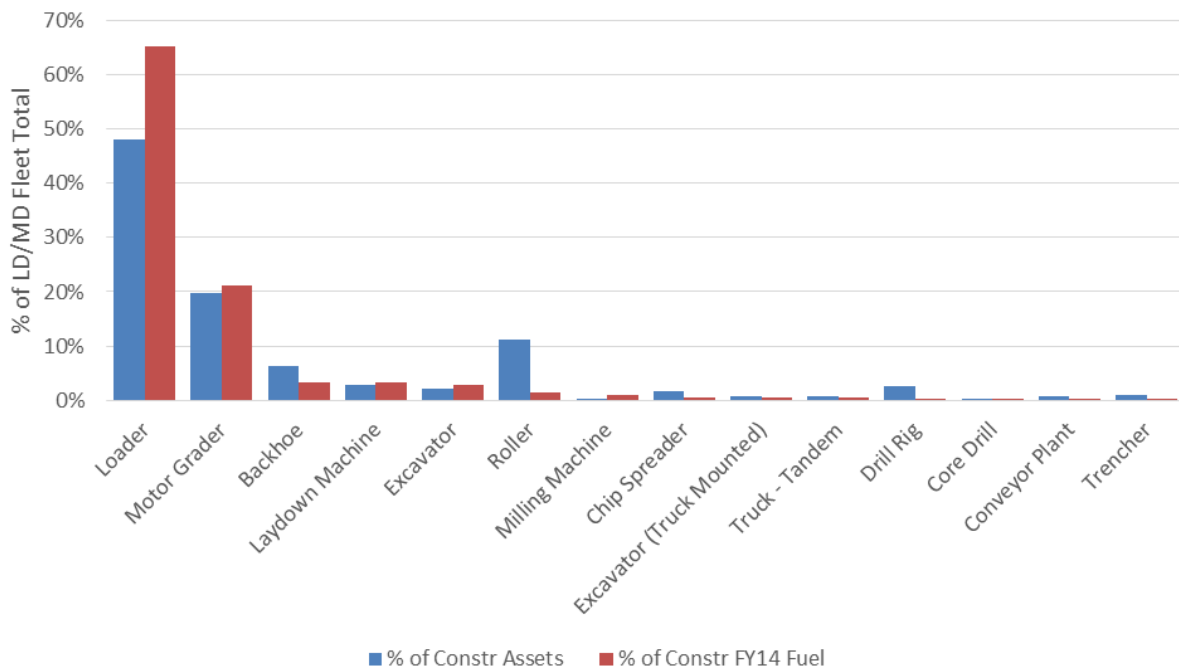*Figure 9. Orange Fleet Share of FY14 Assets and Fuel Consumption for LD/MD Trucks*

Note: Fuel statistics exclude those vehicles missing with missing or suspect fuel data.
Source: Vision Fleet analysis of CDOT FY14 data

Similar to non-plow trucks ≥ 2 tons, these lighter trucks also have a wide range of configurations and responsibilities. Some may also be responsible for snow-removal work during winter months, but involved in road maintenance (e.g., dump trucks hauling asphalt) in non-winter months. As above, a wide variety of uses makes standardized approaches more difficult to implement. What might work for an attenuator truck may not be useful or feasible for a dump truck or bucket truck.

Orange Fleet Segmentation: Construction Equipment

The Construction Equipment segment comprises a relatively small share of fuel usage: 9% for orange fleet and <3% for the State fleet overall. Figure 10 summarizes the share of different types of construction equipment by number of assets and fuel consumption..

Figure 10. Orange Fleet Share of FY14 Assets and Fuel Consumption for Construction Equipment

Note: Fuel statistics exclude those vehicles missing with missing or suspect fuel data.
Source: Vision Fleet analysis of CDOT FY14 data

Of the orange fleet's construction equipment, the vast majority are loaders and motor graders. Notably, both of these equipment categories are involved in snow removal during the winter months. The loaders, in particular, carry a large responsibility in loading snow plows with road sand during winter storms. Both these pieces of equipment are also used in the non-winter months for regular road maintenance and construction activities. Considering the low share of overall fuel consumption and the nature of construction and snow removal equipment, opportunities for the construction segment focused on idle reduction and emissions reduction retrofits, particularly for older equipment.

Section 4: White Fleet Key Findings

This section presents findings from the team's data collection (qualitative and quantitative) and analysis surrounding the prioritization and comparative analysis for white fleet opportunities. It begins with an overview of key trends and feedback discussed in the agency fleet coordinator interviews. It then presents what the Vision Fleet team considered to be the primary technology (e.g., AFV and efficiency-related) and crosscutting (e.g., financing and fleet management) opportunities through which the State could achieve significant, near-term improvements in the financial and environmental costs of operating the white fleet.

Key Fleet Coordinator Input

The Vision Fleet team spoke with fleet coordinators across 10 agencies and more than 20 divisions. These conversations gave the team the opportunity to vet potential opportunities with those individuals closest to the day-to-day mobility requirements of their respective agency staff. In addition, the team asked fleet coordinators about past best practices, lessons learned, potential barriers to, and practical solutions for improving the efficiency and operations of the State fleet.

This section provides a summary of key topics that were either repeatedly raised or lent particular insight to the study team. This qualitative input provides meaningful context for the quantitative results and findings discussed later in this section.

General Fleet Management Concerns and Practices

One of the most consistent trends the team noted was each fleet or vehicle coordinator's high level of knowledge of their agencies' vehicle needs and drivers' perspectives. Many offered several examples of past efforts they had taken to minimize unnecessary travel or improve the efficiency of their fleet operations. Minimizing the impacts of agency travel needs on operating budgets was the most oft-cited driver behind such efforts.

In addition to lowering costs, the other key factors that fleet coordinators focus on involve employees' safety, productivity, and their vehicles' ability to meet their daily job requirements. Several fleet coordinators were particularly sensitive to drivers' perceptions about off-road, winter, or mountain driving. Many drivers, particularly those with assigned vehicles who travel extensively for their work, feel strongly about having a vehicle with all-wheel-drive (AWD) capabilities given their frequency of off-road or high-clearance needs (i.e., on forest or rural roads) or of encountering inclement weather.

AFV Experiences and Considerations

Alternative fuel vehicles have been a focus for the State fleet for more than a decade. Most fleet coordinators were able to comment on current or past experiences with FlexFuel or hybrid-drive vehicles, and several had more recent experience deploying and managing CNG vehicles.

In discussing both past experiences with AFVs and current barriers to broader adoption, several fleet coordinators again emphasized that vehicle functionality and employee job performance are the agency's paramount concern. To the degree that AFVs can be integrated into a division's operations without substantially affecting employee safety or productivity, coordinators

expressed support for doing so. In at least three conversations, coordinators noted that generally low average annual usage for many vehicles makes it difficult to justify the higher upfront price or the cost for things like telematics or idle reduction retrofits (which currently come from operating budgets).

At least two division vehicle coordinators also mentioned their practice of periodically rotating assigned vehicles among drivers with different territories or trip characteristics in order to balance the utilization and overall wear and tear on all vehicles. While beneficial from a fleet management perspective, this practice can complicate AFV deployment planning, as alternative fuel infrastructure (particularly CNG and EV charging) may not be available in all areas of the state where those employees operate.

FlexFuel

FlexFuel (E85-capable) vehicles are currently the most widely deployed AFV in the State fleet, representing more than 25% of SFM vehicles (see Figure 7). Despite this past progress, however, SFM fueling data suggests that drivers have significantly cut back on fueling those vehicles with E85.

The reduced fuel efficiency (and therefore shorter range between fill-ups) of E85 is well-documented and apparently well-understood by State drivers. In addition to the perceived inconvenience of having to fill up more often, drivers may also feel inconvenienced by having to track down an E85 station. In addition, some coordinators cited that the combination of E85 retail prices and lower vehicle efficiency on a gasoline gallon equivalent basis sometimes means that filling up with E85 costs more on a per-mile basis. Given agency concerns about stretching their annual operating budgets, this potential cost premium can further discourage drivers and fleet coordinators from using E85.

Finally, fleet coordinators also shared anecdotal perspectives from drivers that E85 fueling stations have been closing and are, therefore, harder to find in Colorado. Historical data from the Alternative Fuels Data Center, however, shows that this may not be the case. Figure 11 shows the annual number of alternative fuel stations for each fuel type available in Colorado over the past several years.

Figure 11. Historic Alternative Fuel Station Availability in Colorado
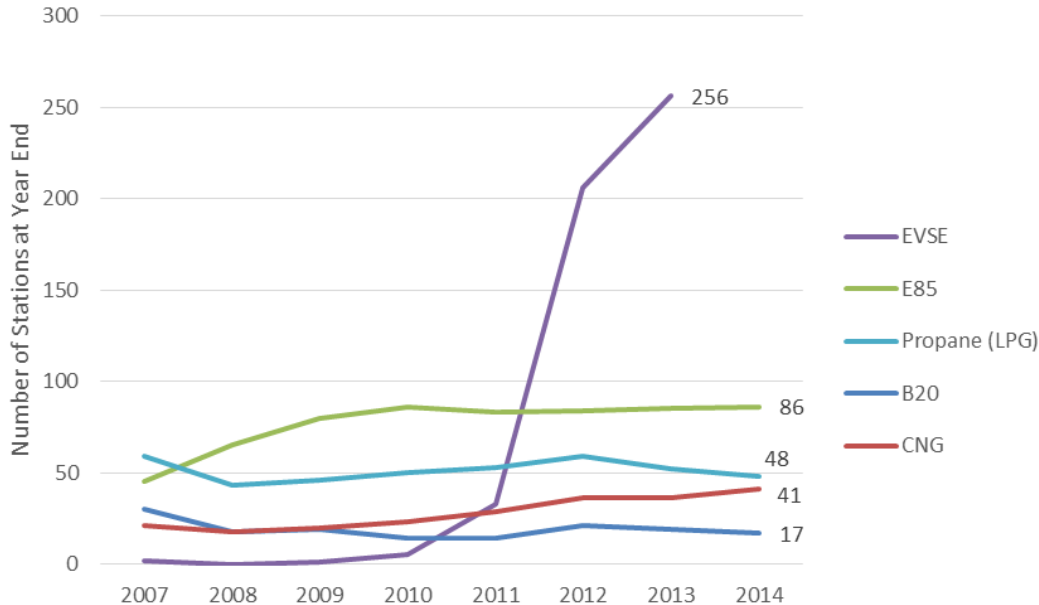
Source: Data Courtesy of NREL

As shown in Figure 11, there were no fewer E85-equipped stations in Colorado in 2014 than five years earlier.[10] However, it is possible that individual stations removed or added E85 pumps. Notably, other alternative fuel stations, particularly CNG and EV charging stations, have increased in availability over the past five years.

Station availability aside, fleet coordinator responses suggest that the reduced fuel efficiency, perceived poorer performance (especially in cold weather), and often higher per-mile costs have dissuaded most drivers from seeking out E85 when driving a FlexFuel vehicle.

Hybrids

Fleet coordinators who discussed hybrid electric vehicles were generally supportive of their performance and resultant cost savings. One agency coordinator specifically cited Ford's discontinuing the Ford Escape hybrid SUV as a particular setback to his fleet greening efforts, as some older hybrid SUVs are due for replacement. Five other division coordinators expressed a willingness to deploy more hybrid SUVs—including in place of small pickups and minivans when possible—but cited a lack of available hybrid SUV options on the State bid.[11] Three agencies mentioned that some drivers perceive lesser performance, particularly with older hybrids, including lack of power when driving in the mountains or concerns about safety in winter driving conditions. Similar perceptions were mentioned for other AFV platforms as well, highlighting the importance of vehicle coordinator and driver outreach and education efforts in support of AFV deployment efforts.

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[10] Data provided by the National Renewable Energy Lab (NREL)

[11] Note that interviews were completed prior to the release of the 2015 State Bid, which included the Toyota Highlander Hybrid.

Electric Vehicles

While only two electric vehicles have been deployed in the State fleet, several fleet coordinators are supportive of trying them, particularly for use in motor pools and for administrative trips. Most are unsure, however, about range and charging infrastructure considerations. One agency (CDPHE) already has charging stations installed at its south Denver headquarters.

Natural Gas Vehicles

Agency experience with both dedicated and bi-fuel CNG vehicles has been increasing in the past few years as the State has prioritized them as an AFV option. While some agencies have integrated these vehicles without too much trouble, some fleet coordinators cited barriers to drivers making more frequent use of NGVs or drivers filling bi-fuel vehicles with CNG on a more regular basis.

The most commonly cited issue is the limited availability of fueling infrastructure. Fleet coordinators reiterated drivers' concerns (as with E85) about productivity losses due to having to drive out of their way to fill with CNG. For dedicated NGVs, the concern is much more tied to the range of the vehicle, and some coordinators shared stories of drivers who fell short of reaching a station or arrived at a station that was temporarily out of order (due to very cold weather). Finally, others expressed difficulties posed in some cases (primarily with bi-fuel pickup trucks) about the loss of storage space due to the vehicle's second fuel tank.

Despite these NGV integration issues, many division vehicle coordinators have worked proactively to educate their drivers and successfully troubleshoot deployments. Several expressed an interest in continuing to look for appropriate opportunities to deploy them into appropriate use cases. As with EVs, however, they expressed some uncertainty about how best to identify good opportunities for NGVs in light of different vehicles' intended functions and routing characteristics.

Improving Efficiency: Idle Reduction and Telematics

Both idle reduction technologies (primarily auxiliary load management and auxiliary power systems) and telematics solutions were perceived by many fleet coordinators as a strong opportunity to improve fleet efficiency and reduce fuel consumption. Coordinators from several agencies (e.g., DNR, CDOT, and CDPS) cited specific use cases that likely have higher than average idling rates, but had no specific data available to evaluate the potential opportunity.

Telematics solutions were cited by numerous coordinators as an option they would like to employ, but were simply unable to afford within their operating budgets. Commonly mentioned benefits included the following:

- Automating vehicle use logs and routing analyses (which are currently done by hand) in order to enhance trip planning and mileage reduction efforts.
- Better assessing opportunities to deploy AFVs, including NGVs, and reduce unnecessary idling.
- Enhancing driver safety, particularly an ability to locate field staff who work in remote locations or in potentially confrontational situations (e.g., tax compliance or parole officers).

Some vehicle coordinators mentioned that they already made limited used of telematics in their fleets. For example, the Department of Corrections has used Cartasite's telematics on its delivery vehicles for the past five years to improve scheduling, routing and staff safety. As of this report's writing, CDOT was in the early stages of deploying a telematics solution (Verizon's Networkfleet) across the entirety of its white fleet vehicles (100 had been installed to date) to support overall fleet operations, improve winter storm management, and collect baseline information to inform petroleum reduction opportunities.

The key barriers preventing broader adoption of these solutions are budget related. Currently, these after-market solutions must be paid from each agency's annual operating budget. For telematics in particular, which require an ongoing monthly or annual service fee, this can strain an agency's already pressed budget. A lack of accurate or timely baseline information about vehicle usage patterns and idle times, as well as strain on fleet coordinators' full schedules, also make it difficult to build a reliable case for an anticipated return on investment for telematics. Even when a promising opportunity is identified, the upfront costs of committing to deployment can be hard to overcome. In some cases, such incremental operating cost competes directly with various program funds or even the budgeted salary for a new hire.

Other Opportunities

Beyond the above technology-oriented opportunities, fleet coordinators also discussed efficiency improvements tied to fleet management practices and alternatives. Some agencies have previously undertaken rightsizing initiatives to reduce the overall size of their fleet, or right-typing efforts to encourage the purchase of more efficient vehicles. Others acknowledged that additional opportunities for such efficiencies remained. However, time constraints, a lack of data or analytic capabilities, and cultural barriers (i.e., drivers wanting specific vehicles) had prevented them from taking steps to use them.

Another set of commonly employed fleet management best practices involves vehicle substitution solutions. For example, several agencies with high concentrations of employees along the Front Range (particularly in metro Denver) provide their staff with complimentary transit passes to encourage trip reduction.[12] The CDOT team also mentioned the agency's efforts to encourage flex-time commuting or telecommuting. Across all such initiatives, CDOT staff also noted that employee education and engagement efforts, as well as top-down directives or protocol, are helpful in driving rightsizing and vehicle substitution participation.

Coordinators for some agencies with an existing motor pool, including some that are co-located with other departments or divisions, mentioned that staff already undertakes some degree of carsharing activities, partly out of necessity (i.e., limited vehicles and budgets). One coordinator, whose staff uses the downtown motor pool, suggested that there may be an opportunity for outside carsharing service (e.g., Car2Go) or virtual motor pool service providers (e.g., ZipCar's FastFleet service or Local Motion). This would lessen the budgetary and administrative burden of each agency managing its own motor pool vehicles.

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[12] This policy is currently left to the discretion of each agency.

Barriers

Agency fleet coordinators listed three barriers to deploying more efficient vehicles or to more efficiently managing their fleets. They are: budgeting and risk, the State bid process, and timely access to fleet data.

Budget and Risk

Vehicle coordinators are generally open to and willing to implement changes to work toward the State's goals for fleet management. But agencies' limited operating budgets and staff's aversion to taking technology-related risks limit the scope of their efforts. This is particularly the case for efficiency-related technology solutions like idle reduction and telematics.

From an individual agency's perspective, taking a risk (even a well-informed one) on the incremental costs of an efficiency technology or program often means choosing not to invest in other agency programs or needs. If that investment falls short of producing its expected operational savings in the short term, it may be criticized as a poor long-term decision. One coordinator suggested that being able to learn from pilot or demonstration projects implemented elsewhere in the fleet would help mitigate that perceived risk.

State Bid Process

Vehicle coordinators from at least four agencies expressed a desire for more involvement with the annual State bid process.[13] They felt that they do not always have access to the optimal vehicles for their agency's particular needs.

And the uncertainty of what will be on the State bid each year makes it more difficult to manage vehicle use and plan future replacement strategies. Two agencies noted a pushback from SFM they had experienced about ordering specific vehicles that had been determined best suited to a specific need, and had difficulty obtaining approval for certain exemptions.

Data and Analytic Support

Coordinators from at least six agencies discussed barriers to obtaining greater or timelier access to data about the vehicles that they are responsible for managing. While SFM provides a great deal of standardized reporting, some coordinators need an enhanced level of data access to improve their ability to analyze and manage their respective fleet operations.

The SFM team uses two primary data systems: the Colorado Automotive Reporting System (CARS) provides most fleet asset management data and capabilities, and Wright Express (WEX) aids in managing statewide fueling data. The SFM team provides agency staff with regular reports, including vehicle utilization and fueling information. However, that data may be subject to administrative lag times as SFM staff works to reconcile inconsistencies and errors. As a result, the timing of these standard reports does not always align with agency planning or analytic needs.

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[13] Each year, SFM issues a request for proposals for dealerships to bid on specific vehicles and configurations against which agencies can order their annual vehicle replacements. This form of aggregated purchasing can help to lower the ultimate purchase price that SFM pays for each vehicle.

Vehicle utilization reports are issued annually, which makes it more difficult to redeploy an underutilized asset. Alternative fuel vehicle fueling reports are issued every four to six weeks. But some coordinators would prefer more frequent reports in order to address poor alternative fueling behavior in a timely manner.[14] While fleet coordinators are able to access portions of the CARS data, they are unable to generate their own custom reports. The SFM team fulfills custom report requests, but response times vary based on staff workloads. It may take multiple requests for a fleet coordinator to receive the needed information.

Primary Technology Opportunities

Based on the above interview findings, the Vision Fleet team further narrowed the scope of the technology-related opportunities included in its quantitative analysis and comparative assessment. The resulting qualified opportunity matrix for the white fleet is shown in Table 6. Using this revised opportunity matrix as a guide, the team conducted its quantitative TCO and ECO analysis on the qualified opportunities. As discussed in Section 2, this modeling approach enabled the team to assess multiple opportunities across a wide range of agencies and vehicle segments. The resulting white fleet technology assessment considered more than 170 specific combinations of agencies, vehicle segments, and AFV or efficiency technologies. Appendix B includes the agency-specific summary output tables from this analysis.

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[14] SFM notes that it collects, cleans and reports WEX fuel card data on a monthly basis. The monthly data set, however, is very large (typically more than 20,000 fuel purchases per month), and many fueling station's fuel-type codes are often inconsistent or erroneous. As a result, it takes a concerted effort for SFM to process and release the data to agency coordinators.

Table 6. SFM White Fleet: Post-Interview, Qualified Opportunity Matrix

Agency	Top 20 Fuel-Use Segments (Highest Use Segments)	Efficient ICE or AFV									Efficiency/Emission Red.			Data
		Efficient ICE	CNG Mono	CNG Bi-fuel	Propane	Hybrid	PHEVs	BEVs	B20	E85	Regen. Brake Retro	ALM/ APS	Emission Retrofits	Telematics
DNR	Pickups (≥ 3/4-Ton)			G						G				G
	Pickups (≤1/2-Ton)			G						G				G
	SUVs			Y		G				G				G
CDPS	Sedan - Patrol											G		G
	SUVs - Patrol									G		G		G
	SUVs	G		Y		G	Y			G				
DOC	Sedans		G			G	G	G		G				G
	Vans		G							G				G
	SUVs			Y		G	Y	Y		G				G
	Sedan - Hybrids		G			G								G
	Pickups (≥ 3/4-Ton)	G				G								
	Buses		G			G					G	G	G	G
	Tractor Trailers		G										G	
CDOT	Pickups (≤1/2-Ton)			G						G		G		
	Pickups (≥ 3/4-Ton)		G							G				
	SUVs			Y		G	Y	Y				G		
CDHE	Sedans - Patrol	G								G				G
	Vans									G				G
CDHS	Vans		G							G		G		G
	Buses		G											G
DOR	Sedans			G						G				G
	Minivans					Y				G				G
	SUVs			Y		G	Y			G				G
DORA	Pickup (≤1/2-Ton)			G		Y				G		G		
CDA	Pickups (≤1/2-Ton)			G		Y				G		G		G
	Minivans			G		Y				G				G
	Pickups (≥ 3/4-Ton)		G			G				G				G
	Sedans		G			G				G				G
CDPHE	SUV - Hybrids			Y			Y	Y						G
	Sedan - Hybrids		G				G	G						G
	SUV			Y		G	Y	Y						G
	Station Wagon			Y		G	Y	Y						G

Source: Vision Fleet analysis

The remainder of this Primary Technology Opportunities section focuses on the opportunities that the team identified from its comparative analysis for further consideration by CEO and fleet management staff. Each of the following subsections shows what the team considered to be the most noteworthy results for each vehicle segment. The first subsection (Pickups ≥ 3/4 ton) includes additional descriptive text to aid in the interpretation of the results.

In reviewing the below findings, readers also should note the following considerations:
- In many cases, multiple potential opportunities or AFV platforms are listed for a single agency/vehicle segment in order to illustrate the comparative results and potential differences (or overlap) in opportunities. Due to this overlap, listed results and opportunities are not additive; there are likely several vehicles in a segment (if not most) that are represented in the results for more than one opportunity.
- Most vehicle segments had some vehicles for which TCO could not be analyzed due to incomplete data. Across the entire white fleet, roughly 8% of active vehicles were excluded from TCO analysis. As such, one could reasonably expect that additional vehicles would meet the minimum TCO requirements for most opportunities.
- The team conducted sensitivity analysis around fuel prices to evaluate the degree to which lower oil prices around the time of this study might affect the economic argument for each opportunity.[15] For any given opportunity, the shift in prices resulted in anywhere from a few vehicles no longer meeting the TCO threshold to a 60% decrease in the number of vehicles meeting the threshold. The team's key finding from this analysis is that economic opportunities will still exist in each of the highlighted categories. Under sustained lower oil prices, however, those vehicles that were close to the TCO margin under baseline assumptions would no longer be economic.

Finally, while this study's approach focused on specific agencies for each vehicle segment, the high-level findings generally can be translated to other agencies. Readers should keep in mind the balance of vehicle-specific and broader segment-level assumptions that were used in this analysis. The results are indicative of the relative costs and benefits of a particular technology. Any decision to transition a specific vehicle or set of vehicles to an AFV or efficiency option should consider the particular usage and characteristics of that vehicle.

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[15] The team's baseline fuel price estimates applied the same approach as the AFLEET model, but used more current, Colorado-specific prices for each fuel. Specifically, the team averaged Colorado-specific quarterly average prices for each fuel across the most recent four quarters for which data was available (January 2014, April 2014, July 2014, and October 2014). As with AFLEET, the team sourced its data from the Clean Cities quarterly Alternative Fuel Price Reports published by the Department of Energy's Alternative Fuels Data Center. We then applied the conversion factors in the reports to convert each fuel into either unleaded gasoline gallon equivalent (GGE) or diesel gallon equivalent (DGE) figures. Finally, we applied the same annual escalation rates to each fuel's price using the same assumptions as the AFLEET model. The resulting baseline cost of gasoline was $3.40; diesel was $3.74. For the alternative (i.e., low oil price) case, we calculated the average retail cost paid by SFM vehicles from the most recently available monthly fuel report (November 24 – December 23, 2014). The resulting alternative cost of gasoline was $2.68; diesel was $3.56.

Pickups (≥ 3/4 ton)

Table 7 provides summary results from the highest-ranking opportunities for ¾-ton and heavier pickup trucks in the CDOT and DNR fleets. Each of the three rows shows results for a combination of a specific agency and a specific opportunity. For example, the first row summarizes results for the opportunity of converting CDOT's ¾-ton and heavier pickups to similarly sized bi-fuel CNG pickups. Each of the subsequent columns reveals the following:

- Of CDOT's existing pickups, 25 met the minimum threshold of no more than a 10% increase in TCO if they were replaced with a bi-fuel CNG pickup.
- Of those 25 pickups that met the TCO threshold, each would:
  - Provide an average annual petroleum savings of 796 gallons;
  - Cost about 1% more on a lifecycle TCO basis compared to business as usual; and
  - Result in an average annual decrease of 1.7 tons of CO2e GHGs.
- The "Notes" column provides additional qualitative considerations that those 25 vehicles would need to be deployed in use cases where they would have adequate access to CNG fueling stations.

Note that any of the above average figures will include a distribution of individual vehicle results around that average; however, we have focused on averages for the purposes of presenting summary data in the final report.

Table 7. High-Priority Technology Opportunities for Pickups ≥ 3/4 Ton

Agency	Opp	# Meeting Minimum TCO Criteria:	Average Annual Petro Savings per Vehicle (gal/yr)	Average Change in TCO for those Meeting	Average Annual GHG Reduction per Vehicle (t/yr)	Notes
CDOT	CNG - Bi-Fuel (High AF)	25	796	1%	1.7	Would need to filter for vehicles within reasonable range of fueling.
DNR	CNG - Bi-Fuel (High AF)	173	783	1%	1.4	Would need to filter for vehicles within reasonable range of fueling.
DNR	ALM	365	93	-3%	1.3	Reasonable case for ALM

Source: Vision Fleet analysis

As shown in the table, the generally lower fuel efficiency of these heavier pickups (e.g., Ford F350 and Silverado 3500) combined with the differential pricing in gasoline and CNG create a meaningful opportunity for replacing these trucks with bi-fuel CNG vehicles. A strong caveat is that these vehicles be located in enough proximity to CNG fueling stations to achieve the 90% share of miles driven on CNG used in the "high AF share" scenario for this analysis.[16] The cab-chassis versions of these trucks can include an "under-bed" configuration for the CNG tank that mitigates potential issues with loss of bed space or attaching a camper shell.

The other opportunity listed for ≥¾-ton pickups is ALM idle reduction solutions for the DNR pickups. As noted in Section 1, ALM devices create the opportunity for substantial reductions in

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[16] Results for the Low AF scenario (67% CNG miles) still reveal that most vehicles would be economic for replacement with CNG bi-fuel. The results indicated that 25 and 168 vehicles would meet the minimum TCO criteria for CDOT and DNR, respectively.

unnecessary idle time by monitoring auxiliary loads in a vehicle and allowing the engine to start and stop while the vehicle is stationary in order to maintain battery power and operation of auxiliary load (e.g., radio communications, laptops, A/C). For vehicles that are not good candidates for bi-fuel CNG, ALM may be another good option for petroleum reduction. A short or long-term telematics deployment on these vehicles could help to adjust the assumptions the team used in its analysis of this opportunity.

Pickups ≤1/2 Ton

Table 8 provides summary results from the highest-ranking opportunities for ½-ton and lighter pickup trucks in the CDOT and DNR fleets.

Table 8. High-Priority Technology Opportunities for Pickups ≤1/2 Ton

Agency	Opp	# Meeting Minimum TCO Criteria:	Average Annual Petro Savings per Vehicle (gal/yr)	Average Change in TCO for those Meeting	Average Annual GHG Reduction per Vehicle (t/yr)	Notes
DNR	CNG - Bi-Fuel (High AF)	20	790	1%	(0.5)	Would need to filter for vehicles within reasonable range of fueling and appropriate use cases.
CDOT	CNG - Bi-Fuel (High AF)	13	758	3%	(0.9)	Would need to filter for vehicles within reasonable range of fueling and appropriate use cases.
CDOT	Hybrid	26	280	3%	3.8	Assumes rightsizing to SUV; slightly higher average TCO
CDOT	Tele	341	101	0%	2.4	Strong case for telematics; reflective of current CDOT decision
DNR	Tele	273	98	-1%	2.2	Strong case for telematics
DNR	ALM	246	90	-3%	1.6	Case for idle reduction
CDOT	ALM	309	88	-2%	1.8	Case for idle reduction, especially for engineer and maintenance vehicles

Source: Vision Fleet analysis

In a noted departure from the results for the ¾-ton pickup results, the bi-fuel CNG replacement opportunity for lighter pickups is less promising, both in terms of the number of vehicles meeting the TCO threshold and the average change in TCO (1-3%) for those that do. Part of this shift may be explained by the generally higher fuel efficiencies for conventional pickups in this segment, particularly as manufacturers' 2015 models provide significant improvements in conventional truck engine efficiencies. In addition, the 2015 State bid did not include a bi-fuel CNG option for ½-ton pickups. As such, these results assume conversion to a ¾-ton bi-fuel CNG configuration, which has comparatively lower fuel economy than a ½-ton truck. As a result, some of these potential conversions could result in slightly higher GHG emissions, despite a significant decrease in average petroleum consumption. Again, these results are dependent on each vehicle's proximity to fueling infrastructure.

For both the CDOT and DNR pickups, telematics and ALM both appear well-suited to provide low- to no-cost (on a lifecycle basis) opportunities to reduce fuel consumption through enhanced efficiency under this study's assumptions about average idle times. CDOT's current telematics effort will be able to provide better primary data for assessing the potential for additional idle reduction efforts (or may help reduce excess idling). One final opportunity noted in the above table is for the potential conversion of selected CDOT pickups to hybrid SUVs (as use cases allow). The modeled 3% average increase in TCO includes several vehicles that are at or below cost parity with a similar conventional pickup truck replacement.

Sport Utility Vehicles

Table 9 shows the high-potential results for the SUV segment, exclusive of pursuit-rated SUVs.

Table 9. High-Priority Technology Opportunities for Non-pursuit SUVs

Agency	Opp	# Meeting Minimum TCO Criteria:	Average Annual Petro Savings per Vehicle (gal/yr)	Average Change in TCO for those Meeting	Average Annual GHG Reduction per Vehicle (t/yr)	Notes
DOC	Hybrid	12	931	-5%	11.4	If downsizing to AFV sedan is not an option or vehicle is for longer-range trips, hybrid SUV is a good option for some vehicles.
DOC	BEV	56	871	-19%	7.4	Assumes rightsizing SUV > BEV sedan; range and use-case dependent
DOC	CNG - Bi-Fuel (High AF)	47	831	-6%	4.8	Assumes rightsizing SUV > bi-fuel Sedan
DOC	PHEV (High AF)	41	826	-14%	8.1	Assumes rightsizing SUV > PHEV sedan; more cost effective than CNG bi-fuel if rightsizing is an option
CDOT	Hybrid	7	701	1%	8.8	If downsizing to a AFV sedan is not feasible, hybrid SUVs provide a cost effective fuel reduction option.
DNR	CNG - Bi-Fuel (High AF)	49	634	-6%	2.6	Assumes replacing SUV with bi-fuel sedan; cost effective where possible
CDOT	CNG - Bi-Fuel (High AF)	79	595	0%	2.0	Assumes rightsizing SUV > CNG Sedan
CDOT	BEV	125	593	-14%	4.0	Assumes rightsizing SUV > BEV sedan; range and use-case dependent
CDOT	PHEV (High AF)	84	479	-8%	3.9	Assumes rightsizing SUV > PHEV Sedan
DNR	Hybrid	12	241	1%	3.2	To the degree SUVs are needed, many would be more cost effective as hybrids
CDOT	ALM	288	91	-4%	1.4	Substantial savings possible from ALM
CDOT	Tele	291	71	-1%	1.2	Supports case for CDOT telematics deployment.

Source: Vision Fleet analysis

With relatively few AFV options available in an SUV configuration, many of the AFV options explored for this vehicle segment are for those use cases where a driver could reasonably down-size into an AFV sedan. As shown in the above table, modeling of these opportunities revealed several potential opportunities for significant cost savings and petroleum reduction. The greatest of these opportunities from a TCO and ECO perspective are replacement with a battery electric vehicle (BEV) or plug-in hybrid electric vehicle (PHEV). The first of these options, however, is

subject to range-related restrictions, as BEVs are currently range-limited to trips within their full-charge round trip (about 80-90 miles) or that have charging available at interim destinations.

For PHEVs, operation is more similar to a bi-fuel CNG vehicle, where the vehicle switches to gasoline power after exhausting its electric power reserve. Notably, bi-fuel CNG sedans are another viable opportunity for SUV use cases where a rightsizing conversion is feasible, with similar levels of petroleum reduction and costs savings as the PHEV option. In cases where rightsizing is not feasible, replacement with a hybrid SUV can still provide a strong ECO and TCO benefit for some vehicles. In light of some concerns expressed about drivers' safety related to SUVs and driving in inclement weather, the projected TCO savings on most of the above options is likely enough to provide for the purchase and installation of snow tires on either motor pool or assigned sedans to improve winter handling and drivers perceptions of safety.

Sedans

Table 10 shows the high-potential results for the conventional sedan segment.

Table 10. High-Priority Technology Opportunities for Sedans

Agency	Opp	# Meeting Minimum TCO Criteria:	Average Annual Petro Savings per Vehicle (gal/yr)	Average Change in TCO for those Meeting	Average Annual GHG Reduction per Vehicle (t/yr)	Notes
DOC	CNG - Mono	40	453	-4%	1.8	Good longer-range AFV option, assuming adequate access to fueling stations.
DOC	BEV	63	446	-5%	2.9	If routing and range allows, BEVs may be a more cost effective fuel reduction approach than other AFVs.
CDA	BEV	8	425	-3%	2.6	If routing and range allows, BEVs may be a more cost effective fuel reduction approach than other AFVs.
DOC	PHEV (High AF)	33	316	5%	2.5	PHEVs provide a good middle-road compromise between petroleum reduction and range.
DOC	Hybrid	59	187	-1%	2.6	If range or fueling access limits adoption of BEVs or CNG sedans, hybrid sedans are a strong option.
DOR	Hybrid	21	161	-2%	2.3	Hybrid sedans provide a good, cost-effective option given the general distance of DOR trips (assigned vehicles, regional trip patterns).

Source: Vision Fleet analysis

The above results use the DOC's relatively large fleet of sedans to demonstrate the comparative results for various sedan AFV opportunities. Again, BEVs top the list in terms of average reduction in TCO; however, they are followed closely by dedicated CNG sedans. In either of these cases, trip routing, range and fueling/charging access are key considerations in the decision

to convert a particular vehicle or group of vehicles. In situations where range or fueling issues prevent adoption of a full AFV option, both PHEVs and hybrids provide significant ECO improvements and potential cost savings.

CDPS Opportunities

Given the prevalence of law enforcement use cases and associated requirements of vehicles in the Department of Public Safety, the team gave particular consideration to opportunities for its leading vehicle segments. Table 11 shows the resulting high-potential opportunities from the analysis.

Table 11. High-Priority Technology Opportunities for CDPS

Vehicle Segment	Opp	# Meeting Minimum TCO Criteria:	Average Annual Petro Savings per Vehicle (gal/yr)	Average Change in TCO for those Meeting	Average Annual GHG Reduction per Vehicle (t/yr)	Notes
SUVs (Non-Patrol)	CNG - Bi-Fuel (High AF)	25	694	-6%	3.2	Assumes rightsizing to bi-fuel sedan
SUVs (Non-Patrol)	PHEV (High AF)	24	595	-11%	5.4	Assumes rightsizing to PHEV sedan
Sedan - Patrol	Tele	362	162	-1%	(0.0)	As a precursor to an idle reduction deployment, telematics could provide other efficiency (and safety) benefits to DPS.
Sedan - Patrol	ALM	260	118	1%	0.0	Good potential for idle management savings. Need to review assumptions with CDPS.

Source: Vision Fleet analysis

For CDPS's non-pursuit SUVs, similar opportunities exist as for the general SUV category. Specifically, rightsizing to an AFV sedan when possible provides substantial opportunity for both cost and fuel savings. Both the PHEV and bi-fuel CNG options provide a high level of flexibility around range and fueling. While each of these highlighted results assume "high AF share" scenarios (50% of miles for PHEVs and 90% for CNG), the TCO results show room for savings to still be achieved well below those levels of alternative fuel miles.

Primary Crosscutting Opportunities

The preceding technology opportunities are indicative of the magnitude of cost savings and fuel reduction achievable across several AFV and efficiency-related options at the vehicle level. The findings in this section relate to a broader set of opportunities and associated fleet management costs and benefits.

Detailed quantitative analysis of these crosscutting opportunities generally falls beyond the scope of the TCO approach employed for this analysis. As noted in Section 2, this would require additional data about the costs and benefits associated with employee productivity, reduced fleet administration costs, and similar metrics that are difficult to measure. Despite these analytic limitations, case-study evidence from other fleets provides meaningful guidance on the potential that lies in some crosscutting opportunities. This section discusses three such opportunities that the team's assessment suggests could create both financial and environmental efficiencies for the

white fleet: telematics solutions, virtual carsharing and motor pools, and options for leasing AFVs in order to expedite or facilitate their deployment.

Telematics

Building the case for any large deployment of telematics devices can be challenging, as many of the potential benefits their application provides are difficult to measure. However, the State's environmental and economic fleet management goals along with fleet coordinators' stated barriers to greater AFV and efficiency technology adoption suggest that substantial gains could be made from a targeted and well-managed telematics solution.

In the immediate context of this report, telematics solutions that allow fleet coordinators and SFM to better understand trip routing and idling can directly inform the identification, accurate assessment and ongoing evaluation of appropriate AFV and idle reduction opportunities. In the longer term, these same solutions can provide operating efficiencies via improved driving habits (less aggressive driving saves on fuel and maintenance), better management of preventative vehicle maintenance, enhanced law enforcement safety and response coordination, and the automation of timely vehicle trip logging and monthly utilization reporting.

Case studies and experiential evidence from other public fleets are reasonably indicative of the types of costs and savings that Colorado's state agencies can expect for a targeted and well-managed telematics solution. As noted in Section 1, California's Department of Transportation (Caltrans) is in the process of implementing a fleet-wide telematics program that it expects to provide substantial savings from petroleum reductions and productivity gains. Under a similar program, the City of Sacramento achieved near-term fuel savings of 10% (Ortiz 2014). For comparison, the white fleet accrued more than $13M in fuel from December 2013 through November 2014, suggesting a potential fuel savings of $1.3M to $2.0M annually.[17] In addition, a targeted telematics deployment in the white fleet could create the opportunity for additional savings by enhancing preventative maintenance and providing more accurate baseline information for potential AFV and idle reduction opportunities.

Fleet coordinator interviews indicated that the desire and willingness to implement a telematics solution exists, but that limited operating budgets have prevented more serious consideration. The recent CDOT telematics pilot deployment (which is using the same platform as the Caltrans project) could provide an opportunity for SFM to consider expanding the program to other agencies' white fleet vehicles.[18] A larger deployment across multiple agencies could help decrease the per-unit costs of a deployment via a centralized bidding process. Notably, the CDOT approach also shifts the cost burden off individual divisions' operating budgets, instead putting the onus of proving a return on investment on CDOT's central fleet management team.

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[17] Based on Vision Fleet review of SFM's monthly WEX invoice data.

[18] As of this report's writing, CDOT was in the early stages of deploying a telematics solution (Verizon's Networkfleet) across the entirety of its white fleet vehicles. To date, CDOT had installed devices in 100 white fleet vehicles, where it planned to evaluate their benefits before expanding to additional vehicles. The goals of the deployment are to support overall fleet operations, improve winter storm management, and collect baseline information to inform petroleum reduction opportunities.

Carsharing and Motor Pool Management Solutions

Approximately 20% of SFM vehicles are assigned to agency motor pools for either local agency use or regional travel. According to interviewed fleet coordinators, some agencies are already sharing their assigned motor pool vehicles with other co-located agencies, as those borrowing agencies' periodic vehicle needs may not justify a full-time vehicle allocation (particularly in the context of limited budgets). Given the prevalence of such cross-agency carsharing among motor pool vehicles, there may be opportunities to reduce the costs and administrative burden of operating and maintaining a motor pool by partnering with a private carsharing or motor pool management provider.

In many cases, these service providers offer a motor pool management solution that uses a fleet's existing vehicles. An integrated hardware and software solution provides online vehicle scheduling, automated vehicle and key access, and enhanced reporting capabilities, often enabled by some type of telematics device (Government Fleet 2012, 2013). As a result, vehicle coordinators are freed from manually tracking pool vehicle usage and costs from other agencies, drivers have improved access to a range of use-appropriate vehicles, and telematics reporting can improve tracking of scheduled preventative maintenance or diagnostic trouble codes from the vehicles' on-board computers.

AFV Leasing and Shared Savings Deployments

As discussed in Section 1, third-party solutions can also help facilitate or expedite the deployment of AFVs within a fleet through various leasing arrangements. In these cases, an agency or fleet outsources the ownership and management of a set of vehicles, avoiding the large periodic capital costs and maintenance requirements of those vehicles. Instead, the agency pays some combination of a fixed and variable rate that bundles those costs together, much like SFM's arrangement with individual agencies. A current example of this approach is being employed by the City of Indianapolis's "Freedom Fleet" EV program. Under this program, the city leases EVs and PHEVs on a cost-per-mile basis through a contract with guaranteed and shared savings features. The city estimates that it will save $8.7 million over a ten-year period by deploying a combination of 425 EVs and PHEVs in place of more than 500 older conventional sedans (Grass 2014).[19]

The advantages of third-party leasing lie in the broader selection of vehicles, the decreased administrative burden of managing those vehicles, and the various value-added services provided by the third party (including the carsharing or motor pool management solutions discussed above). In the case of AFVs, the leasing company also can often leverage available tax credits to pass lower costs on to the fleet through lower lease rates. From an implementation perspective, leasing electric or natural gas vehicles shifts the risks associated with proper deployment planning, charging infrastructure and each vehicle's future residual value away from the fleet an onto the third party.

Notably, the State's ability to take advantage of such leasing approaches may require a more detailed review and potential updates to State procurement rules. In 2013, Colorado amended its energy performance contract (EPC) laws to allow energy savings contracting (wherein resulting

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[19] Vision Fleet, which authored this study, is the prime contractor for the City of Indianapolis EV program.

energy savings help pay for the improvements) to be used for vehicle fleet efficiency improvements. Current procurement rules, however, generally limit State agencies' ability to lease vehicles to situations where those vehicles cannot be procured off the State bid or where substantial cost savings can be justified. Notably, no pure EVs were included in the 2015 State bid award.

Section 5: Orange Fleet Key Findings

This section presents findings from the team's data collection and analysis surrounding the prioritization and comparative analysis for orange fleet opportunities. Like Section 4, it begins with a summary of trends and feedback from fleet management staff interviews. It then discusses what the Vision Fleet team considered to be the primary technology and crosscutting opportunities through which the CDOT orange fleet could achieve significant, near-term improvements in its financial and environmental costs. Notably, the relative homogeneity and standardization of equipment across the orange fleet, along with more limited AFV opportunities, meant that there was a more limited field of technically feasible opportunities to assess.

Key Fleet Coordinator Input

For the orange fleet, the Vision Fleet team spoke with equipment managers and maintenance shop supervisors from seven locations across the state to ensure a variety of opinions, best practices and lessons learned. The discussions allowed the team to gain input on various opportunities from those responsible for overseeing fleet operations on a daily basis. This section is organized around findings developed from that input for each of three primary equipment segments – snow plows, non-plow work trucks, and construction equipment – as well as overarching comments regarding barriers to enhancing fleet efficiency efforts. This qualitative input provides important context for the quantitative results and findings discussed later in this section.

Snow plows

As discussed in Section 3, CDOT's heavy-duty snow plows account for nearly half of the orange fleet's annual fuel consumption, or about 22% of fuel consumption across the entire State fleet (including white fleet usage).[20] As such, they are frequently considered as a potential opportunity for efficiency improvements. A key consideration in any such efforts, however, is the mission-critical nature of a plow's winter storm response function. Public safety is the agency's primary concern during such events, and staff emphasized that any efforts to improve efficiency or reduce fuel consumption from plows must not hinder operators' storm response capabilities. As a result, fleet managers were more likely to prefer exploring potential idle reduction opportunities to less proven NGV engine options.

CNG Potential

With advances in natural gas engine technology, there are now heavy-duty (up to 12 L), dedicated natural gas engines available for work truck applications. However, their use thus far in snow removal applications has been limited, and as of this report's writing, there were no published case studies regarding their use in snow plows. Both the Fort Collins and Grand Junction municipal fleets have recently acquired a dedicated-CNG dump truck (albeit with the smaller 8.9 L engine) that they plan to operate as a plow in the winter 2014-2015 season in an effort to assess their usefulness (or limitations) in this application.

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[20] This includes usage in both winter and non-winter months, when plows may support road maintenance activities (e.g., hauling asphalt for road repairs).

In addition to concerns about the availability of adequate fast-fill fueling infrastructure, orange fleet equipment staff expressed uncertainty about how the relatively new heavy-duty dedicated CNG engines would perform under a combination of cold temperatures, higher elevations and with the added weight of pushing snow off the road. Assuming that CDOT could take advantage of existing publicly available CNG fueling stations in the near term, the agency could avoid the significant incremental costs (typically $1M to $2M) of developing its own station. However, any region where such equipment would be stationed would need to up-fit any associated storage or maintenance facility where those plows would be stored or where maintenance might be performed, a cost that might range from $50,000 to $200,000, depending on the size and type of facility.

Despite these potential barriers and concerns, several CDOT shop supervisors expressed an interest and willingness to participate in a pilot deployment of a CNG-powered snow plow in their region. They cautioned, however, that their own operating budgets might not support the incremental costs for the pilot vehicle and any associated shop modifications.

Idle Reduction and Telematics

Most equipment staff agreed that a considerable opportunity exists for reducing unnecessary idling among their snow plow fleets, particularly during storm events. Despite general agreement that an opportunity exists, there was little consistency regarding the best approach or technologies for achieving such reductions. Overall, focused employee education coupled with anti-idling engine shutdown switches garnered the most support. Some drivers, however, have previously expressed complaints or concerns about potential safety issues or productivity losses associated with auto-shutoff switches (i.e., if a truck will not restart after the switch is triggered).

More equipment-dependent options, including auxiliary power units or engine pre-heaters were met with greater skepticism from equipment managers. For APUs, there were concerns about whether CDOT's plows had enough room to accommodate the additional equipment. Two respondents familiar with engine pre-heaters noted that they had been unreliable in the past or that most snowplows are already stored indoors in light of safety and vehicle readiness considerations.

Several equipment managers noted CDOT's recent commitment to incorporating telematics across the orange fleet, with a goal of outfitting most of the fleet by 2019. In the near-term, the data gained from this effort, particularly around current idling practices, will help to more accurately assess the potential for additional idle reduction efforts.

Non-plow Medium-Duty and Heavy-Duty Trucks

The study team asked fleet staff about similar types of opportunities for the remainder of CDOT's orange fleet work trucks, which range from Class 3 up to Class 8, depending on application. In addition to dedicated CNG options, the team also sought feedback on potential bi-fuel options for those on the lower end of the class scale. In general, respondents expressed similar concerns as they did for snowplows, but showed greater interest and flexibility when it came to potentially implementing some AFV and idle reduction opportunities.

Diesel Engine Troubles

One important issue that was mentioned by staff in several regions is the recent increase in maintenance costs associated with newer diesel engines. Shop maintenance supervisors reported that the enhanced emissions controls on many of the newer diesel engines (particularly those in the 6-L to 7-L range) are contributing to substantial engine problems or replacements, and other unplanned maintenance. Respondents tied these engine failures primarily to the engine's diesel particulate filters (DPFs) getting plugged with soot, which is exacerbated by prolonged or excessive engine idling. The DPFs periodically have to be regenerated (i.e., cleaned), which is accomplished by the engine injecting fuel into the filter to burn out the accumulated soot. The vehicle's computer does this by over-fueling two of the engine cylinders, which is suspected to be contributing to the failures. The more recent introduction of selective catalyst reduction (SCR) in heavy-duty diesel engines has reportedly helped, but not eliminated, the issue.

Some respondents also noted that the need to regenerate the DPFs also leads to lower overall fuel economy due to the extra fuel that is burned in the process. Staff representing at least two shops noted that they had begun transitioning most of their 1-ton trucks from diesel to gasoline in order to avoid the issue. Consequently, a few respondents noted that these added costs and uncertainty around emissions filters' impacts on diesel engines made them less likely to be willing to implement any emission control retrofits on older vehicles in the near-term. To the degree, however, that either CNG replacements or idle reduction technologies reduce the need for diesel emissions controls or the frequency of filter regeneration cycles, those benefits could be factored into any return on investment for those opportunities.

CNG Potential

Orange fleet staff was generally more open to potential NGV opportunities for equipment that is less essential to snow removal and storm response operations. Respondents suggested foreman trucks, maintenance and traffic staff pickup trucks, and variable message sign (VMS) trucks are specific opportunities where a CNG engine might make sense. Equipment managers generally felt that dedicated CNG options were more suitable, as bi-fuel CNG vehicles may encounter space constraints due to the need for a second fuel tank.

As with the white fleet, any such deployments would need to account for the ready availability of fueling infrastructure where those vehicles operate. Similarly, to the degree that those vehicles would be stored indoors or maintained directly by CDOT staff (rather than a third party), the associated maintenance shop would need to up-fit its facilities to comply with fire code and safety requirements.

Idle Reduction and Telematics

Staff from each shop offered several potential suggestions for applications where unnecessary idling was likely to occur. In particular, maintenance and traffic control trucks tend to have signal or safety lights that many drivers will use by leaving the engine running to avoid draining the truck's battery. Specific applications mentioned for consideration include the following: foreman and supervisor trucks, 1- to 2-ton dump trucks, utility trucks and maintenance trucks. Several respondents also discussed successful past efforts to outfit VMS and attenuator trucks with solar PV or small gas generators to power their signage for extended periods in lieu of leaving the engine running. In general, equipment staff was supportive of these auxiliary power

system solutions, and they provided anecdotal evidence of the associated fuel savings. In many cases, these systems can offset an entire eight-hour shift's worth of vehicle engine idling.

As with the snow plows, telematics solutions commonly were cited as a strong opportunity to enhance fleet operations and reduce costs. Maintenance benefits (e.g., remote notification of engine trouble codes) are seen as one of most important impacts, as was the ability to establish baselines for excess idling. Again, respondents noted CDOT's current telematics implementation as a promising effort to demonstrate the potential benefits.

Construction Equipment

For construction equipment, conversations focused primarily on loaders and motor graders, which comprise the majority of fuel consumption within the category. A large share of this fuel consumption is related to winter storm activities, during which both loaders and graders may be involved in snow removal activities, while loaders are also used to load road sand into snow plows. In the case of storm materials management, staff noted that equipment is likely to spend a large portion of time idling in between snow plows arriving for additional sand. Respondents noted that idle reduction technologies could present significant opportunities, but again noted the importance that they not impact the capability or availability of that mission-critical equipment during a storm.

Staff was more likely to prefer idle reduction technologies to retrofitting older equipment with emissions controls. Part of this hesitation appeared to be tied to the above-mentioned engine failure issues for which staff blamed newer emissions control requirements. In addition, the perceived prevalence of heavy idling would be more likely to clog any diesel emissions filters more quickly. The preferred approach to improved emissions focused on replacing older equipment rather than retrofitting it, as newer equipment would comply with current standards. In addition, several respondents noted that most new loaders and graders came with OEM-installed telematics devices and up to three free years of data access; however, few had been trained on or made much effort to use that data.

Barriers

As with the white fleet, orange fleet representatives noted similar barriers to more actively pursuing efforts to reduce fuel consumption or deploy alternative technologies. Most notably, orange fleet supervisors were most likely to note budget and risk issues. Each CDOT section is responsible for its own operating expenses, and investments in efficiency improvements and retrofits compete directly with budgets for paving roads or buying road sand for storm responses. In addition, staff from some sections reported having tried innovative things in the past only later to be reprimanded by headquarters staff when things did not work out. This has caused some hesitancy among sections to pursue new initiatives.

Respondents from at least three sections noted that the greatest resistance to efficiency efforts tends to be from drivers and equipment operators. They expressed that education is critical to demonstrating benefits and gaining staff buy-in. One respondent cited the importance of top-down directives and support (such as with the recent telematics commitment) as helpful to gaining participation and encouraging the extra effort to pursue potential improvements (even with uncertain outcomes).

Primary Technology Opportunities

Based on the input described above, the Vision Fleet team slightly narrowed the scope of the technology-related opportunities included in its quantitative analysis and comparative assessment for the orange fleet. The resulting qualified opportunity matrix for the white fleet is shown in Table 12. Using this revised opportunity matrix as a guide, the team conducted its quantitative TCO and ECO analysis on the qualified opportunities. Appendix B includes the full summary output tables from this analysis.

Table 12. CDOT Orange Fleet Post-Interview, Qualified Opportunity Matrix

Equipment Category	# of Assets	% of FY14 Fuel (Orange Fleet)	Efficient ICE	CNG Mono	CNG Bi-fuel	Propane	Hybrid Electric	B20	E85	ALM/APS	Emission Filters
			Efficient ICE or AFV							Efficiency	
MD/HD Truck (Snow Plow)	734	49%		●						●	
MD/HD Truck	439	21%		●						●	
LD/MD Truck	438	19%		●	●		●			●	
Construction Equipment	444	8%								●	●

Source: Vision Fleet analysis

The remainder of this Primary Technology Opportunities section focuses on the opportunities that the team identified from its comparative analysis for further consideration by CEO and CDOT fleet management staff. Each of the following subsections discusses the best opportunities for each major equipment segment.

As with the white fleet results, some equipment may be listed under multiple opportunities or AFV platforms; thus the estimated totals should not be considered additive. Similarly, readers should recall that the results are indicative of the relative costs and benefits of a particular technology, given a combination of vehicle-specific and general category assumptions. Any decision to transition a specific vehicle or set of vehicles to an AFV or efficiency option should consider the particular usage and characteristics of that vehicle.

Table 13 summarizes the high-potential opportunities that arose from the orange fleet assessment. A discussion of results for each major equipment category follows.

Table 13. High-priority Opportunities from the Orange Fleet Assessment

Vehicle Segment	Opp	# Meeting Minimum TCO Criteria:	Average Annual Petro Savings per Vehicle (gal/yr)	Average Change in TCO for those Meeting Criteria:	Average Annual GHG Reduction per Vehicle (t/yr)	Notes
MD/HD Truck (Snow Plow)	CNG - Mono (High CapEx)	76	6,476	-2%	57.0	High potential savings, but significant hurdles to implementation.
LD/MD Truck	CNG - Mono (High CapEx)	22	4,872	-8%	50.1	May require some early replacements or redeploying current vehicles to accomodate need to locate near currently available fueling.
MD/HD Truck	CNG - Mono (High CapEx)	71	2,910	-4%	18.7	May require some early replacements or redeploying current vehicles to accomodate need to locate near currently available fueling.
MD/HD Truck (Snow Plow)	ALM	696	201	-2%	2.9	Telematics can establish baseline to more accurately assess potential savings.
MD/HD Truck	Hybrid (Low Savings)	116	179	0%	2.6	Telematics can inform most meaningful opportunities.
Loaders	ALM	198	90	0%	1.3	Telematics can establish baseline to more accurately assess potential savings.

Source: Vision Fleet analysis

Snow Plows

Despite the large potential per-vehicle petroleum reduction (nearly 6,000 gallons per year) and apparent lifetime savings (even under high incremental cost scenarios) that could accrue from converting some snow plows to a CNG platform, this is not likely CDOT's best near-term opportunity to deploy natural gas vehicles. Staff said that the uncertain and untested performance of CNG engines in CDOT's demanding and highly variable (i.e., rotating vehicles to areas far from existing CNG stations and operating at varied elevations) snow plow application, combined with snow plows' mission-critical requirements, makes them inappropriate for near-term conversion to CNG.

The long-term potential for both per-vehicle and aggregate petroleum reductions is substantial, and the team's modeling indicated that the transition will, on average, save money over the lifetime of each converted snow plow. The team recommends that CDOT pursue opportunities to reduce the uncertainty around future deployments of CNG plows, potentially including its own pilot test. Based on this team's conservative assumptions about idling time and the cost of idle reduction technologies, the potential per-vehicle fuel and cost savings are substantial. However, rather than immediately pursuing new idle reduction equipment, CDOT should use its current telematics deployment to better assess current vehicle idling and more accurately determine the fit and potential savings on a vehicle-specific basis.

Non-Plow Trucks

Based on the orange fleet staff interviews, there is greater willingness to adopt CNG for non-plow trucks. As shown by Table 13 results, the team's analysis identified more than 90 trucks

that were good candidates for a dedicated CNG replacement based on the minimum TCO criteria. On average, each replacement would offset an estimated 2,800 to 4,600 gallons of diesel fuel each year based on average lifetime usage and reduce the truck's per-mile costs by 4-8%. These cost savings do not account for any additional decreases in maintenance costs that may arise from shifting away from recently problematic diesel engines.

Notably, some of the current trucks that met the TCO criteria are currently located too far from currently available CNG fueling stations. However, CDOT could redeploy existing equipment from another section in order to deploy CNG trucks within suitable range to fueling stations. Depending on the expected costs for up-fitting maintenance facilities to comply with CNG-related safety and fire codes, CDOT could reasonably select one or two sections for an initial demonstration deployment of CNG-powered trucks.

In addition to CNG replacements, the team's modeling also showed reasonably attractive petroleum savings from replacing certain medium-duty work trucks with hybrid electric drive trucks. This included aerial, attenuator, digger derrick, dump trucks, mechanic and crane trucks, and hook lift trucks. The results, which assumed a conservative 10% fuel savings, showed a net lifetime cost savings for about one-third of the vehicles that passed the minimum TCO criteria. That percentage increased to about one half of the vehicles that would save money under more aggressive (20%) fuel savings assumptions.[21] Transitioning to a hybrid electric platform also avoids barriers associated with fueling infrastructure availability. Again, beginning with a limited demonstration-scale deployment could help CDOT to assess the capabilities of these vehicles for its needs.

Construction Equipment

For construction equipment, the team used staff's example of loaders as the primary focus for assessing idle reduction opportunities. Based on the team's assumptions about current idling practices and the costs of reliable idle reduction technologies (e.g., ALM), adding idle reduction controls to this equipment is likely to provide substantial petroleum and cost savings. Given the large number of loaders across the fleet, this could add up to substantial aggregate savings if widely deployed. Again, CDOT's current telematics deployment can provide vehicle-specific idling information that will allow the agency to more accurately assess the potential savings for this equipment segment before making any significant commitments.

Primary Crosscutting Opportunities

The preceding technology opportunities are indicative of the magnitude of cost savings and fuel reduction achievable across specific AFV and idle reduction options. As with the white fleet findings, there are other crosscutting opportunities worth discussing where potential costs and benefits are difficult to assess. At the time of this reports' writing, CDOT was in the early stage of deploying a fleet-wide telematics program. With proper management and data analysis, a program at that scale is likely to open the door to accurately assessing and implementing additional fleet efficiency opportunities, including AFV and idle reduction solutions. Given CDOT's current focus on such a large and high-potential program, this section highlights only

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[21] These fuel savings assumptions were based on published case studies that cited fuel reductions ranging from 30-60% (Tomic 2010).

one additional crosscutting opportunity: retrofitting maintenance facilities to accommodate NGVs.

Retrofitting Maintenance Facilities for NGVs

The costs for up-fitting vehicle maintenance and (to a lesser degree) storage facilities is significant and can present a substantial barrier to the adoption of NGV vehicles. This is particularly the case for smaller vehicle deployments where the effective per-vehicle share of that incremental cost is greater. The magnitude of those costs depends greatly on the characteristics of an individual facility and the types of repairs the facility is expected to handle. For storage facilities and those where staff may conduct minor repairs (those not involving the fuel system), code requirements are fairly limited and may be as little as $5,000 to $10,000 per vehicle bay (America's Natural Gas Alliance 2012). For major repair facilities, wherein work will be performed on the fuel system and may require open flames or welding, the requirements are more extensive and may cost from $40,000 to $75,000 per vehicle bay, though costs exceeding $125,000 per bay are possible (Thomason 2014, ET Environmental 2013).

As an alternative to undertaking these upgrades, at least during initial demonstration efforts, CDOT could consider outsourcing the major maintenance of any heavy-duty CNG equipment (Havrilla 2013). Cummins, a major OEM for heavy-duty CNG engines, has service facilities in Denver and Grand Junction. In the meantime, CEO and CDOT could take action to better understand the potential options and costs for up-fitting specific facilities by contracting with a professional engineering firm to assess one-to-three target facilities.

Section 6: Recommendations

This section outlines a set of recommendations for the State to enhance the economic and environmental efficiency of its fleet composition and operations. These recommendations build upon both the quantitative analysis and qualitative factors described throughout this report, and offer a mix of both near-term and longer-term strategies.

Recommendation 1: Pursue focused deployment of a broader set of AFV technologies across the white fleet, including CNG, PHEV and BEVs.

The team's white fleet assessment revealed substantial opportunities for petroleum and cost savings across several AFV platforms. Fleet coordinator interviews also demonstrated a willingness from within several agencies to find ways to effectively deploy those vehicles into appropriate use cases. Vision Fleet recommends CEO and SFM to consider the following strategies to enhance and facilitate an increased level of AFV deployments.

Flexibility in Identifying AFV Opportunities

Use this assessment as a starting point for further agency and vehicle-specific analysis on appropriate opportunities and use cases for AFV deployments. In addition, consider using temporary deployments of telematics devices across a particular agency or subset of vehicles to identify range requirements and driving patterns that could help justify deployment of an EV, PHEV, or NGV (either bi-fuel or dedicated). After collecting adequate data on a subset of vehicles, redeploy those telematics devices into another group of AFV candidate vehicles, thereby reducing the effective up-front cost associated with those devices.

As a part of this study, the Vision Fleet team deployed a limited number of telematics devices into two Department of Corrections' motor pools, with a goal of demonstrating the role of telematics in assessing AFV options. The team's approach and findings from this pilot project appear in Appendix A. The study's limited duration meant that pilot data was only collected over a short time period. Nonetheless, the team was able to show how that information can be used to help justify adoption of AFVs and mitigate potential concerns about AFV range.

In lieu of telematics, SFM should consider developing a replicable approach for using monthly fueling data to assess geographic patterns for specific vehicles. This information can be used as a rough proxy for the more precise routing data that telematics can provide. Through the DOC telematics pilot, the team attempted to use SFM's historical monthly fueling data to compare the AFV assessment conclusions that could be reached from each approach. However, data quality concerns and the relatively limited sample size of vehicles made it difficult to reach strong conclusions about the reliability of the team's proxy approach.

Finally, SFM should be willing to replace AFV candidate vehicles early, regardless of their age or mileage. Given AFV's range characteristics and required access to adequate fueling infrastructure, each vehicle's use plays a large role in determining its appropriateness for conversion to an alternative fuel. Limiting the universe of AFV candidates to only those vehicles that are otherwise slated for replacement hinders the State's ability to achieve economies of scale and demonstrate the benefits of AFVs in their most appropriate uses.

Notably, the State's current procurement rules may present some barriers to this approach. As such, the State should develop policies and procedures to facilitate the redeployment of current vehicles elsewhere in the fleet (both within and across agencies) in order to prioritize the deployment of AFVs into appropriate use cases. This could include giving preferential replacement status to vehicles that agencies are willing to convert to an AFV.

Targeted AFV Deployments

Several agency or division fleet coordinators expressed a willingness to pursue demonstration deployments of AFVs, but felt they would need initial support from SFM to manage the project effectively. CEO and fleet management should consider refocusing their attention for AFVs on creating replicable, agency- or division-specific examples of more widespread deployments of different AFV technologies (as opposed to smaller piecemeal deployments across every agency).

Using this report's analysis as a starting point, the State can prioritize or expedite opportunities where vehicle usage patterns or access to fueling infrastructure would best support the shift to AFVs. During implementation of those AFV deployments, SFM and CEO should provide focused support to the agencies and drivers involved to help ensure their success. By working with these agencies, the State can help to prove the AFV concept and develop best practices and lessons learned that will facilitate future deployments to other agencies and locations, particularly as technology and access to fueling stations continue to improve.

AFV-specific Education, Training, and Incentives

Any deployment of new technologies will require focused education and training to help ensure that vehicle operators and coordinators can achieve the efficiency improvements those vehicles afford. Vehicle coordinators and drivers need clear and consistent training around key issues (e.g., cold weather, charging/fueling, range) to avoid pushback or drivers choosing non-AFV vehicles.

There was little evidence from fleet coordinator interviews that the State undertakes any ongoing or consistent driver training or incentive programs. The State could engage in simple driver education and training programs to help meet its AFV adoption goals. In particular, messaging could focus on improving understanding of AFV options and policies, dispelling myths about AFV limitations, and encourage open feedback about persistent barriers to agencies adopting AFVs. Many fleets engage in web-based driver training, which is likely a relatively low-cost option that Colorado could explore.

The team further recommends that any driver training program be paired with some type of reward or recognition program. The effects of driver education and training can quickly subside unless good habits are reinforced consistently and continuously over time (Environmental Defense Fund 2014). Several examples exist from public fleets that have successfully implemented these types of programs. Polk County, Florida, for example, instituted a shared-savings incentive program whereby drivers received a 50% share of any monetary savings tied to their fuel economy over a one-year period (Stanton 2011).

SFM could consider similar driver incentive programs geared toward increasing appropriate use of AFVs and other efficient driving behaviors. However, the level and types of incentives that

can be offered may be subject to State employment rules. Most public fleets will have an ethics policy in place that will limit the amount of "gifts" or bonuses an employee can receive in one gift, and also will limit the total amount they can receive per year. Any such incentive programs would need to be designed in consultation with the State's Department of Personnel and Administration to ensure that these policies are followed.

Alternative Options to AFV Deployment and Management

Admittedly, both SFM and agency fleet coordinators have limited time and resources for undertaking additional projects like the demonstrations described above. SFM should consider options for leveraging the third-party leasing or carsharing services discussed in Section 4. These approaches, and the access to vendor's enhanced analytic capabilities, can help to expedite the transition to AFVs and provide the operational support required to ensure their success. Such efforts could similarly target specific agencies or vehicle uses (e.g., motor pools).

Recommendation 2: Where there isn't a clear TCO case for AFVs, consider hybrids for vehicle replacements.

The team's quantitative analysis revealed that in many cases a hybrid electric vehicle will provide substantial petroleum and operational cost savings across its fleet lifetime. This is particularly the case for sedans; however, in some cases a hybrid SUV can provide a cost-effective replacement for conventional SUVs, minivans, or small pickup trucks.

In addition, future State bids should specify offers for hybrid-electric options (or hydraulic hybrids, where applicable) on all vehicle classes where such options exist. 2015 model year options for affordable hybrid-electric SUVs are limited. However, reasonably affordable options exist for hybrid-electric crossovers, as well as retrofits for light- and medium-duty cargo and passenger vans.

Recommendation 3: Build upon CDOT's experience with its recent pilot telematics deployment to consider similar opportunities in other agencies.

The CDOT fleet management team is taking an organized and deliberate approach to evaluating the costs and benefits of telematics in both its orange and white fleet vehicles. This assessment, along with the best practices and lessons developed by the CDOT team, can provide a jumpstart to similar efforts elsewhere in the white fleet. This is particularly the case for other agencies with similar types of vehicles and use cases (e.g., DNR's pickup trucks). Pending initial results from CDOT's white fleet pilot, SFM and target agencies should investigate opportunities to leverage CDOT's experience and contract for additional deployments.

If budget or policy barriers make a long-term commitment to such a telematics program unlikely, the State should consider temporary telematics projects to enhance its understanding of other efficiency opportunities. SFM and agencies could partner to conduct a more thorough assessment of idling baselines across high-potential vehicle segments. This data could be used to better identify and evaluate potential idle reduction technology opportunities. Analysis and interviews with the State's largest fleet customers (i.e., DNR, CDOT, and CDPS) suggest that substantial opportunity exists for cost-effective deployments of these solutions.

Recommendation 4: Break down the first-cost and technology risk barriers preventing adoption of AFV, idle reduction, and other efficiency technologies.

Several fleet managers discussed two critical barriers to pursuing more AFV and efficiency improvement opportunities – higher upfront cost and technology risk. The State should take formal steps to reducing these obstacles.

Formalize TCO and Whole-cost Accounting

The State should develop a standard procedure and set of formulas for modeling potential AFV and other fuel reduction efforts that better link acquisition (i.e., Joint Budget Committee [JBC]) and operations (i.e., agency) budgets. This approach should account for externalities such as employee productivity gains or losses associated with various AFV and fuel reduction options. For example, telematics would likely lessen the administrative burden of manually gathering and reporting usage and fueling data, a cost not generally included in TCO calculations. In addition to providing a framework to justify such investments, this approach also could be used to monitor and evaluate the actual savings achieved by these efforts on an ongoing basis.

Look Beyond Vehicles for the Annual Bid

The State should consider including standard idle reduction technologies (e.g., auxiliary load management devices) in the State bid and budgeting process. In addition to added choice and flexibility, this would allow agencies to factor that incremental cost into their vehicle replacement budgets. Similarly, the State could allow one or more standard telematics solution to be included in the central procurement process. A portion of the upfront costs for the telematics offering could be allocated to each agency's vehicle replacement budget to lessen the burden of those costs on its operating budget. For example, the JBC could provide a limited set- aside budget for agencies that wish to take advantage of the available telematics solutions. While that budget could cover all or a portion of the telematics upfront costs, the agency would be responsible for covering the ongoing costs from its own operating budget. Such an arrangement would place the responsibility to use the telematics solution in a cost-effective manner squarely on the agency itself.

Research and Demonstration Funding

Many agency fleet coordinators stated a desire to implement innovative fuel-saving approaches, but most are averse to taking substantial risks against their limited operating budgets. The State should consider setting aside an annual fund for agency-led demonstrations of larger AFV deployments and other petroleum reduction approaches that can help reduce operating budgets. The fund should prioritize scalable projects that can provide case studies and institutional knowledge to other agencies with similar types of vehicle and use cases. Depending on its size, such a fund may require legislative action or outside funding (e.g., federal grants). There also may be opportunities to creatively structure a fund so that a portion of the savings achieved by agencies that use the fund replenishes the fund for future projects (i.e., a revolving loan fund).

Data and Information

Proactive agency fleet coordinators desire improved or more timely access to fleet data in order to inform their operations and offer the consideration of AFV and efficiency opportunities. SFM should consider offering agency staff enhanced access to its CARS data, including the ability to generate custom reports, as well as periodic training and forums for those coordinators to learn

best practices for using that data to improve fleet efficiency. For vehicle fueling reports, SFM also should consider ways to expedite the delivery of data on bi-fuel vehicles' alternative fuel consumption to agency vehicle coordinators. This might include providing raw (i.e., un-cleaned) data to vehicle coordinators as soon as it's available (e.g., weekly), and then following up with corrected data on a monthly basis.

Recommendation 5: Improve collaboration and participation in the State Bid Process

In general, agency fleet coordinators expressed a desire for more vehicle options on the State bid, as well as more consistent availability of options from one year to the next. SFM should enhance its approach to collecting and considering qualitative input from agency fleet coordinators (and the State's participating municipalities) into the bid specification process. This input should include not only what types of vehicles agency staff would like to procure, but also where they feel that past vehicles have fallen short of their needs. This could be as simple as a periodic (e.g., quarterly) online survey to agency fleet coordinators. To enhance collaboration, however, SFM could also set up an online fleet coordinators' forum where agency staff could exchange ideas, best practices, and requests related to vehicle needs and fleet management practices.

For vehicles of particular interest or that historically have attracted few or no bids, the State should enhance its outreach to dealerships to encourage participation and clarify the level of demand expected from State agencies and municipalities.

Recommendation 6: Begin a pilot or demonstration-scale effort to test medium- and heavy-duty CNG truck capabilities in the CDOT orange fleet

Based on the team's orange fleet findings, substantial petroleum and cost-savings opportunities exist for medium- and heavy-duty vehicles operating on CNG, potentially including one or more CNG snow plows. Again, using this analysis as a starting point, CDOT and CEO should collaborate to identify specific sets of vehicles located in proximity to existing (or expected soon) fueling infrastructure that provide suitable use cases for CNG replacements.

For the identified locations, the State should conduct a professional assessment of the facility-specific requirements and costs to store or maintain those vehicles (or, alternately, to outsource maintenance). As a part of this demonstration effort process, the State should reach out to CNG engine OEMs, fuel station owners, and CNG service providers regarding interest in a public-private partnership that would facilitate and lower the costs of such a demonstration.

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