BUSINESS

STRATEGIC PLANNING TO ENABLE ESCOS TO ACCELERATE NGV FLEET DEPLOYMENT: A GUIDE FOR BUSINESSES AND POLICYMAKERS

C2ES CENTER FOR CLIMATE AND ENERGY SOLUTIONS

NASEO National Association of State Energy Officials

Clean Cities U. S. Department of Energy

STRATEGIC PLANNING TO ENABLE ESCOS TO ACCELERATE NGV FLEET DEPLOYMENT: A GUIDE FOR BUSINESSES AND POLICYMAKERS

by

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NOTICE

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UNLOCKING PRIVATE SECTOR FINANCING FOR ALTERNATIVE FUEL VEHICLES AND FUELING INFRASTRUCTURE

NASEO and C2ES, with funding from the U.S. Department of Energy's Clean Cities Program, began a two-year project in 2013 to develop innovative finance mechanisms aimed at accelerating the deployment of alternative fuel vehicles (AFVs) and fueling infrastructure. C2ES has assembled an advisory group of experts on AFVs, infrastructure, and finance from the public and private sectors to help guide its work. The project aims to:

- Identify barriers that hinder private sector investment;
- Develop and evaluate innovative financing concepts for vehicle purchase and fueling infrastructure in order to make AFVs more accessible to consumers and fleet operators; and
- Stimulate private-sector investment in AFVs and the associated infrastructure deployment, building upon and complementing investments previously made by the public sector.

C2ES researched financial barriers, prepared case studies, and developed strategies to deploy innovative financing concepts that states can consider piloting:

Alternative Fuel Vehicle & Fueling Infrastructure Deployment Barriers

Barriers to deployment of electric, natural gas, and hydrogen fuel cell vehicles and fueling infrastructure

Potential role of private sector financial solutions

Case Studies on Natural Gas Vehicle Fleets and Electric Vehicle Charging

Applying the energy service company model to advance deployment of fleet natural gas vehicles and fueling infrastructure

The role of clean energy banks in increasing private investment in electric vehicle charging infrastructure

Strategic Planning Guides

Electric vehicle charging and natural gas vehicle fleets

Key factors that affect financial performance

Business model application to a particular market

Implementation guidance for policymakers and businesses

The project specifically emphasizes two fuels that offer significant opportunities for growth—electricity and natural gas. Biofuels are not considered because the deployment of biofuel-powered vehicles is already being facilitated by many government and private sector stakeholders. Vehicles powered by hydrogen are included, but they are not a major focus because hydrogen fuel cell vehicles are not yet widely available.

This project is a part of C2ES's AFV Finance Initiative. More information is available at www.c2es.org/initiatives/alternative-fuel-vehicle-finance.

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EXECUTIVE SUMMARY

Increasing the use of natural gas vehicles (NGVs) could significantly reduce gasoline and diesel use in the transportation sector. The displacement of petroleum by natural gas can improve local air quality, reduce greenhouse gas emissions, and enhance domestic energy security.

Public and private fleets are among the most promising stakeholders to advance NGV deployment because they may be able to more readily overcome the barriers to NGV deployment than individual vehicle owners. Although fleet managers have explored the potential of natural gas in the past decade, high upfront vehicle costs and the lack of available fueling infrastructure have prevented the widespread adoption of NGVs. Many of these challenges can be overcome through the development and implementation of innovative financial agreements and with expert project facilitation by knowledgeable third parties.

This guide addresses questions that private investors and state and local agencies may have about key considerations and strategies for deploying NGVs in public and private fleets. The guide analyzes a range of scenarios for tractor-trailer truck, school bus, and light-duty vehicle fleets. Each scenario estimates the potential for NGVs to achieve net cost savings compared to conventional vehicles. Although switching to natural gas can lower costs, many fleet managers have not converted their fleets to NGVs. The business model that energy service companies (ESCOs) apply to energy efficiency projects may help fleet managers transition to NGV projects and realize these potential cost savings.

BACKGROUND

Fuel cost is often the largest component of a fleet's operating costs, so switching to a less expensive fuel can significantly improve a fleet's budget. Between January 2012 and January 2015, the average price for compressed natural gas (CNG) was between $0.57 and $2.06 less expensive than diesel and between $0.03 and $2.03 less expensive than gasoline in regions across the United States. The Energy Information Administration forecasts that this price advantage will remain in place over the next several decades, despite the recent drop in petroleum prices.

Although natural gas has offered potential fuel cost savings over the past several years, NGVs have not been widely deployed in most public and private fleets. Several barriers have prevented widespread deployment:

- The higher upfront costs of NGVs may reduce fleet managers' incentives to invest in the alternative technology. NGVs across all weight classes are currently more expensive than their gasoline or diesel counterparts.
- The small NGV market at present has not yet created a strong demand for publicly available fueling infrastructure, which has been deployed on a limited basis to date. The long-term growth of an NGV market may expand the infrastructure network, but currently limited demand may restrict investment to certain types of fueling infrastructure, such as fleet hubs and airports.
- Consumer uncertainty about the cost benefits and performance of NGVs and natural gas fueling infrastructure may inhibit investment in NGVs. Typical consumers do not understand the total cost of vehicle ownership, performance, and fueling needs of NGVs, which leads to a lack of confidence in the technology and a lack of demand for vehicles and infrastructure.

To realize the potential cost savings of NGVs, fleet managers may contract with energy service providers to receive services similar to those offered by ESCOs in the energy efficiency sector. An ESCO is a business that develops, arranges financing for, and installs equipment for projects designed to improve the energy efficiency of and reduce maintenance costs for buildings, usually over a seven- to 20-year time period. The ESCO business model would enable fleet managers to reduce their risks, identify best opportunities, and adopt unfamiliar technologies. ESCO-like services could also include the provision of upfront capital and leasing equipment to avoid potential complications with owning vehicles or fueling infrastructure.

KEY STRATEGIC QUESTIONS TO ASSESS THE FINANCIAL VIABILITY OF CONTRACTING ESCO-LIKE SERVICES

This guide analyzes a range of scenarios that will inform the decision-making process for public and private fleet managers. The guide is structured to be high-level, presenting findings and analyses based on two years of research on alternative financing and deployment methods for NGVs. The guide consists of four questions, each exploring a key opportunity in the wider adoption of NGVs:

1. What is the potential to reduce petroleum use and emissions by incorporating NGVs into fleets?
2. What key factors affect the financial performance of NGV fleets?
3. Under what conditions will NGV fleet projects result in net cost savings and is there value to having an energy service provider help with the transition?
4. What is the role of an energy service provider in facilitating NGV deployment?

1. What is the potential to reduce petroleum use and emissions by incorporating NGVs into fleets?

NGVs can reduce petroleum use and greenhouse gas emissions in each of the three types of fleets considered: tractor-trailers, school buses, and light-duty vehicles.

Each of these NGV vehicle types emit lower greenhouse gas emissions per mile traveled than an equivalent vehicle fueled by gasoline or diesel. Natural gas combustion also produces fewer criteria pollutants than diesel or gasoline and exceeds the efficiency losses of these vehicles on an energy equivalent basis.

The opportunity to reduce petroleum consumption and emissions depends on fleet size, fleet vehicle fuel economy, and annual vehicle miles traveled (VMT). Over time, tractor-trailer fleets provide the greatest opportunities to reduce petroleum use and vehicle emissions because of the high volume of petroleum fuel that each vehicle consumes and the low fuel economy per vehicle. The long lifespan and low fuel economy of school buses also offer a large potential to reduce petroleum use and greenhouse gas emissions. Light-duty vehicle fleets have high turnover rates, which creates an opportunity to replace conventional vehicles with NGVs. However, light-duty NGVs are not widely available, and sales of light-duty NGVs have recently decreased.

2. What key factors affect the financial performance of NGV fleets?

The price of natural gas compared to the energy equivalent volume of gasoline or diesel greatly affects the financial performance of an NGV fleet. The steep decline in global oil prices that began in late 2014 has reduced the competitive advantage that CNG had held over gasoline since the beginning of 2012, although CNG prices continue to be favorable to diesel prices. Current gasoline and diesel prices may decrease interest in NGVs, which have higher upfront costs than gasoline or diesel vehicles. However, fleet managers are more likely than typical consumers to consider expected future prices, which the EIA forecasts will favor CNG in the coming years and decades as gasoline and diesel prices increase.

In addition to the price of natural gas, gasoline, and diesel, three other factors affect the financial performance of NGV fleets are:

- **Fleet characteristics and travel patterns**: A high total annual fleet VMT will increase potential fuel cost savings, since each mile traveled on CNG can be less expensive than the equivalent vehicle fueled by gasoline or diesel. Fleets that have vehicles with low fuel economy, high annual VMT, and a large number of vehicles may save the most on fuel costs.
- **Publicly available fueling infrastructure**: The presence of natural gas fueling infrastructure also affects the financial performance of an NGV fleet project. Adding new fueling infrastructure increases upfront costs and can extend the payback period of a project beyond the expected life of the equipment, which would make NGV projects financially infeasible.

- **Public financial incentives:** Public financial incentives can help overcome the financial barriers that prevent NGV fleet deployment. Some states, for example, offer grants or rebates for the purchase or lease of vehicles that reduce greenhouse gas emissions or criteria air pollutants. Similarly, public grants may reduce the upfront cost of fueling infrastructure.

3. Under what conditions will NGV fleet projects result in net cost savings, and is there value to having energy service provider help with the transition?

The financial performance of converting from diesel- or gasoline-powered vehicles to NGVs depends on the following previously introduced key factors: the price difference between diesel and CNG, fleet characteristics (fuel economy, total average annual fleet VMT, and vehicle lifetime), and the necessity of installing fueling infrastructure. Each of these factors can significantly affect the net cost savings of converting a fleet to NGVs, although the price difference between diesel and CNG is the largest single factor. In cases where these factors can produce net cost savings, fleet managers may be able to afford services from energy service providers to help transition to NGVs.

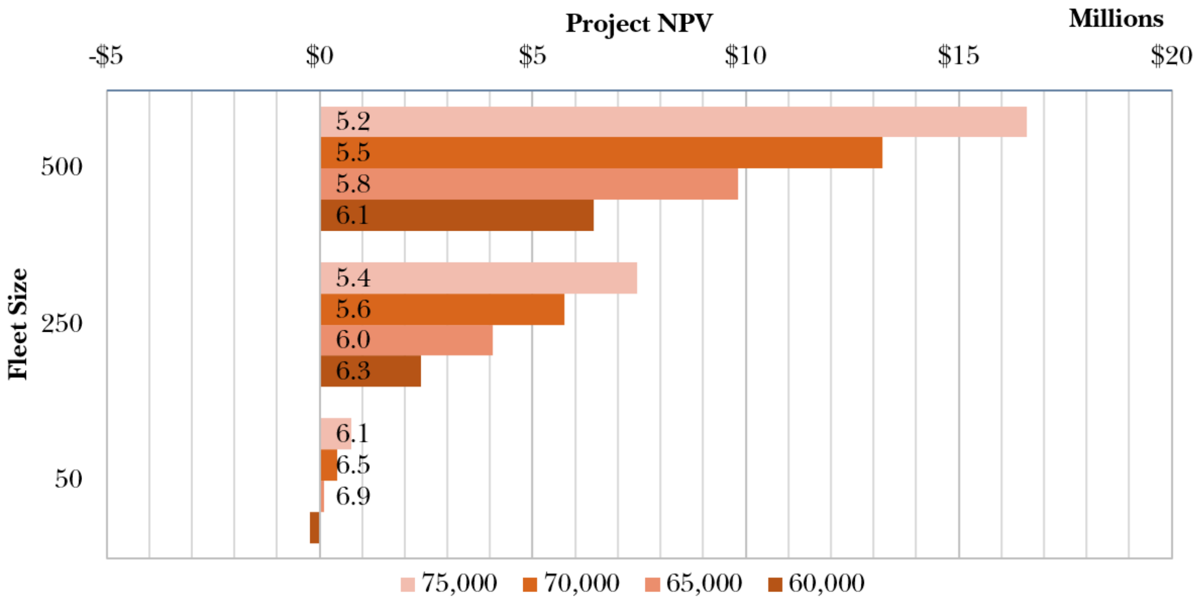
All of these factors were included in a financial analysis for a range of hypothetical tractor-trailer, school bus, and light-duty NGV fleets. Each fleet type achieves net cost savings in some scenarios, but only tractor-trailer fleets provide net cost savings in a wide range of scenarios. School bus fleets with a high annual VMT achieve net cost savings, and if new fueling infrastructure is required, only the largest fleets yield a profit (see **Figure ES-1** and **Figure ES-2**). Light-duty vehicle fleets achieve net cost savings in very few scenarios—only delivery truck NGV fleets that do not require new fueling infrastructure yield a positive investment.

As **Figure ES-2** illustrates, some projects may not accrue enough savings from fuel costs to offset the upfront expenses of using NGVs. The cost savings that projects earn must be large enough to provide value for the energy service provider and the fleet manager. Projects that achieve greater cost savings will be able to afford more ESCO-like services.

4. What is the role of an energy service provider in facilitating NGV deployment?

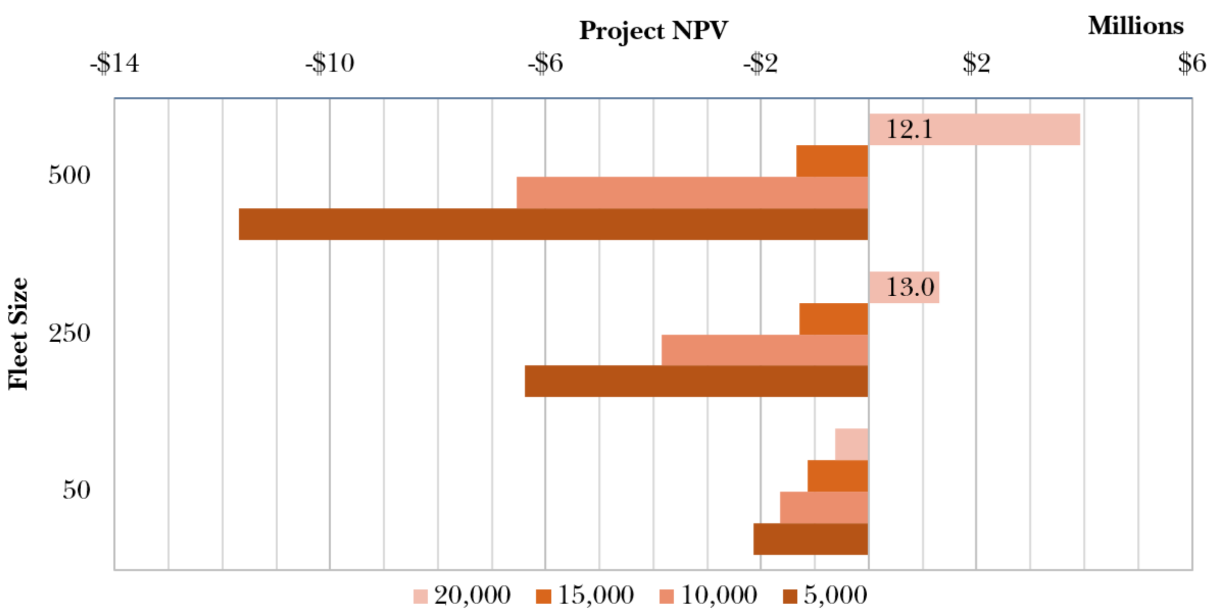
Energy service providers may be able to assist fleet managers through a range of ESCO-like services (see **Table ES-1**), although the specific services may depend upon the project's fueling infrastructure needs, the fleet size, and the technical capacity of the fleet. Energy service providers could help familiarize fleet managers with the new technology, identify the project's greatest savings potential, reduce their financial risk, and maximize their financial payoff.

FIGURE ES-1: **Tractor-Trailer Fleet with New Investment in Fueling Infrastructure Scenario Analysis Results**



Where possible, payback in years is noted in the figure. The project lifetime is 7 years, which is the equivalent of the expected life of the vehicle. The legend denotes the annual VMT for each vehicle in the fleet.

FIGURE ES-2: **School Bus Fleet with New Investment in Fueling Infrastructure Scenario Analysis Results**



Where possible, payback in years is noted in the figure. The project lifetime is 15 years, which is the equivalent of the expected life of the vehicle. The legend denotes the annual VMT for each vehicle in the fleet.

TABLE ES-1: Issues and Options for Fleet Managers Working with Energy Service Providers

POTENTIAL ESCO-LIKE SERVICE	DESCRIPTION	BARRIER(S) ADDRESSED
1. Identification and evaluation of project opportunities	Leverage energy service provider's extensive experience with the scope of technological solutions. Provide authoritative assessments on the suitability of new technologies.	Lack of Experience
2. Management of technology transition	Manage NGV technology transition to address fleet resource constraints. Especially useful for fleets that already lease vehicles.	Project Risk, Limited Resources
3. Alternatives to equipment ownership	Help public fleets avoid upfront capital outlays by avoiding equipment ownership in order to benefit public budgets. In some cases, construct contracts that prioritize fueling station access over ownership.	Budget Constraints, Public Fueling Dependency
4. Energy cost savings and technology performance guarantees	Use scenario analysis to reduce risk and provide a fleet manager an understanding of the project's financial viability. Construct contracts to account for cost savings approach of NGV conversion projects and provide cost protection for both parties.	Project Risk
5. Bundling projects into a portfolio	Bundle fleet NGV conversion projects with more profitable building energy efficiency projects to make vehicle projects more attractive to investors.	Project Risk
6. Partnership facilitation	Leverage public-private partnerships that encourage shared use of fueling stations to improve financial performance.	Financial Performance

Energy service providers could adapt the ESCO business model for vehicle projects by structuring contracts to reflect the factors that affect financial performance of NGV fleets. For instance, a contract could be designed to focus on fuel cost savings by agreeing upon a baseline fuel price and expected fuel price changes over time, stipulating fleet vehicles' fueling requirements, and reducing the uncertainty of predicting the performance of the vehicle technology. A contract could also influence driver behavior by specifying driving techniques and routes, which could improve efficiency and reduce fuel consumption.

In situations where fleets can achieve net cost savings or where the energy security and environmental benefits of NGVs are valued, energy service providers can greatly ease the transition to natural gas.

I. INTRODUCTION

Using natural gas vehicles (NGVs) in place of gasoline- and diesel-powered vehicles can simultaneously help address growing public concerns about air quality, climate change, and energy security. While the use of natural gas as an alternative to gasoline and diesel fuel in the last decade has been steadily increasing in public and private fleets, serious challenges exist, such as high upfront vehicle costs and available fueling infrastructure, that still inhibit greater NGV deployment. Innovative financial tools, however, can help overcome some of these barriers as they have for other clean energy technologies.

The purpose of this guide is to identify implementation strategies and key considerations for deploying one particular type of financial tool, the energy service company (ESCO) business model, which can potentially help expand the use of natural gas in public and private fleets. An ESCO is a business that develops, arranges financing for, and installs equipment for projects designed to improve the energy efficiency of and reduce maintenance costs for buildings, usually over a seven- to 20-year time period. This guide provides decision-relevant information on whether ESCO-like services (e.g., identification and evaluation of project opportunities, technology performance guarantees, fuel cost savings, and management of technology transition) can advance NGV deployment in tractor-trailer, school bus, and light-duty vehicle fleets in particular. This guide only considers vehicles powered by compressed natural gas (CNG). Liquefied natural gas vehicles, propane vehicles, or other alternative fuel vehicles are not included in any analysis completed for this guide. See **Box 1** for additional information about the scope of this guide, the overall project, and the methodology used.

In this guide, the term "ESCO" refers to a traditional energy service company that manages building energy efficiency projects, while the term "energy service provider" refers to the broader set of companies that could provide some ESCO-like services to fleets.

KEY QUESTIONS ANSWERED IN THIS GUIDE

This guide is informed by research and analysis that examines using the ESCO business model to accelerate natural gas use in fleets, and consists of four main sections corresponding to the questions below:

1. **What is the potential to reduce petroleum use and emissions by incorporating NGVs into fleets?** Section 1 discusses the potential for NGV market transformation by examining key metrics for fleets. Included are total applicable vehicles and fuel use, per-vehicle fuel use, avoided greenhouse gas and local air pollutant emissions, upfront vehicle and fueling infrastructure costs, availability of NGV technology and infrastructure, and potential for petroleum displacement.
2. **What key factors affect the financial performance of NGV fleets?** The lower price per unit of energy of natural gas (versus gasoline or diesel) can offset the higher upfront costs of fueling infrastructure and vehicles over time, offering a potential return on investment. Section 2 discusses the various factors that affect financial performance, including fuel prices, the presence of fueling infrastructure, implementation costs for different fleet types, the travel and vehicle needs of the fleet, and public policies.
3. **Under what conditions will NGV fleet projects result in net cost savings and is there value to having an energy service provider help with the transition?** Section 3 answers this question using the financial performance of fleet conversion projects for a range of fleet sizes and average annual vehicle miles traveled (VMT). Factors in the analysis include the upfront vehicle and fueling infrastructure costs, operating costs for the life of the vehicle fleet, and opportunities to use cost savings to team with an energy service provider to oversee and execute the project.

4. **What is the role of an energy service provider in facilitating NGV deployment?** Section 4 inspects the degree to which ESCO-like services address NGV deployment barriers for different fleet types and, correspondingly, the applicability of the ESCO business model in the NGV market.

Box 1. About this Guide for Businesses and Policymakers

This guide provides decision-relevant information for private businesses and policymakers interested in deploying NGVs in public and private fleets. The guide is the final phase of a multi-year project, a collaboration between the Center for Climate and Energy Solutions (C2ES) and the National Association of State Energy Officials (NASEO), on innovative finance mechanisms to accelerate the deployment of alternative fuel vehicles (AFVs) and fueling infrastructure. The goal of the project is to identify ways to increase private investment in AFVs and fueling infrastructure, with a focus on publicly available EV charging and the use of natural gas in vehicle fleets. Publicly available EV charging infrastructure is discussed in a related publication, *Strategic Planning to Deploy Publicly Available Electric Vehicle Charging Stations: A Guide for Businesses and Policy Makers*, available at http://naseo.org/publications and http://www.c2es.org/initiatives/alternative-fuel-vehicle-finance/publications-and-tools.

The project focuses on the use of natural gas in vehicle fleets for two reasons:

1. The development of abundant, domestic natural gas supplies has lowered the price of natural gas fuel relative to diesel and gasoline and created an opportunity for vehicle fuel cost savings.
2. Public and private fleets are among the most promising stakeholders to advance NGVs because the unique needs of fleet operators put them in a position to more readily overcome barriers to NGV deployment. Many fleets have predictable routes and fuel use patterns, and many fleets return to a central location each day, typically requiring only one dedicated refueling station. In addition, the total cost of vehicle ownership (as opposed to an upfront cost) of NGVs can be less than that of a comparable gasoline or diesel vehicle, lowering costs for fleet owners.

This guide highlights the findings from two years of research and analysis on barriers to private investment, the application of the energy service company business model in vehicle fleets, and a financial analysis of using natural gas in three fleet types: tractor-trailers, school buses, and light-duty vehicles. In particular, the guide builds off the 2014 report, *Applying the Energy Service Company Model to Advance Deployment of Fleet Natural Gas Vehicles and Fueling Infrastructure*, which introduces and explores the concept of applying the ESCO business model to NGV fleet projects. Readers interested in learning more about ESCO-like businesses and the application of this business model to NGV fleet projects should consult that report.

To estimate the cost savings and payback period of natural gas fleet projects, C2ES used the National Renewable Energy Laboratory's Vehicle and Infrastructure Cash-Flow Evaluation (VICE) tool. This tool features a cost calculator that demonstrates the ways in which net savings are sensitive to various assumptions such as fleet characteristics, fuel price, equipment costs, and operation and maintenance costs. The VICE tool can be downloaded at: http://www.afdc.energy.gov/fuels/natural_gas_infrastructure.html.

BARRIERS TO NGV DEPLOYMENT IN FLEETS

As discussed in a recent report, *Applying the Energy Service Company Model to Advance Deployment of Fleet Natural Gas Vehicles and Fueling Infrastructure* (see **Box 1**), use of natural gas is on the rise as an alternative fuel in the transportation market. One key driver has been the development of abundant, domestic natural gas supplies, lowering the price of natural gas fuel relative to diesel and gasoline in recent years, and creating an opportunity for vehicle fuel cost savings. NGVs also offer environmental benefits over conventional vehicles because they emit fewer air pollutants and greenhouse gases.[1]

Public and private fleet decision makers are among the most promising stakeholders to advance

NGVs. Many fleets have predictable routes and fuel use patterns, and many fleets return to a central location each day, typically requiring only one dedicated refueling station. In addition, the total cost of vehicle ownership (as opposed to an upfront cost) of NGVs can be less than that of a comparable gasoline or diesel vehicle, lowering costs for fleet owners.[2]

Programs and activities in state and local governments across the United States have also encouraged the adoption of NGVs in fleets through vehicle grant programs, fueling infrastructure partnerships, and leadership from state governors' offices. For example, the New York State Energy Research and Development Authority (NYSERDA) helped to deploy NGVs in private fleets through a grant program.[3] In addition, the unified efforts of governors from several states resulted in more than 100 auto dealers making NGVs available to purchase for state fleets.[4] Both efforts are covered in greater detail in Section 4.

Although the benefits of adoption are becoming widely understood, and many public and private fleets are interested in deploying NGVs, their expanded use faces several significant barriers, including the following:

- **Higher upfront cost of NGVs**: Currently, NGVs across all weight classes and fuel types are generally more expensive than similar gasoline or diesel vehicles (see **Table 1**). Government incentives designed to reduce the upfront costs have increased demand for NGVs, but not all buyers are able to use these incentives. The low residual value of NGVs may also be a barrier to investment and deployment, but this guide does not address the secondary vehicle market.[5]
- **Limited near-term demand for widespread NGV fueling infrastructure**: The small consumer NGV market limits the development of widespread publicly available fueling infrastructure. Only certain types of refueling infrastructure (e.g., airports and fleet hubs) are likely sufficient to justify project investment.
- **Consumer uncertainty about the benefits and costs of NGVs and related infrastructure**: Typical consumers do not fully understand the vehicle total cost of ownership, performance, and fueling needs of NGVs, which can lead to a lack of confidence in the technology and a lack of demand for the product.[6]

TABLE 1: Incremental Upfront Cost of NGVs

VEHICLE INVESTMENT TYPE	APPROXIMATE INCREMENTAL COST
Taxi (price premium for CNG compared to gasoline)[7,8]	$3,750-$8,000
Ford F150 pickup truck (price premium for CNG model compared to gasoline model)[9]	$6,300-$9,800
General Motors Sierra 2500 pickup truck (price premium for bi-fuel (gasoline + CNG) model compared to the gasoline-only model)[10]	$11,000
Delivery truck (price premium for CNG compared to gasoline)[11,12]	$15,000-$36,300
Trash truck (price premium for CNG compared to diesel)[13,14]	$30,300-$60,000
School bus (price premium for CNG compared to diesel)[15,16]	$31,400-$40,000
Transit bus (price premium for CNG compared to diesel)[17,18]	$31,500-$50,500
Class 8 tractor-trailer (price premium for CNG compared to diesel)[19,20]	$60,000-$65,000
Class 8 tractor-trailer (price premium for LNG compared to diesel)[21]	$90,000

Source: Frades, Matt. 2014. "Applying the Energy Service Company Model to Advance Deployment of Fleet Natural Gas Vehicles and Fueling Infrastructure. Center for Climate and Energy Solutions. http://www.c2es.org/publications/applying-energy-service-company-model-advance-deployment-fleet-natural-gas-vehicles-fue.

In addition to the barriers related to uncertainty, a lack of fueling infrastructure, and high upfront vehicle costs, NGV deployment also faces barriers more specific to public and private fleets.

- Fleet managers often have a small appetite for risk and have little experience with NGVs.
- Public fleets managers often base their decisions on strict budgeting or procurement rules, which in some cases may favor conventional vehicles with lower upfront costs, even if the lifecycle costs of NGVs are lower.
- Public fleet managers, in particular, often have limited funds to devote to capital-intensive projects.
- Public fleet managers may also face restrictions on their authority to devote capital to longer-term energy cost savings projects.
- Private fleet managers, particularly those operating Class 8 tractor-trailers (heavy-duty), may not have a central refueling facility, thus requiring a widely distributed network of publicly available fueling infrastructure to support their decision to invest in NGVs.[22]

Many of the barriers specific to public and private fleets listed above can be addressed, in part, through the application of an ESCO business model. ESCOs typically help to complete building upgrades that improve energy efficiency and reduce maintenance costs by providing technical expertise and by leveraging overall cost savings to provide upfront capital. The barriers that limit building owners from investing in facility upgrades are often similar to those limiting public and private fleets from investing in NGVs, including high upfront costs, risk aversion, and uncertainty barriers.[23]

OPPORTUNITIES FOR APPLYING THE ESCO MODEL TO SPECIFIC FLEET TYPES

As discussed in *Applying the Energy Service Company Model to Advance Deployment of Fleet Natural Gas Vehicles and Fueling Infrastructure*, the ESCO business model can improve the value proposition of using natural gas in public and private vehicle fleets through the following activities:

- **Identifying and evaluating project opportunities**: upfront evaluation of opportunities to reduce project costs.
- **Offering fuel cost savings and technology performance guarantees**: guaranteed energy cost savings or some level of technology performance associated with the project.
- **Managing the technology transition**: assistance with conversion projects and transition to new, less familiar technology.
- **Offering alternatives to equipment ownership**: purchase equipment, including vehicles and fueling infrastructure to reduce the need for fleet managers to invest upfront capital and allow for projects to be funded entirely under operating budgets, which is financially advantageous for some companies and necessary for public agencies that have restrictions on shifting funds between operating and capital budgets.
- **Bundling conversion projects into a portfolio**: reduce investment risks by bundling together a suite of cost saving projects (including building energy efficiency upgrades) with a diverse set of upfront investment costs and payback schedules.
- **Facilitating partnerships**: provide additional support and expertise for clients by leveraging their partner networks that can assist with technical or financial matters.

Energy service providers could offer these ESCO-like services to a variety of public and private fleets. Three fleet types that could benefit from these services include public school buses, public light-duty vehicles (passenger cars, light trucks, and delivery trucks), and private tractor-trailers.[24]

II. ASSESSING THE BENEFITS AND VIABILITY OF NGV FLEETS: KEY STRATEGIC QUESTIONS

NGVs offer many public benefits, but financial barriers to deployment persist. Given the uncertainties about NGV demand, the limited nature of public funding, and the newness of the technology, this guide addresses the fundamental issue of the financial viability of NGV fleet deployment. Policymakers or companies should ask and answer the following questions as they consider their options for increasing both the number of NGVs on the road and the level of private sector investment in vehicles and fueling infrastructure.

QUESTION 1. WHAT IS THE POTENTIAL TO REDUCE PETROLEUM USE AND EMISSIONS BY INCORPORATING NGVS INTO FLEETS?

This section summarizes the potential effect on petroleum use and emissions of using natural gas in three fleet types: private tractor-trailers, public school buses, and public light-duty vehicles (passenger cars, light trucks, and delivery trucks). While the relative importance of each effect depends on an individual stakeholder's needs, each is an important element of consideration as a public or private fleet owner considers converting their fleet to natural gas. For example, NGV manufacturers may be interested in the number of applicable vehicles that could be converted to natural gas, whereas policymakers may be interested in the potential for petroleum displacement or greenhouse gas emission reductions.

The potential to reduce petroleum use, greenhouse gas emissions, and/or local air quality emissions depends on vehicle technology and fleets' vehicle usage patterns. For petroleum use, the fuel economy of the diesel or gasoline vehicle and average annual VMT determine how much petroleum can be displaced by switching to natural gas. Diesel or gasoline vehicles with low fuel economy and high annual VMT provide the greatest opportunity for petroleum displacement. For greenhouse gas and local air quality emissions, any potential emission benefits depend on the per-mile emissions and annual VMT of each NGV and conventional vehicle type. **Table 2** summarizes assumptions related to vehicle performance and use for each vehicle type examined in this guide.

TABLE 2: Vehicle Performance and Use Assumptions

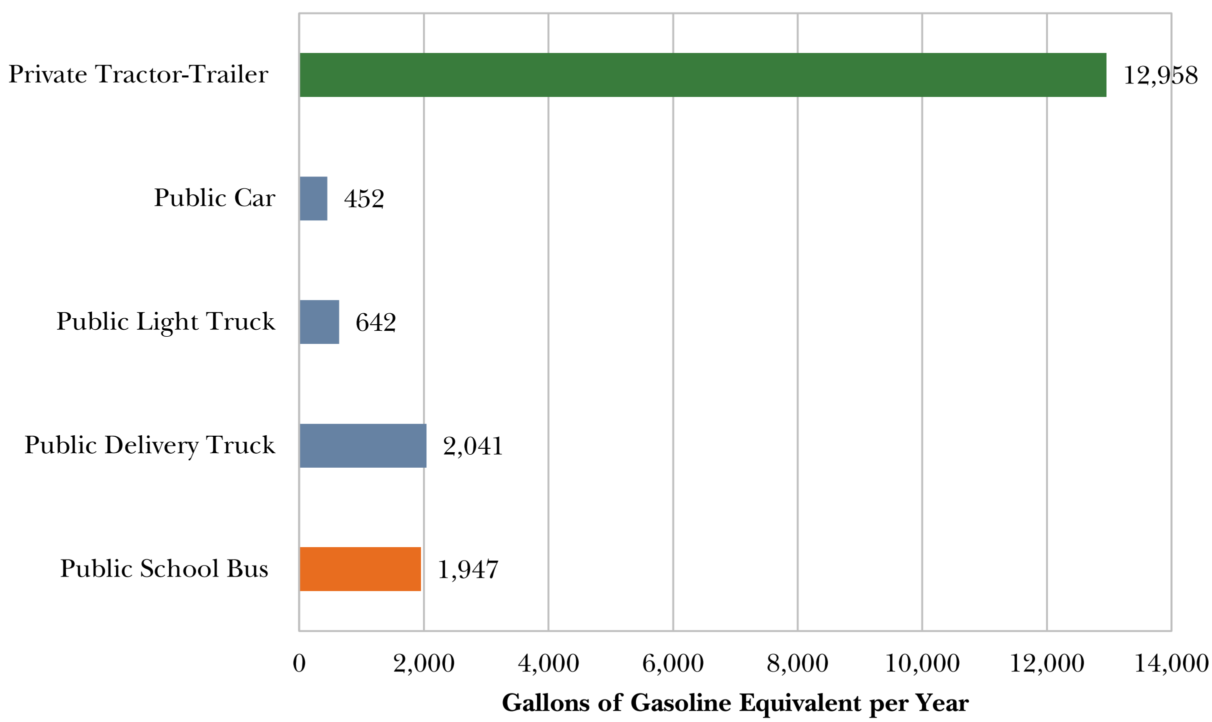
VEHICLE TYPE	BASE FUEL USED	2012 AVERAGE VMT (MILES/YEAR)	FUEL ECONOMY (MPG)	CNG FUEL ECONOMY (% REDUCTION)	EXPECTED LIFE (YEARS)
Tractor Trailer	Diesel	66,161	5.8	5.3%	7
School bus	Diesel	12,000	7	12.5%	15
Delivery Truck	Gasoline	13,469	6.6	5.3%	7.4
Light Truck	Gasoline	11,882	18.5	5.3%	6.5
Passenger Car	Gasoline	11,265	24.9	5.3%	6.5

This table summarizes assumptions about fuel economy and annual VMT for the vehicles examined in this guide. Currently, CNG vehicles have a lower fuel economy than their conventional counterparts as noted in the table. Aside from average VMT, all data was from the 2014 VICE Model. Additional fleet data used in this guide is in Appendix B.

Source: Oak Ridge National Laboratory. "Transportation Energy Data Book: Chapter 5 Heavy Vehicles and Characteristics." Accessed July 1, 2015. http://cta.ornl.gov/data/chapter5.shtml.

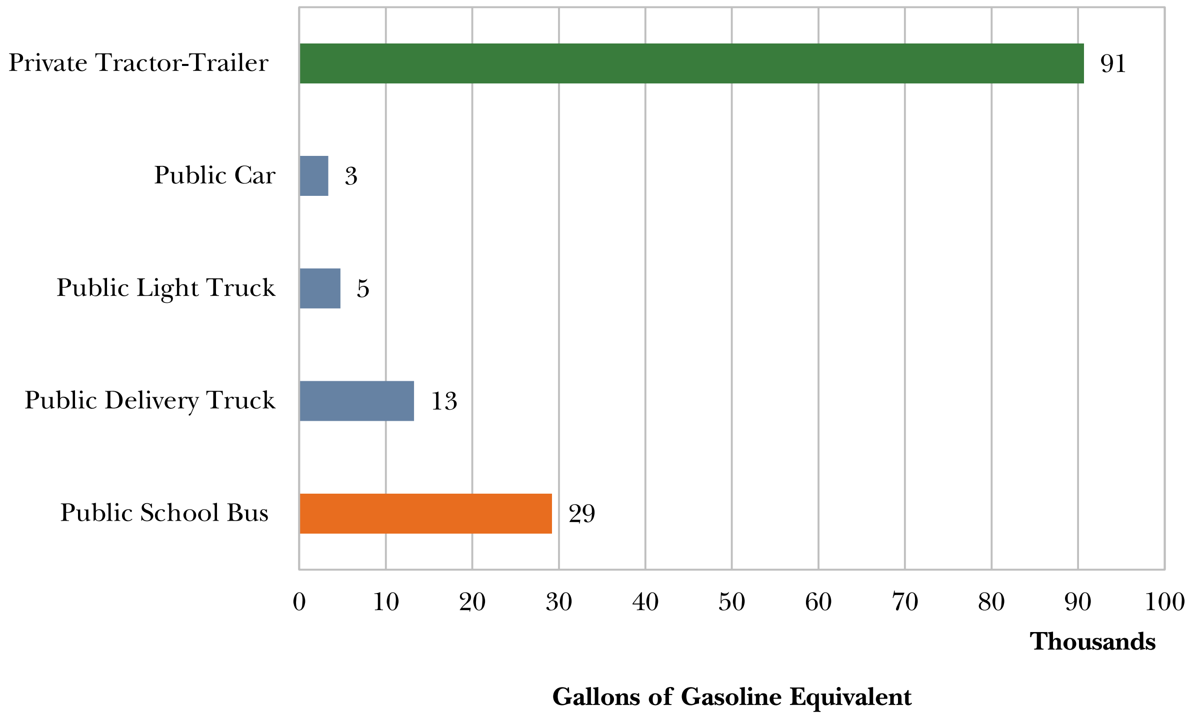
All NGV fleet types show potential to displace petroleum. Displacing petroleum use in the United States with alternative fuels can offer considerable benefits to society. Without accounting for military-related costs to secure the supply and transit of oil, petroleum dependence costs the U.S. economy billions annually due to wealth transfer, dislocation losses, and the loss of potential GDP.[25] Tractor-trailer fleets show the greatest potential to displace petroleum because these vehicles use much more fuel over their expected lifetime, on average, than either school buses or light-duty fleets. Tractor-trailers have the lowest average fuel economy (5.8 miles per gallon) and the highest VMT (66,161 miles per year) of all vehicles in the three fleet types considered. For public sector light-duty vehicles, the potential for petroleum displacement (and related fuel cost savings) depends on the vehicle type, with a range of more than 452 to 2,041 gallons per year between delivery trucks and passenger cars. **Figure 1** provides a comparison of the annual petroleum displacement for each fleet type and **Figure 2** shows the expected lifetime petroleum displacement for each fleet type.

FIGURE 1: Per-Vehicle Annual Average Petroleum Use Displacement (2012)



Source: American School Bus Council. "Environmental Benefits." Accessed July 1, 2015. http://www.americanschoolbuscouncil.org/issues/ environmental-benefits; U.S. Energy Information Administration. "Freight Transportation Use, Reference case." Accessed July 1, 2015. http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2014&subject=15-AEO2014&table=58-AEO2014&region=0-0&cases=ref2014-d102413a; U.S. Department of Transportation, Federal Highway Administration, "Highway Statistic Series 2012 – January 2014 Table MV-7." Accessed July 1, 2015. https://www.fhwa.dot.gov/policyinformation/statistics/2012/mv7.cfm; U.S. Department of Transportation, Federal Highway Administration, "Highway Statistic Series 2012 – January 2014 Table VM-1" Accessed July 1, 2015. http://www.fhwa.dot.gov/policyinformation/statistics/2012/ vm1.cfm.

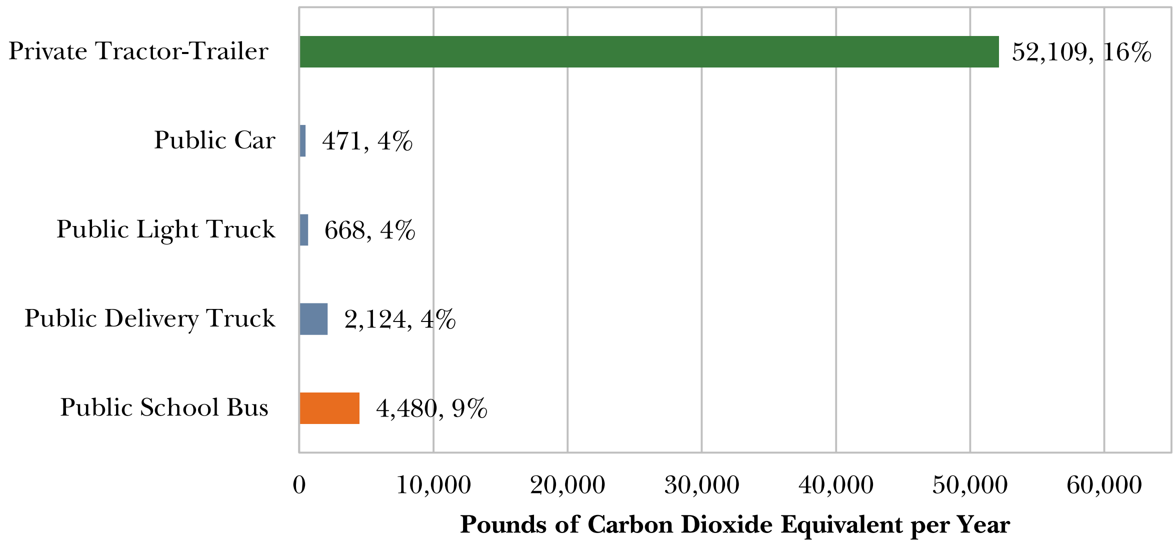
FIGURE 2: Per-Vehicle Lifetime Average Petroleum Use Displacement (2012)



Source: American School Bus Council. "Environmental Benefits"; U.S. Energy Information Administration. "Freight Transportation Use, Reference case"; U.S. Department of Transportation, Federal Highway Administration, "Highway Statistic Series 2012 – January 2014 Table MV-7"; U.S. Department of Transportation, Federal Highway Administration, "Highway Statistic Series 2012 – January 2014 Table VM-1"; U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0."

All fleet types show potential to reduce greenhouse gas emissions. While some uncertainty exists about the full lifecycle greenhouse gas emissions associated with NGVs due to the potential for methane leaks in production and distribution, [26] Argonne National Laboratory's GREET lifecycle greenhouse gas emission model indicates NGVs offer a greenhouse gas benefit compared to similar diesel and gasoline vehicles.[27] Tractor-trailers conversions result in the largest greenhouse gas emissions reduction on a per-vehicle basis because of their relatively high annual VMT and low fuel economy compared to the other fleet types. Other fleet types where NGVs can help reduce greenhouse gas emissions include school buses and public light-duty vehicles. Of these fleet types, tractor-trailers and school buses both offer a larger potential to reduce greenhouse gas emissions compared to light-duty vehicles. School buses in municipal fleets, in particular, could help meet municipal greenhouse gas goals through high per-vehicle reductions and long vehicle lifespans. Although the emission reductions for light-duty vehicles are smaller than other fleet types on average, large fleets of light-duty vehicles could see substantial aggregate emission reductions. **Figure 3** illustrates per-vehicle annual greenhouse gas emissions reductions for each vehicle type to demonstrate the potential greenhouse gas emissions benefits of converting to natural gas. **Figure 4** shows the expected lifetime greenhouse gas emissions savings for each vehicle type in order to demonstrate the potential greenhouse gas emissions benefits of switching to natural gas based on the expected life of each vehicle.

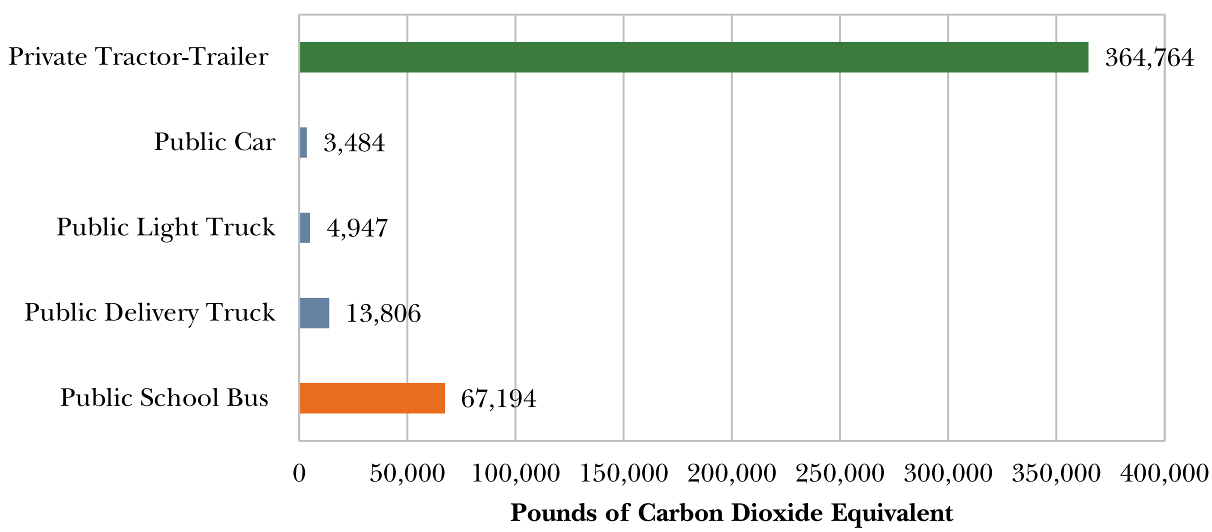
FIGURE 3: Per-Vehicle Annual Greenhouse Gas Emissions Reductions (2012)



Per-vehicle GHG reduction from using natural gas compared to gasoline and diesel in absolute and relative terms.

Source: American School Bus Council. "Environmental Benefits"; U.S. Energy Information Administration. "Freight Transportation Use, Reference case"; U.S. Department of Transportation, Federal Highway Administration, "Highway Statistic Series 2012 – January 2014 Table MV-7"; U.S. Department of Transportation, Federal Highway Administration, "Highway Statistic Series 2012 – January 2014 Table VM-1"; U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0."

FIGURE 4: Per-Vehicle Lifetime Greenhouse Gas Emissions Reductions (2012)



Source: American School Bus Council. "Environmental Benefits"; U.S. Energy Information Administration. "Freight Transportation Use, Reference case"; U.S. Department of Transportation, Federal Highway Administration, "Highway Statistic Series 2012 – January 2014 Table MV-7"; U.S. Department of Transportation, Federal Highway Administration, "Highway Statistic Series 2012 – January 2014 Table VM-1"; U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0."

NGVs can help reduce criteria pollution. In past years, many city fleets have turned to NGVs to help reduce conventional pollutants like nitrogen oxides (NOx) and particular matter (PM2.5). While the benefits of reducing criteria pollutants from vehicle conversions can be difficult to quantify and vary by location and vehicle type, NGVs generally tend to have lower emissions, despite their typically lower fuel economy (on an energy equivalent basis) relative to analogous gasoline or diesel vehicles. For example, 2013 natural gas engines can have about 50 percent lower emissions than diesel engines for some criteria pollutants.[28] The conventional pollutant advantage of NGVs, however, will likely decline in the future as it has in recent years due to more stringent emission controls for diesel engines. The U.S. Environmental Protection Agency has tightened emissions standards by 98 percent for NO_x and $PM_{2.5}$ emissions from heavy-duty engines since 1998, leading to noticeable improvements in particulate emissions from both diesel and natural gas engines.[29] For example, NO_x emissions for a 1996 Cummins 10-Liter diesel engine averaged more than 4 grams per brake horsepower-hour (g/bhp-hr) while a 2013 Cummins 9-Liter diesel engine emitted less than 0.5 g/bhp-hr. For $PM_{2.5}$, the 1996 Cummins diesel engine emitted about 0.16 g/bhp-hr while the 2013 diesel engine had no particulate emissions.[30] **Table 3** highlights the current criteria pollutant advantage of NGVs.

TABLE 3: Criteria Pollutant Emissions of NGVs Relative to Conventional Fuel Vehicles (Emissions Savings Per-Vehicle)

FACTORS	PUBLIC SCHOOL BUS FLEETS (2014)	PUBLIC LIGHT-DUTY FLEETS (2012)			PRIVATE TRACTOR-TRAILER FLEETS (2014)
		DELIVERY TRUCK	LIGHT TRUCK	CAR	
Per-vehicle NO_x Savings (lbs/year)	50%	79%	0%	0%	50%
Per-vehicle $PM_{2.5}$ Savings (lbs/year)	0%	92%	0%	0%	0%
Per-vehicle VOC Savings (lbs/year)	0%	89%	10%	10%	0%

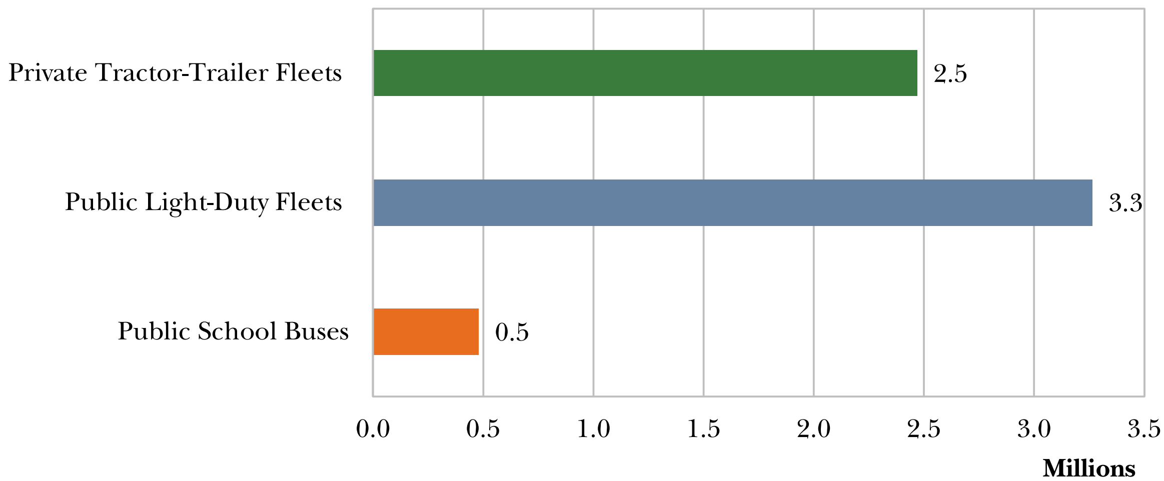
Per-vehicle reduction in local air pollutant emissions relative to diesel vehicles for school buses and tractor-trailers from Argonne National Laboratory analysis. Per-vehicle reduction in emissions from light-duty vehicles are from Argonne's GREET Model.

Source: U.S. Department of Energy –Argonne National Laboratory Transportation Technology R&D Center. "The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model." Accessed July 30, 2015. https:/ /greet.es.anl.gov/; (Cai, et al. 2015).

Assessing the long-term potential of NGVs to reduce petroleum and emissions requires an evaluation of potential fleet opportunities. The size of the vehicle market and the annual fleet turnover determine how many conventional vehicles reaching the end of their useful lives can be replaced with NGVs. Larger fleets that turn over rapidly (due to shorter vehicle lifespans) may present more opportunities to introduce NGVs than fleets with long turnover time (see **Table 2** for expected vehicle lifespans). Public light-duty fleets have the potential to power a large number of vehicles with natural gas because these fleets have the highest annual turnover of the vehicles considered (see **Figure 5** and **Figure 6**). With 3.3 million light-duty vehicles in fleets on the road, the average annual turnover exceeds 450,000 vehicles.

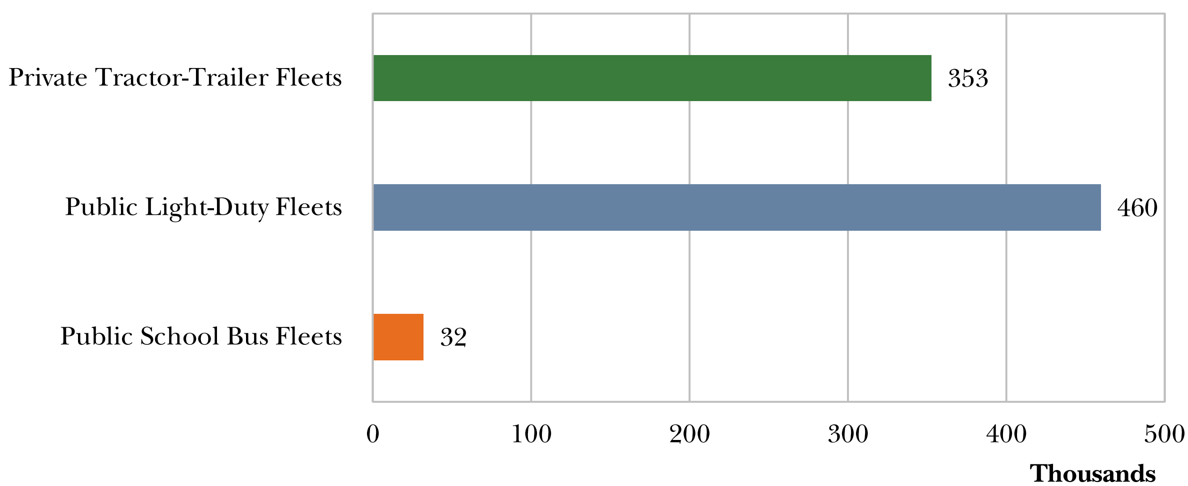
Private tractor-trailers may also present a large opportunity for NGVs because they have an annual turnover of 353,000 vehicles and an average lifespan of 7 years. In contrast, school buses are a smaller market with a significantly lower annual turnover (32,000 vehicles) and an average lifespan of 15 years. However, while school buses may not have the largest potential market opportunity in the long run, they also may not face the same hurdles that light-duty vehicles and some tractor-trailers face in the short run. Many states offer financial support for the purchase of CNG school buses and fueling infrastructure, such as Arkansas' CNG Grant and Loan Pilot Program,[31] Colorado's CNG School Bus Matching Grants,[32] or West Virginia's AFV School Bus Incentive.[33]

FIGURE 5: Number of Vehicles by Fleet Type in 2012



Source: American School Bus Council. "Environmental Benefits"; U.S. Energy Information Administration. "Freight Transportation Use, Reference case"; U.S. Department of Transportation, Federal Highway Administration, "Highway Statistic Series 2012 – January 2014 Table MV-7"; U.S. Department of Transportation, Federal Highway Administration, "Highway Statistic Series 2012 – January 2014 Table VM-1."

FIGURE 6: Annual Turnover by Vehicle Fleet Type in 2012



The annual turnover was calculated by dividing the total number of vehicles on the road divided by the average life for each vehicle type.

Source: American School Bus Council. "Environmental Benefits"; U.S. Energy Information Administration. "Freight Transportation Use, Reference case"; U.S. Department of Transportation, Federal Highway Administration, "Highway Statistic Series 2012 – January 2014 Table MV-7"; U.S. Department of Transportation, Federal Highway Administration, "Highway Statistic Series 2012 – January 2014 Table VM-1"; U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0."

Although light-duty vehicles have the highest annual turnover, no natural gas passenger cars will be mass produced beginning in 2016. The Honda Civic Natural Gas was discontinued in 2015.[34] Honda sold less than 3,000 units in 2014, and sales of overall light-duty NGVs fell 34 percent in 2014 from 2013 levels.[35,36] The Civic, which was the only light-duty NGV choice on the market at the time, had reduced storage capacity because of the trunk required for CNG storage. A wider range of NGV models could appeal to a broader consumer market and increase the familiarity and confidence in NGV technology. Vehicle manufacturers have not made natural gas-powered light-duty trucks widely available, and they are generally not reporting sales figures.[37] One exception is Ford, which offers CNG or propane prep kits for its F-series trucks, including the best-selling F-150. The automaker has sold 57,000 kits since 2009, far more than any other automaker.[38] Using the latest available national data from 2011, less than 70,000 natural gas passenger vehicles were on the road in the United States.[39]

Tractor-trailers weighing more than 80,000 pounds may not be able to convert to CNG because no 15-liter CNG engine is currently produced due to uncertainty over demand. However, CNG engines are available for many truck applications, with engines ranging from 6 to 12 liter, which would accommodate many heavy-duty vehicle needs.[40] In 2013, Cummins Westport began production of a 12-liter CNG engine that can accommodate vehicles up to 80,000 pounds.[41] Cummins Westport stalled its work on a 15-liter CNG engine in 2014 due to demand uncertainty.[42]

Summary: Petroleum Use and Greenhouse Gas Emission Reductions

The use of natural-gas powered tractor-trailers, school buses, and light-duty vehicles offers opportunities to reduce petroleum use and greenhouse gas emissions in the longer term. All natural gas-powered vehicles evaluated in this guide have lower greenhouse gas emissions per mile traveled than a comparable gasoline or diesel vehicle. The combustion of natural gas results in lower criteria pollutant and greenhouse gas emissions than diesel or gasoline and exceeds the efficiency losses of these vehicles on a gasoline-gallon-equivalent basis.

Over time, tractor-trailers may offer the largest opportunity to reduce greenhouse gas emissions and petroleum use because of the high amount of fuel they consume on a per-vehicle basis; tractor-trailers have a relatively low fuel economy and high annual VMT compared to the other vehicles considered. School buses also offer a large potential to reduce greenhouse gas emissions, which could help meet municipal climate change goals, because of high per-vehicle reductions and long vehicle lifespans. Large light-duty vehicle fleets could reduce petroleum use and greenhouse gas emissions, but light-duty NGVs are not widely available at this time and sales have recently decreased.

The next section identifies some of the key considerations that could affect fleet conversion projects for fleets composed of tractor-trailers, school buses, or light-duty vehicles.

QUESTION 2. WHAT KEY FACTORS AFFECT THE FINANCIAL PERFORMANCE OF USING NGVS IN FLEETS?

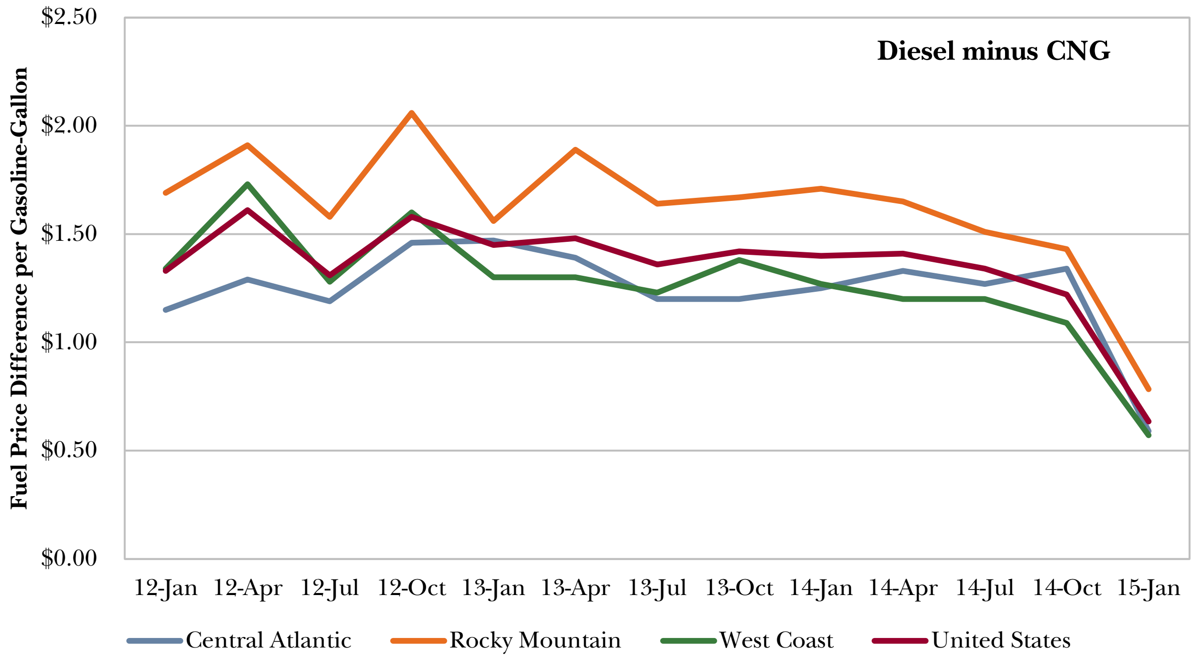
The findings in this section summarize the effects of the following factors on the financial performance of using natural gas in vehicle fleets:

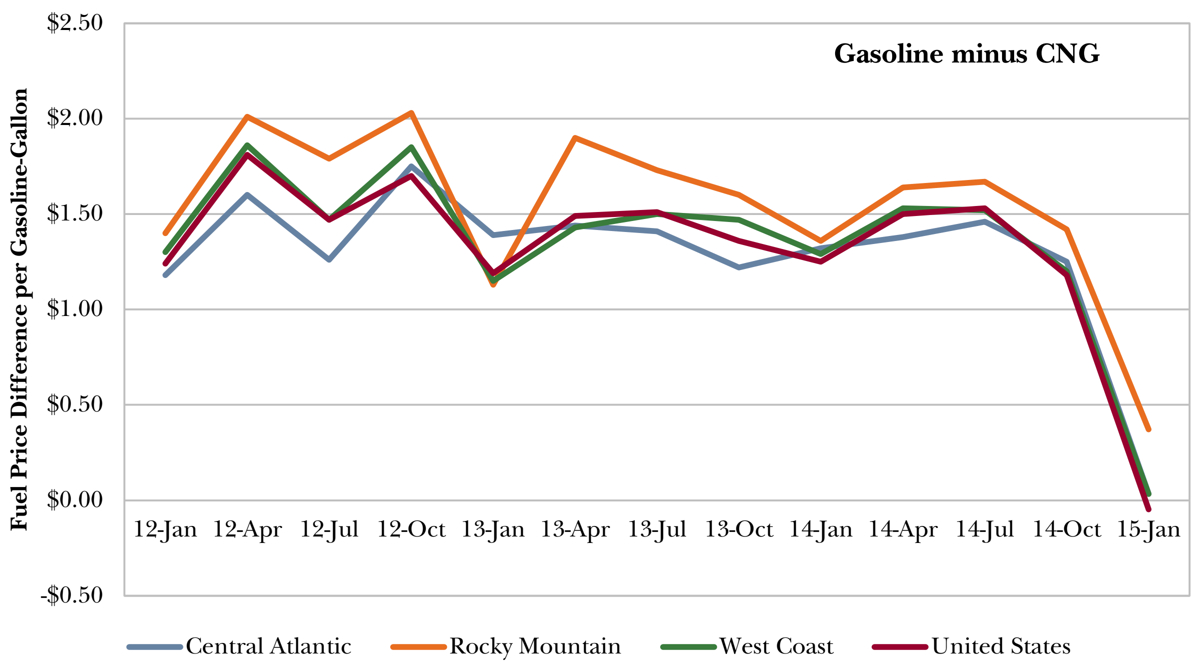
- Local gasoline, diesel, and CNG prices;
- The cost and presence of natural gas fueling infrastructure;
- Fleet characteristics and travel patterns; and
- Public policies that encourage the use of NGVs by reducing existing financial barriers to deployment.

Individually and collectively, these factors could have a significant effect on the net cost savings of a natural gas fleet conversion project. In general, savings from converting a fleet to natural gas depend on the upfront cost difference of NGVs, the difference in cost per mile of running on natural gas versus diesel or gasoline, the fleet's miles traveled, and the need for fueling infrastructure. A robust publicly available fueling infrastructure and state vehicle purchase incentives could sufficiently reduce the cost differences of switching to natural gas to make a project financially feasible.

FIGURE 7: Fuel Price Difference per Gallon from January 2012 to January 2015

These charts show the difference between the price of diesel/gasoline and CNG on an energy-equivalent basis for three regions of the United States and the U.S. overall. The price difference drops in 2014 due to the fall in oil prices to a range of 9 and 37 percent lower in January 2015 than the maximum price difference during the three-year period.





Source: U.S. Department of Energy Alternative Fuels Data Center. "Publications: Alternative Fuels Price Report". Accessed on July 30, 2015. http://www.afdc.energy.gov/publications/search/keyword/?q=alternative%20fuel%20price%20report.

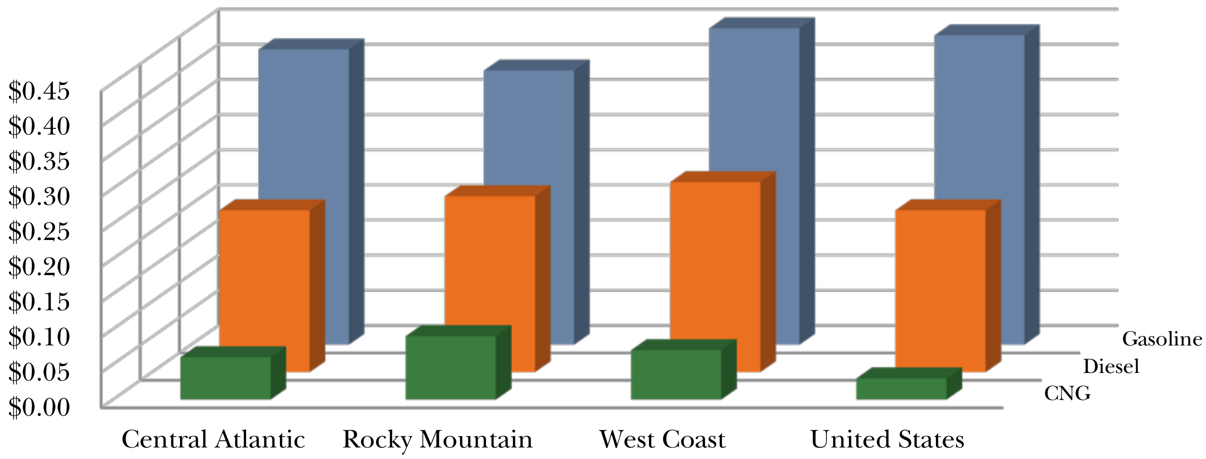
The fuel price difference between diesel/gasoline and CNG can yield an advantage for NGV fleet operators. Fuel costs for fleet vehicles are often the largest contributor to operating costs, so fuel saving can significantly affect a fleet's operating expenses. From January 2012 to January 2015, the difference in U.S. fuel prices between diesel and CNG ranged from $0.57 to $2.06 per gallon of gasoline equivalent in the Central Atlantic, West Coast, and Rocky Mountain regions. The range of price differences between gasoline and CNG was $0.03 to $2.03, as gasoline nearly reached price parity with CNG in the Central Atlantic and West Coast in January 2015. In fact, the average price of gasoline in the overall United States was lower than CNG on an energy-equivalent basis by January 2015 because CNG prices remained relatively constant as petroleum prices decreased in the second half of 2014. See **Figure 7** for the price difference between diesel/gasoline and CNG from January 2012 and January 2015. Importantly, the U.S. Energy Information Administration (EIA) forecasts that gasoline and diesel prices will rebound and remain higher than natural gas prices for the next several decades.[43]

While the fuel price spread between diesel/gasoline and CNG has reduced the fuel savings associated with NGVs, less volatility in CNG price may be advantageous to fleet managers. In the last three years, CNG prices have been comparatively stable. From January 2012 to January 2015, most quarterly CNG prices in the overall United States were within $0.03 of the average price. Diesel price volatility was greater than CNG volatility, with most quarterly prices in the same regions ranging from $0.23 (Central Atlantic) to $0.27 (West Coast) from the average price. Gasoline prices were the most volatile, as most prices ranged from $0.39 (Rocky Mountain) to $0.45 (West Coast) from the average price. See **Table 4** for a summary of price volatility for these regions from January 2012 to January 2015. Volatility in fuel prices may leave fleet managers exposed to market fluctuations and uncertain about fueling costs. The predicted lower price of natural gas in the coming decades, combined with the relative stability of natural gas prices, may give fleet managers confidence about the financial return of investing in NGV projects.

New fueling infrastructure can add millions to the cost of an NGV deployment project for fleets. According to the VICE model, providing fueling infrastructure for tractor-trailers and school buses can add between $400 thousand and $22 million to the cost of an NGV fleet project, depending on the size of the fleet and annual VMT. Fleets at the extremes of these values could need very little new infrastructure, or extensive new infrastructure, which explains the large range in projected costs. The VICE model estimates the costs of providing fueling infrastructure for a fleet project based on a fixed installation cost and a variable cost based on fuel use, which depends on vehicle fuel economy, VMT, and total vehicle count. See **Figure 8** for a summary of fueling infrastructure costs for various NGV fleet projects for tractor-trailers and school buses.

Existing CNG fueling infrastructure varies regionally and tends to be concentrated in dense urban areas and natural gas producing regions. Natural gas producing regions like Colorado, Ohio, Oklahoma, Pennsylvania, and Utah have CNG fueling stations deployed throughout the state, but large CNG fueling infrastructure gaps exist in sections of the West and Midwest that include regions in Nevada, Nebraska, Kansas, and the Dakotas, making long distance travel along major interstates in these regions very difficult for NGVs. New infrastructure would be required for NGVs that must travel major road corridors in these states, including Interstates 70 and 80. **Figure 9** highlights existing CNG fueling infrastructure.

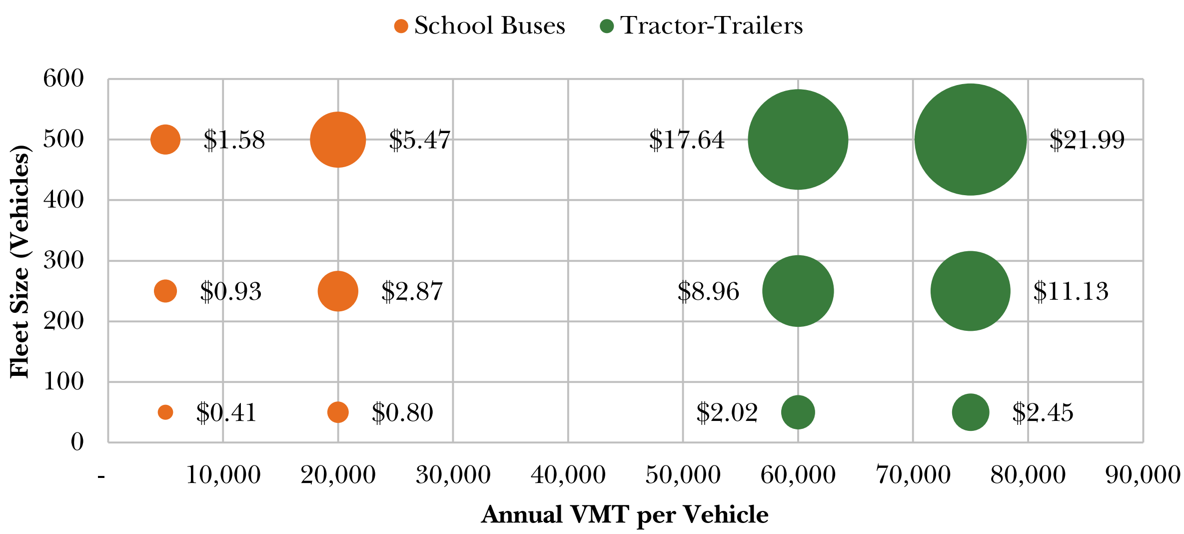
TABLE 4: Price Volatility of CNG, Gasoline, and Diesel from January 2012 to January 2015



Price volatility is a way to measure the extent to which a price changes over time. The amount by which prices deviated from the average price over a period is considered here the volatility value.

Source: C2ES Analysis, U.S. Department of Energy Alternative Fuels Data Center. "Publications: Alternative Fuels Price Report".

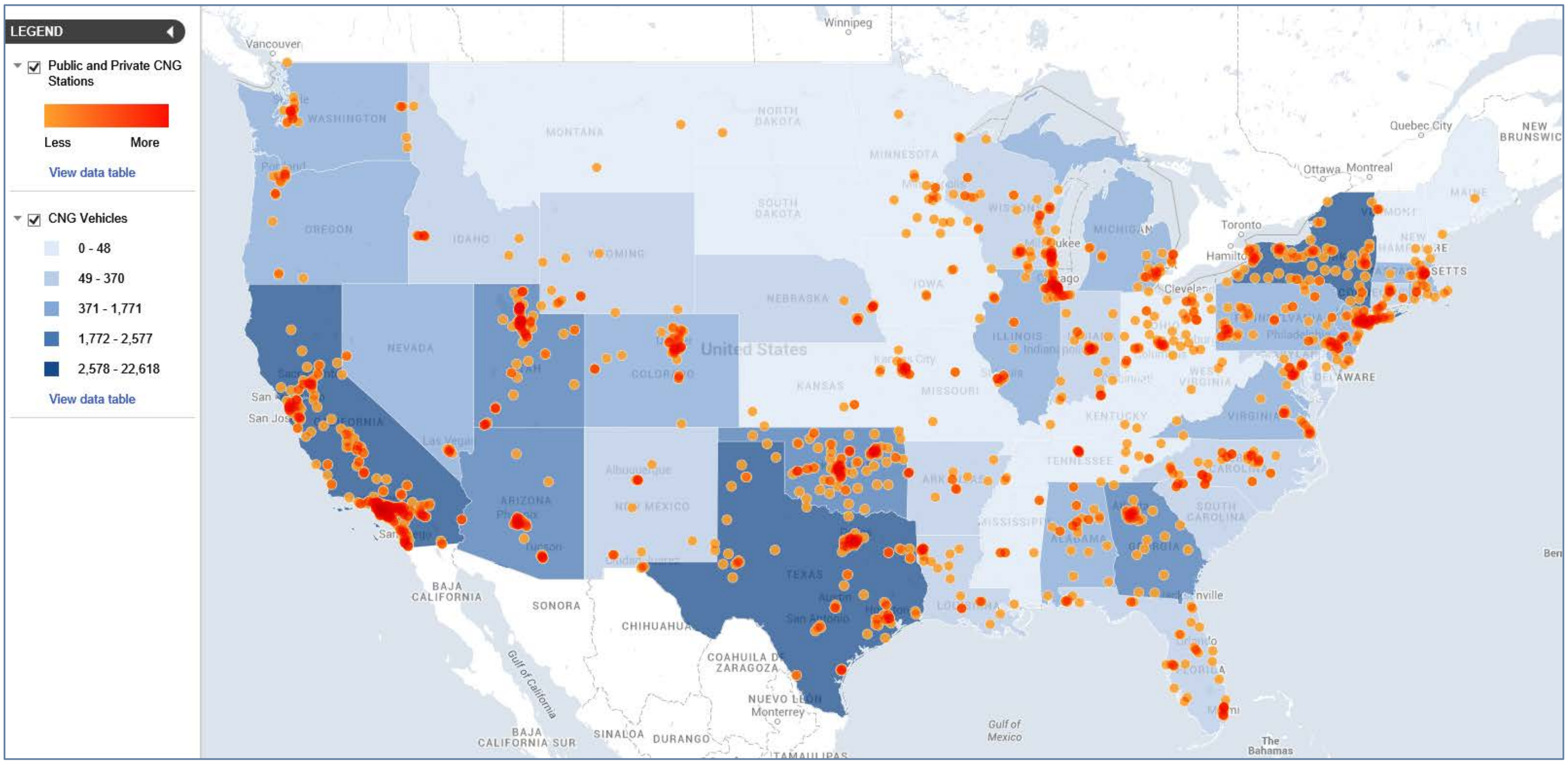
FIGURE 8: Fueling Infrastructure Costs for School Buses and Tractor-Trailers



This figure illustrates the estimated cost for fueling infrastructure for various school bus and tractor-trailer fleet projects by fleet size and VMT. The size of the bubbles is proportional to the additional cost for fueling infrastructure, which is labeled for each fleet scenario in millions of U.S. dollars.

Source: C2ES Analysis, U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0."

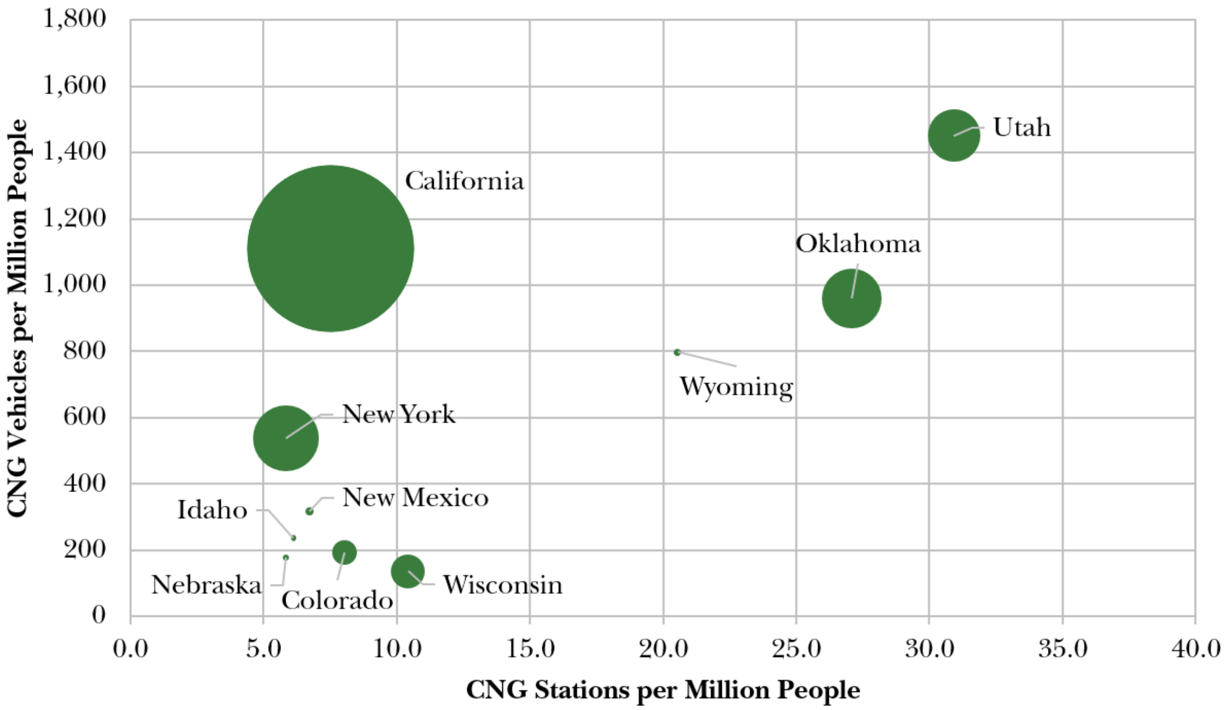
FIGURE 9: Deployment of CNG Vehicles and Fueling Infrastructure



This figure shows the deployment of CNG vehicles and public and private refueling infrastructure. The latest vehicle data is from 2011, while the infrastructure data is from February 2015. The most populous states (Texas, New York, and California) have the highest concentration of vehicles and infrastructure. Notably, infrastructure deployment in Oklahoma and Utah is high relative to population, and vehicle deployment in Georgia, Arizona, and Utah is high relative to population.

Source: C2ES, AFDC, U.S. EIA. "Maps: CNG Vehicle and Fueling Infrastructure Deployment." http://bit.ly/1H0zBpI.

FIGURE 10: Top 10 States for CNG Fueling Station Deployment



This figure shows the top 10 states for CNG fueling station deployment as a share of population compared to CNG vehicles as a share of population. The size of bubbles is illustrative of the overall number of public and private CNG stations.

Source: U.S. Department of Energy Alternative Fuels Data Center. "Natural Gas Fueling Station Locations". Accessed July 30, 2015. http://www.afdc.energy.gov/laws.

Locating projects in regions with existing infrastructure can significantly improve the financial viability of an NGV fleet. On a per capita basis, most CNG vehicles and fueling stations are located in only 10 states—New York, California, and eight states in the Rocky Mountain and Midwest regions (see **Figure 10**). Leveraging existing infrastructure for use among multiple fleets will significantly reduce the upfront costs of fueling station deployment. One option for managing shared infrastructure is the use of a fuel card system that identifies individual fleets and enables fueling tracking among fleet users.

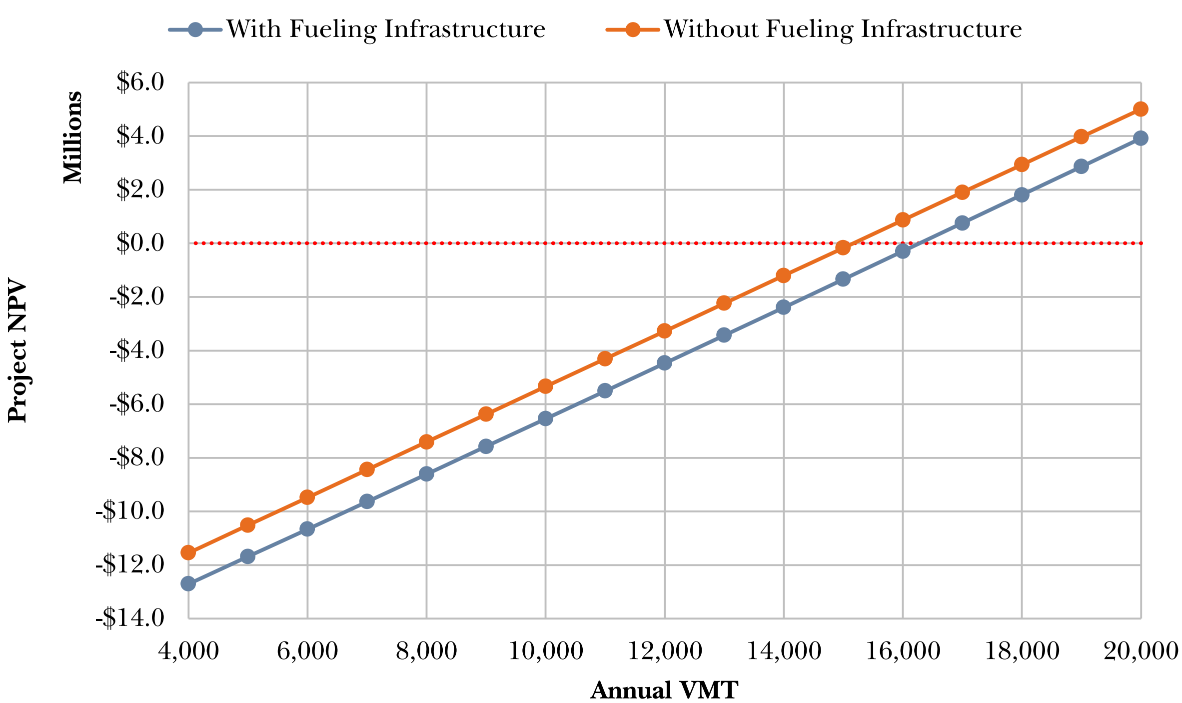
Existing public CNG fueling stations may be unable to accommodate particular fleet vehicles, even if the stations are located along key routes. Fueling time, fueling nozzle compatibility, and station location can all inhibit vehicles' ability to use fueling stations. Some fleet vehicles require fast-fill stations in order to refuel and quickly begin using the vehicle again, while other fleets can be accommodated by slower time-fill stations because they are expected to be parked for several hours between uses. The type of NGV refueling nozzle that a vehicle requires may depend on its uses. Vehicles that require higher volume can use the CT5000 nozzle (3/8-inch tubing), while other vehicles use the CT1000 nozzle (1/4-inch tubing).[44] These nozzle standards are not compatible.

The condition and the location of existing stations may also exclude vehicles that would otherwise be able to use the stations. In New York, many of the public stations are unreliable, outdated, and potentially incompatible with current vehicle offerings; many stations are also not sited in locations that are conducive to tractor-trailers and other very large vehicles.[45]

The total number of existing stations within a region also affects the need for new fueling infrastructure. The entire state of Colorado has only 19 public CNG stations, which would be unlikely to accommodate a large number of vehicles, even though the stations may be in high traffic locations. As a result, additional infrastructure may be needed for new projects in these states, which would add to the cost of a fleet conversion project. For that reason, the Colorado Energy Office launched ALT Fuels Colorado, a program designed to fund 20 to 30 CNG fueling stations along the state's major transportation corridors by 2018. The program focuses on heavy-duty vehicles, so the majority of the stations will be able to support tractor-trailers.[46]

The need for CNG station infrastructure does not eliminate the value proposition for NGVs, but does increase the project payback time. The value of converting to natural gas increases as travel increases due to fuel cost savings, although projects requiring new fueling infrastructure improve at a slower rate than projects that can make use of existing infrastructure. A conversion project for a hypothetical school bus fleet with no new fueling infrastructure and an average annual VMT of 20,000 has a net value, considering the future value of money (net present value or NPV), that is 500 percent higher than a fleet averaging 4,000 VMT annually. The NPV of a 20,000 annual VMT project requiring new fueling infrastructure is 400 percent higher than the same project with a 4,000 annual VMT fleet (see **Figure 11**).

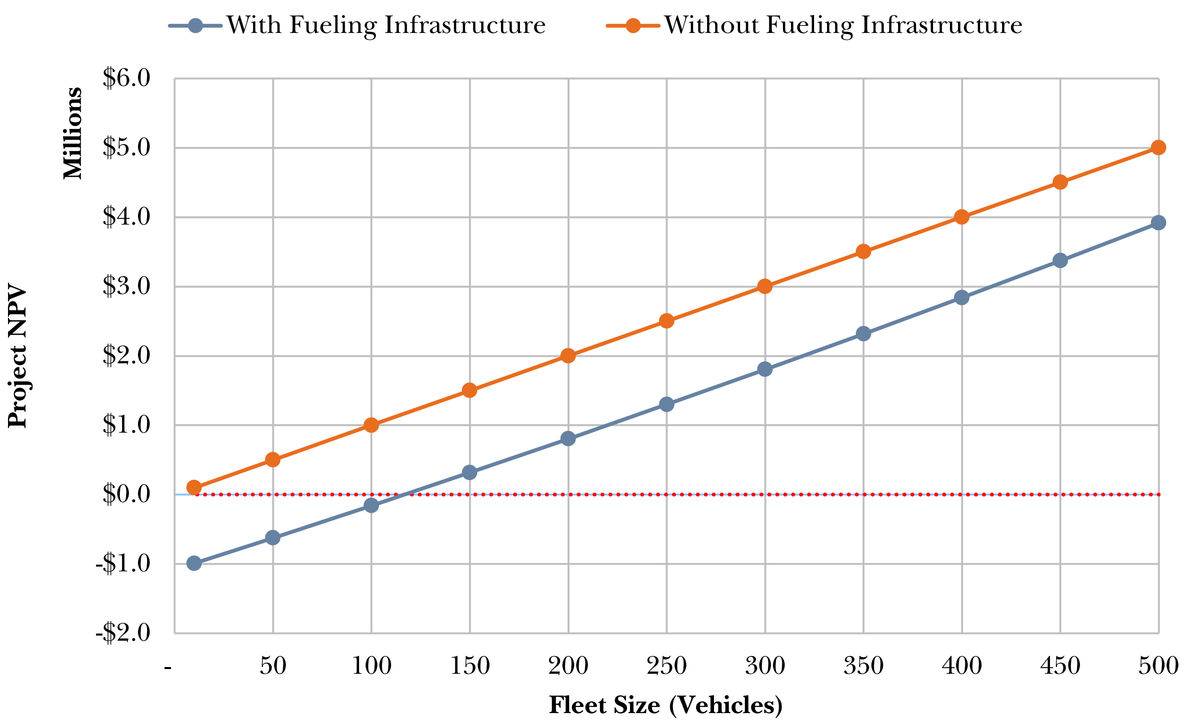
FIGURE 11: Effect of VMT on Project Net Cost Saving for School Buses



Source: This figure shows the effect of annual VMT on the financial performance of a hypothetical natural gas conversion project for school buses. Only the annual VMT was varied for a project with and without new fueling infrastructure in order to isolate the effects of vehicle use. The fleet size was 500, the price for CNG with new fueling infrastructure was $1.67 per gasoline-gallon equivalent (the price of natural gas from the local utility), and the price for CNG using existing fueling infrastructure was $2.13 per gasoline-gallon equivalent (the retail price of CNG). All other assumptions matched the base case assumptions listed in Appendix C.

Source: C2ES Analysis, U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0."

FIGURE 12: Effect of Fleet Size on Project Net Cost Savings for School Buses



Source: This figure shows the effect of fleet size on the financial performance of a hypothetical natural gas conversion project for school buses. Only the fleet size was varied for a project with and without new fueling infrastructure in order to isolate the effect of fleet size on NPV. The annual VMT for each vehicle was 20,000, the price for CNG with fueling infrastructure was $1.67 per gasoline-gallon equivalent, and the price for CNG without fueling infrastructure was $2.13 per gasoline-gallon equivalent. All other assumptions matched the base case assumptions listed in Appendix C.

Source: C2ES Analysis, U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0."

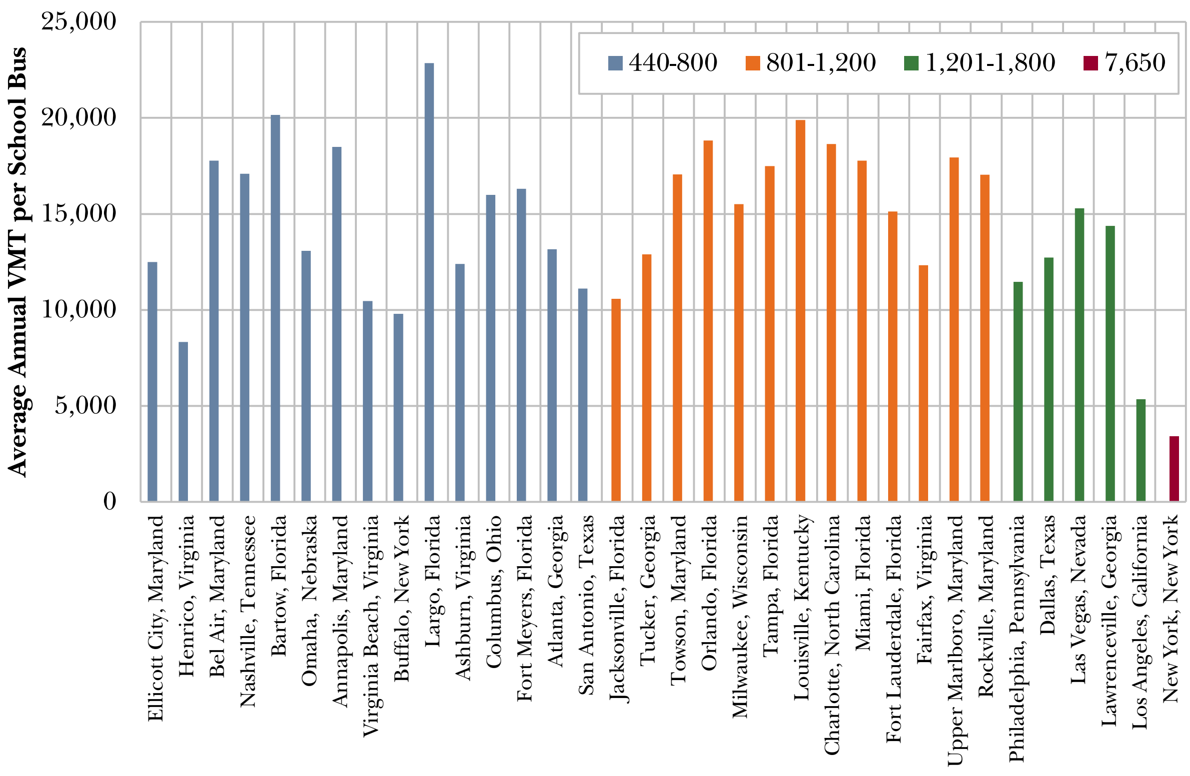
For fleets requiring new fueling infrastructure, larger fleets will more likely be able to achieve a net cost savings than small fleets. When average annual VMT is held constant, the net savings for the hypothetical projects with and without new fueling infrastructure are mostly linear as the fleet size increases. The increase in net savings is due to the lower price of acquiring natural gas and compressing it on site when new fueling infrastructure is included in the project. The analysis assumed natural gas supplied directly by the local utility cost $1.67 per gasoline-gallon equivalent and CNG from a local retailer cost $2.13 per gasoline-gallon equivalent. The cost of new fueling infrastructure reduces the financial benefit of lower natural gas prices, but a fleet of 500 buses still has an NPV nearly five times higher than a project with 10 buses when new fueling infrastructure is required. The fleet size would have to be greater than 100 vehicles to reach payback with new fueling infrastructure in this example, while a fleet of 10 could achieve net cost savings if it did not require new fueling infrastructure (see **Figure 12**).

The fuel cost savings of large fleets with high mileage may offset or exceed fixed and variable costs such as vehicle purchases, fueling infrastructure installation, and replacement equipment. The costs of added fueling infrastructure are shown in **Figure 8**, where increases in VMT and fleet size result in higher operating costs. However, **Figure 11** and **Figure 12** illustrate scenarios in which high VMT and very large fleet size save sufficient fuel costs to achieve net profitability by converting school bus fleets to natural gas. Notably, the two scenarios illustrated by **Figure 11** and **Figure 12** have different fuel prices, but due to differing variable costs, each project's NPV rises at a very similar rate as VMT and fleet size increase. The scenarios that require new fueling infrastructure use less expensive CNG, but the variable costs of fuel provision and infrastructure maintenance give the projects a similar cost curve to the scenarios that use more expensive CNG but do not require new fueling infrastructure.

Many of the largest school bus fleets in the United States could be suitable for NGV deployment projects.

As mentioned above, fleet size and VMT are critical determinants for a natural gas school bus project to achieve a net cost savings. Of the 50 largest school bus fleets where travel data is available (35 out of 50), 18 fleets' buses average more than 15,000 miles per year, and all but one of those fleets use more than 500 buses per day.[47] As **Figure 11** illustrates, fleets with school buses that average approximately 15,000 miles per year may approach net profitability. **Figure 13** shows the average annual VMT for the largest U.S. school bus fleets. Notably, some fleets comprise smaller private contractors that in aggregate constitute the city's fleet, as is the case in New York City. Fleet size data on private tractor-trailer fleets is not currently publicly available.

FIGURE 13: Average Annual VMT for Largest U.S. School Bus Fleets



This figure shows the average annual VMT for the largest school bus fleets in the United States. The categories indicate the number of buses in daily use for each fleet. The smallest fleet in this group has 440 vehicles (Ellicott City, Maryland) and the largest has 7,650 vehicles (New York City). VMT data was only available for 35 of the top 50 school districts.

Source: McMahon, Thomas. School Bus Fleet. October 2015. Accessed July 30, 2015.

State and local utility programs can directly reduce the financial barriers to NGV deployment and improve the financial performance of a fleet conversion project. According to the U.S. Department of Energy Alternative Fuel Data Center, 34 states and the District of Columbia have some financial inventive in place to facilitate NGV deployment for fleets, including grant, loan, and rebate programs and tax incentives.[48] These programs can lower upfront vehicle costs and reduce the cost of fueling infrastructure and CNG.

The Colorado Energy Office, for example, offers grant funding up to $500,000 per station for publicly available CNG stations through ALT Fuels Colorado.[49] By restricting the funding to public stations, the state is encouraging fuel providers to install shared use stations, which could lead to a more robust publicly available fueling network. By early 2016, a series of publicly accessible CNG stations funded through the program will connect Colorado's most heavily trafficked fleet corridor, Interstate 25. As the program advances, more of these corridors are expected to develop across the state with a greater role from the private sector. In addition, the Colorado Department of Local Affairs is funding a publicly available CNG station and helping offset the cost of five natural gas buses for use at the Valley Re-1 School District in Gilcrest, Colorado. The project's private sector partner, Noble Energy, contributed more than $875,000 to fund the station and a maintenance barn.[50] Through ALT Fuels Colorado, the Regional Air Quality Council also helps to fund up to 80 percent of the incremental cost of natural gas, liquefied petroleum gas, or electric drive school buses, trash trucks, water trucks, delivery vehicles, transit buses, pickup trucks, vans, and other on-road Class 2-8 vehicles.[51]

Colorado also offers energy coaching services to fleets through the Refuel Colorado Fleet Coaching program. Program coaches help fleet managers calculate the life-cycle cost savings of switching to AFVs and help identify grant programs and tax credits. The coaches also provide technical guidance on issues including fueling or charging, maintenance, and safety. Coaches help fleet managers understand which incentives apply to their vehicles based on their location, vehicle class, fuel type, and whether the fleets are public or private. They also identify the locations of existing fueling infrastructure and inform fleets about stations that are in the planning and construction phases. The advice that the coaches offer serves the program's aim to build self-sustaining alternative fuel markets by working with community leaders, fuel providers, and dealerships.[52]

Similarly, New York's Voucher Incentive Program may fund up to 80 percent of the incremental cost (up to $40,000) of CNG medium- and heavy-duty trucks (Class 3 through 8) that operate 70 percent of the time and garage in New York City.[53] Lowering the incremental cost of the vehicle or fueling infrastructure would increase the likelihood of an NGV project achieving a net cost savings and would reduce the project's payback period. New York's Clean Air School Bus Program provided grants for CNG school buses up to $7,500 per vehicle. The program expired at the end of 2014.[54]

One California utility, Southern California Gas Company, offers a rate reduction of less than 5 percent from the standard natural gas rates at retail CNG stations.[55,56] This rate reduction can lower the cost of fuel below retail and commercial rates, thereby increasing the fuel price spread between CNG and diesel or gasoline.

Summary: Financial Performance Key Factors

Local fuel prices, publicly available fueling infrastructure, and state financial incentives can all have a significant effect on the financial performance of an NGV fleet conversion project. For instance, comparative fuel prices in the United States favored CNG projects from January 2012 to January 2015, when CNG cost at least $1.40 less per gasoline-gallon equivalent. The steep decline in global oil prices that began in late 2014, however, eliminated much of the price advantage of CNG over gasoline by January 2015, though CNG prices continue to be favorable to diesel prices. Although fleet managers would likely consider expected future prices, which the EIA predicts will again favor CNG over the coming decades, in addition to current market conditions, the low price of oil can deter near term action.

The state of natural gas fueling infrastructure is also an important consideration for fleet managers. Adding new fueling infrastructure to a project significantly increases upfront costs and can extend payback periods beyond the expected life of equipment, making projects financially infeasible. The ability for fleet managers to partially or fully leverage existing public fueling infrastructure can greatly improve financial performance.

CNG fleet conversion projects are most likely to be financially viable with large fleets that have high VMT. The potential fuel cost savings of CNG use would be magnified through greater use, as each mile traveled by each vehicle would be less expensive than an equivalent mile fueled by gasoline or diesel. The fuel cost savings would help to offset the upfront costs of vehicle conversions and any new fueling infrastructure that the project may need.

Public incentives can work to overcome some of the financial barriers to deployment. For example, vehicle rebates or grants that seek to promote vehicles that emit lower greenhouse gas emissions or local criteria pollutants can encourage fleet managers to act on fleet conversion projects in the near term in spite of low oil prices. Public grants that fund fueling infrastructure and require those stations to be made available to the public can make future projects more cost effective and encourage small fleets to adopt NGVs.

Where projects are financially viable, energy service providers can leverage their technical expertise and project experience by offering fleet managers a number of services that ease the transition to natural gas. The next section identifies fleet conversion projects that could yield a net cost savings and the level of funding that fleet managers could pay an energy service provider in exchange for ESCO-like services.

QUESTION 3. UNDER WHAT CONDITIONS WILL NGV FLEET PROJECTS RESULT IN NET COST SAVINGS, AND IS THERE VALUE TO HAVING AN ENERGY SERVICE PROVIDER HELP WITH THE TRANSITION?

To illustrate the options and analyses that any fleet manager might want to consider, the following section summarizes scenario financial analyses of switching from gasoline- or diesel-powered vehicles to natural gas for three fleet types: private tractor-trailers, public school buses, and public light-duty vehicles (passenger cars, light trucks, and delivery trucks). Also considered is under which potential conditions a fleet operator could share the net savings of switching to natural gas with an energy service provider in exchange for ESCO-like services. In general, the cost savings of switching to NGVs must be great enough to cover the energy service provider's costs and provide the necessary benefit for the fleet owner (see **Box 2**).

Box 2. Energy Service Provider Fee Assessment

The cost of natural gas conversion services can be difficult to estimate. One way for energy service providers to structure their service fees is to share in a portion of the energy cost savings associated with a project. The analysis presented in this guide assumes that energy service providers will offer increasing amounts of services as its share of the energy cost savings increases. Fleet managers may choose to solicit services based on their needs up to but not exceeding the net fuel cost savings.

As discussed in Section 2, the net cost savings of NGV projects depends upon several factors, including fuel prices, equipment costs, and fleet use patterns. The estimated future costs of business-as-usual fleet operations (purchasing and using diesel or gasoline and vehicles powered by these fuels) was compared to the estimated costs of purchasing and using comparable NGVs and natural gas fuel. The National Renewable Energy Laboratory's VICE model provided two metrics to evaluate the financial viability of the conversion project—the net present value (NPV) and the payback period of the project. The duration of each project was assumed to be equivalent to the expected life of each vehicle type, so these analyses assume that the fleets use their vehicles for their entire useful life and do not sell them in the secondary market. The following scenarios were considered for each fleet type:

- **Fleet Sizes**: Fleets consisting of 50, 250, and 500 vehicles.
- **Annual VMT**: Fleets with 5,000, 10,000,15,000, and 20,000 annual VMT for school bus and

public light-duty fleets. For tractor-trailer fleets, scenarios were analyzed for 60,000, 65,000. 70,000, and 75,000 annual VMT.

- **Fueling Infrastructure**: Projects with and without new fueling infrastructure costs.

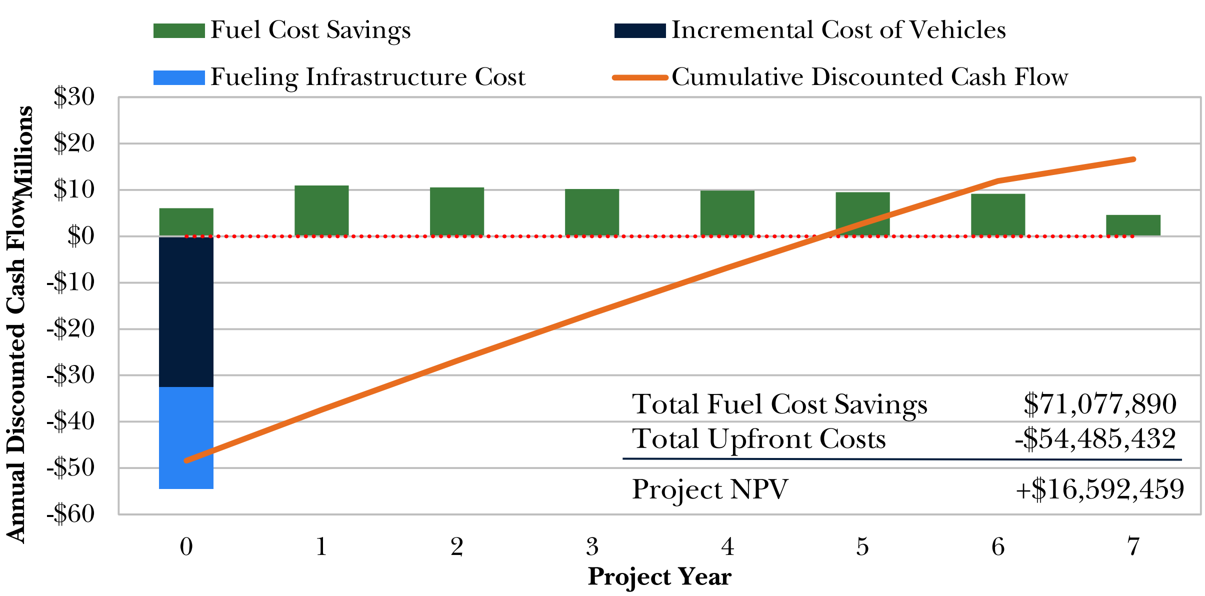
See Appendix C for all assumptions and Appendix D for detailed results from the financial analyses discussed in this section.

The financial performance of an NGV deployment project depends primarily on fuel cost savings, which is a function of the following factors:

- Price differences between diesel/gasoline and CNG;
- Fuel economies of the NGV and conventional diesel/gasoline vehicles;
- Average annual VMT including for the entire fleet;
- Fleet size; and
- Expected life of the NGVs.

For an NGV project to achieve net cost savings, the NPV of annual fuel cost savings must be greater than the incremental vehicle and fueling infrastructure costs. The project must achieve payback sooner than the expected life of the equipment, and often within five years of investment in order for private investors to consider the project. **Figure 14** shows the discounted cash flow of an example tractor-trailer fleet conversion project that achieves payback in about five years with an NPV of more than $16 million. The analysis uses the CNG and diesel prices from the 2014 U.S. EIA's Annual Energy Outlook. The analysis also assumes the NGV is used for its entire useful life, so there is no residual value for the vehicle, which would otherwise have an impact on financial calculations.

FIGURE 14: Example Discounted Cash Flow for Tractor-Trailer Fleet Project with New Fueling Infrastructure

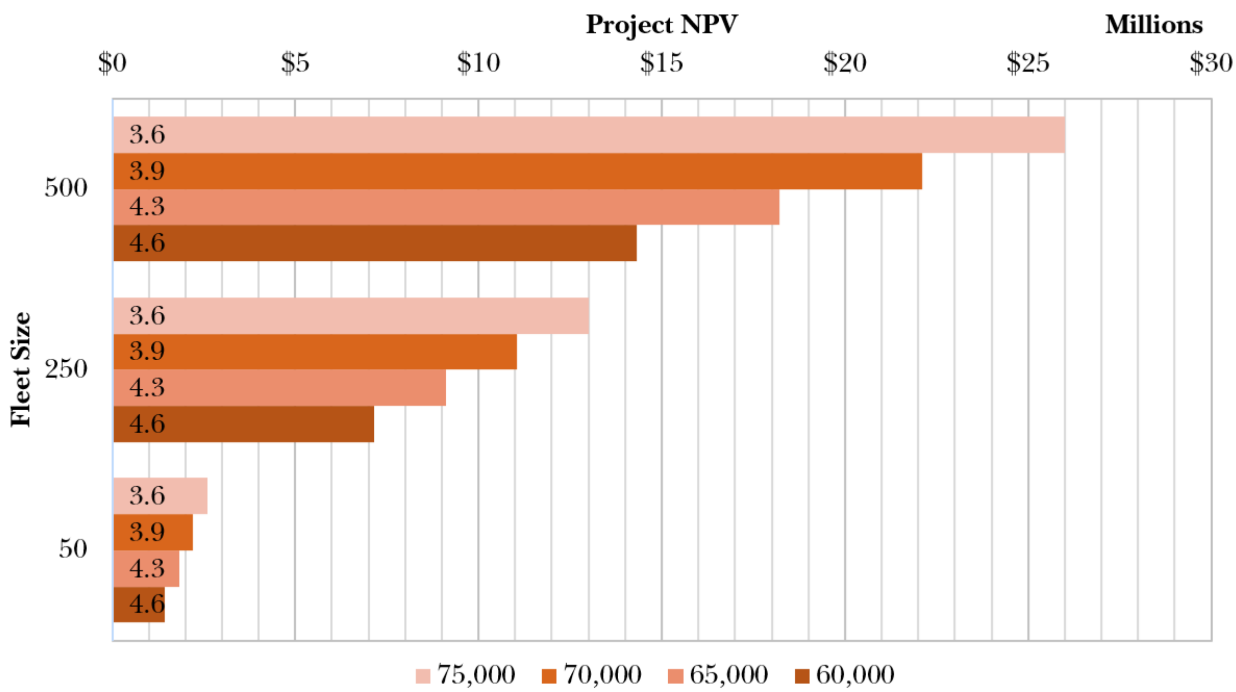


This figure shows the discounted cash flow for a tractor-trailer fleet conversion project with new fueling infrastructure costs. The fleet consists of 500 vehicles, each traveling an average of 75,000 miles per year. Otherwise, all assumptions matched the baseline assumptions defined in Appendix C. Fuel cost savings are realized each year since natural gas costs less than diesel beginning in the project's first year, when the upfront costs of purchasing the vehicles and fueling infrastructure are assessed. The project achieves a payback in 5.2 years with an NPV of more than $16 million, assuming the vehicles will last 7 years.

Source: C2ES Analysis, U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0."

Transitioning from diesel to natural gas can achieve a net cost savings for private tractor-trailer fleets under a wide range of conditions. Using fuel prices from the U.S. EIA's 2014 Annual Energy Outlook, all tractor-trailer scenario combinations of fleet size, VMT, and the inclusion of new fueling infrastructure but one yield net cost savings by transitioning to natural gas. Because these vehicles use large volumes of fuel, the upfront costs of fueling infrastructure and the natural gas engine conversions are paid back quickly relative to other vehicle types. For projects without new fueling infrastructure requirements, payback can be achieved in less than five years under all scenarios. Tractor-trailer conversion projects may not require fueling infrastructure investments because they often travel long routes and do not return to the fleet's home base each night, so the vehicles tend to depend more on existing publicly available fueling infrastructure than other fleet types. Projects with new fueling infrastructure costs that achieve a net cost savings have a payback period greater than five years. For these projects, sharing new fueling infrastructure with other fleets could help lower the incremental costs of providing a fueling station. **Figure 15** and **Figure 16** illustrate the degree of cost savings over the life of a project under each scenario evaluated.

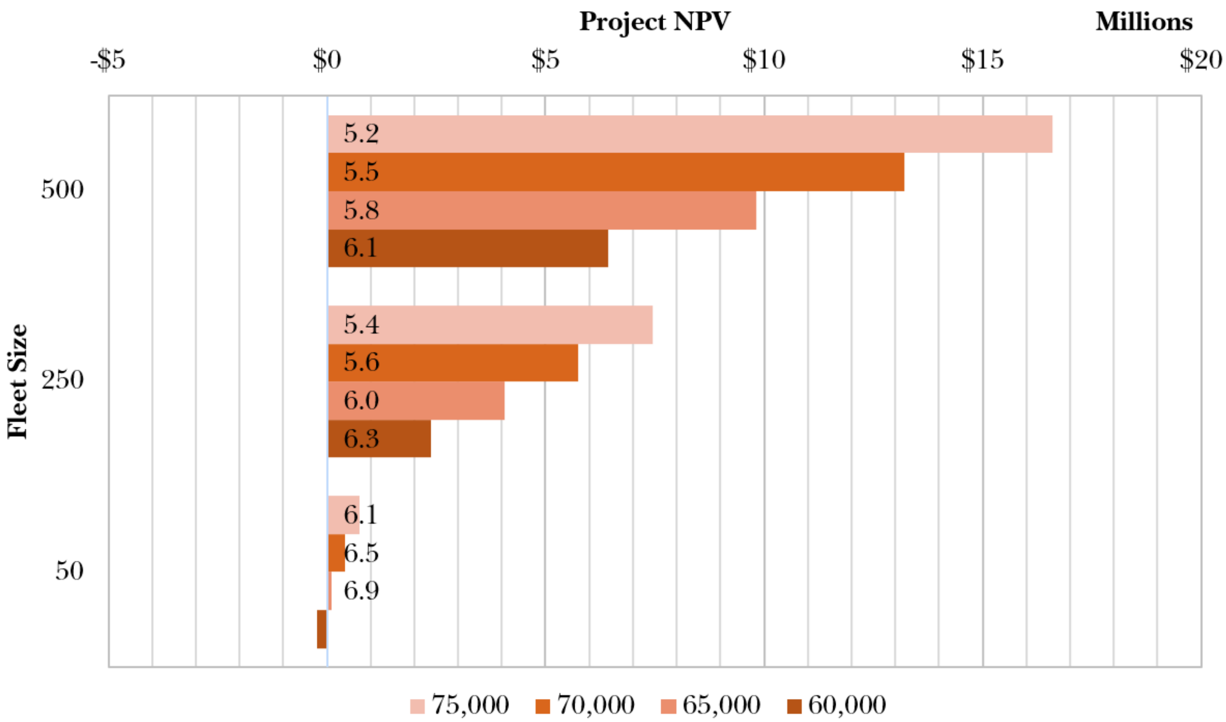
FIGURE 15: Tractor-Trailer Fleet without New Investment in Fueling Infrastructure Scenario Analysis Results



Payback in years is noted in the figure. The project lifetime is 7 years, which is the equivalent of the expected life of the vehicle. The legend denotes the annual VMT for each vehicle in the fleet.

Source: C2ES Analysis, U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0."

FIGURE 16: **Tractor-Trailer Fleet with New Investment in Fueling Infrastructure Scenario Analysis Results**



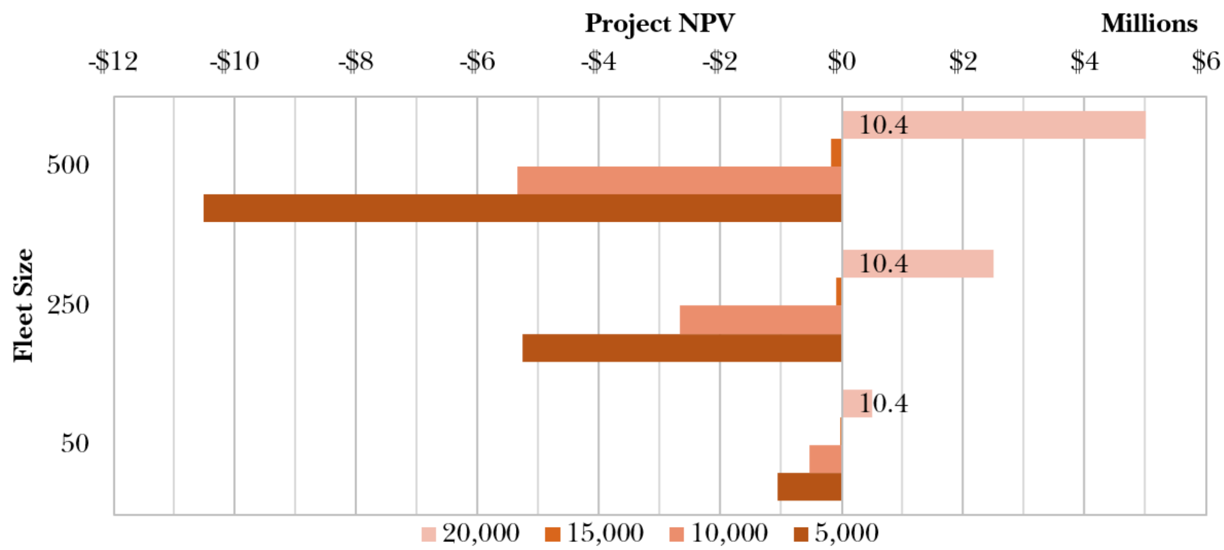
Where possible, payback in years is noted in the figure. The project lifetime is 7 years, which is the equivalent of the expected life of the vehicle. The legend denotes the annual VMT for each vehicle in the fleet.

Source: C2ES Analysis, U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0."

School bus fleets must have a very high annual VMT in order to achieve a net cost savings from converting to natural gas. Under the scenarios analyzed, the financial return on projects range from a loss of $11.7 million to a gain of $5 million (see **Figure 17** and **Figure 18**). Only school bus fleets that have an average annual VMT of 20,000 or more achieve a positive payback, regardless of the need for new fueling infrastructure. When new infrastructure is required, fleets of only 50 vehicles do not achieve payback even when they average 20,000 miles annually. According to the 2014 *School Bus Fleet* maintenance survey, 63 percent of fleets travel between 10,000 and 19,999 miles on average, and 16 percent of fleets travel more than 20,000 miles.[57]

The travel needs of a bus fleet depend on a number of factors such as fleet size, bus routes for the school district, and the number of students to transport. Thus, fleets with low annual VMT, including dense urban areas with short routes, may not achieve a net cost savings by switching to natural gas. New York City, for example, has more than 7,000 active daily buses, but they travel less than 3,500 miles per year on average.[58] See **Figure 17** and **Figure 18** for a summary of the financial performance of school bus fleet conversion projects.

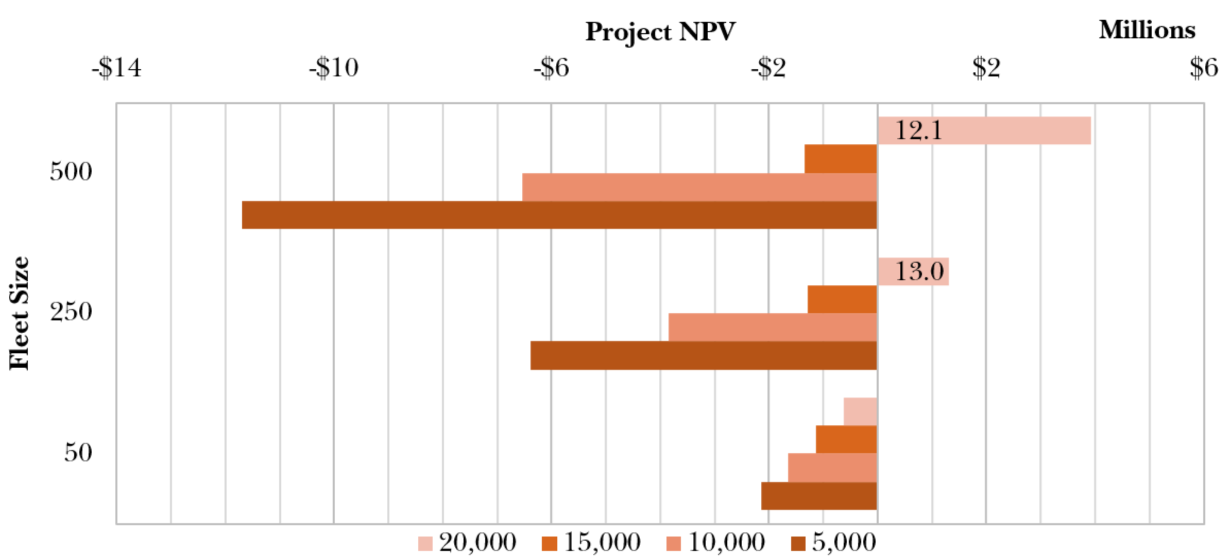
FIGURE 17: School Bus Fleet without New Investment in Fueling Infrastructure Scenario Analysis Results



Where possible, payback in years is noted in the figure. The project lifetime is 15 years, which is the equivalent of the expected life of the vehicle. The legend denotes the annual VMT for each vehicle in the fleet.

Source: C2ES Analysis, U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0."

FIGURE 18: School Bus Fleet with New Investment in Fueling Infrastructure Scenario Analysis Results



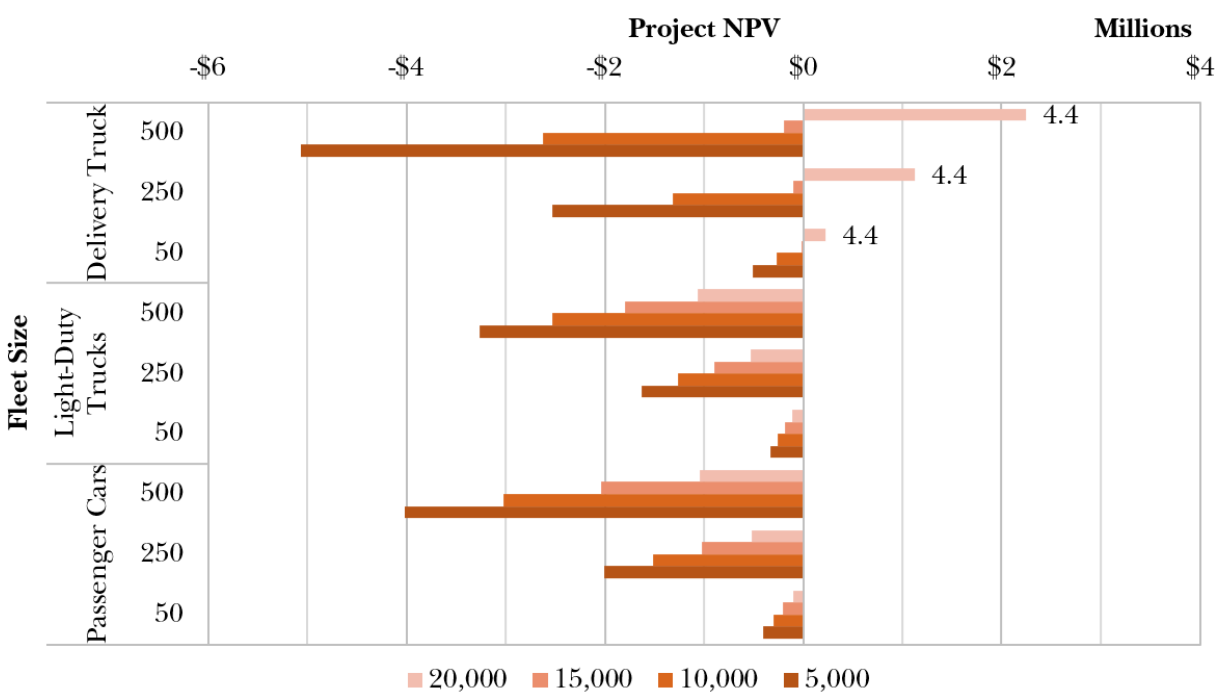
Where possible, payback in years is noted in the figure. The project lifetime is 15 years, which is the equivalent of the expected life of the vehicle. The legend denotes the annual VMT for each vehicle in the fleet.

Source: C2ES Analysis, U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0."

Public light-duty vehicles may only achieve payback when VMT is high and no new fueling infrastructure is required. The financial returns on these projects range from a loss of $6.5 million to a net cost savings of $2.2 million (see **Figure 19** and **Figure 20**). Given the assumed price spread between gasoline and CNG, delivery truck fleets, for example, can achieve a net cost savings from switching to natural gas in less than 5 years, but only if no additional fueling infrastructure is required and if the fleets have a sufficiently large annual VMT (20,000), regardless of fleet size. In contrast, most types of light-duty trucks and passenger cars will have difficulty achieving a payback regardless of the fleet's size, average annual VMT, or need for fueling infrastructure because these vehicles do not consume enough fuel on an annual basis to offset the higher upfront vehicle costs.

The high fuel economy of light-duty gasoline vehicles is a major factor affecting fuel cost savings because these vehicles consume only a fraction of the fuel that a delivery truck, school bus, or tractor-trailer consumes (see **Table 2**). **Figure 19** and **Figure 20** summarize the financial performance of public light-duty vehicle conversion projects. From the figures, even without added fueling infrastructure, light trucks' per-vehicle fuel cost savings ($1,115 per year) accumulated over the life of a vehicle would not be high enough to pay for a vehicle's incremental cost of $10,000. Similarly, the per-vehicle fuel cost savings for passenger cars ($786 per year), accrued over the vehicle's lifetime would not exceed the vehicle's incremental cost of $8,000. The delivery truck's annual fuel cost savings under a high annual VMT scenario ($3,544 per year) more than make up for its shorter average vehicle life due to its greater fuel use.

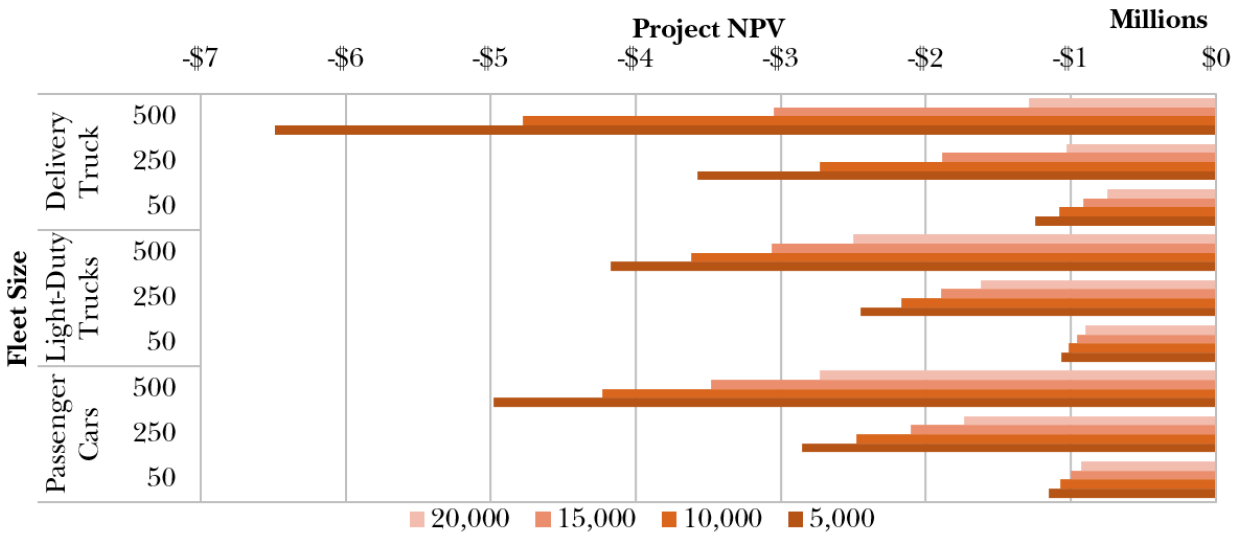
FIGURE 19: Light-Duty Vehicle Fleet without New Investment in Fueling Infrastructure Scenario Analysis Results



This figure shows the financial performance for delivery trucks, passenger cars, and light-duty trucks. Delivery trucks averaging 20,000 annual VMT are the only scenarios that reach payback, as noted in the figure. The project lifetime is 6.5 years for delivery trucks and 7.4 years for light-duty trucks and passenger cars. The legend denotes the annual VMT for each vehicle in the fleet.

Source: C2ES Analysis, U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0."

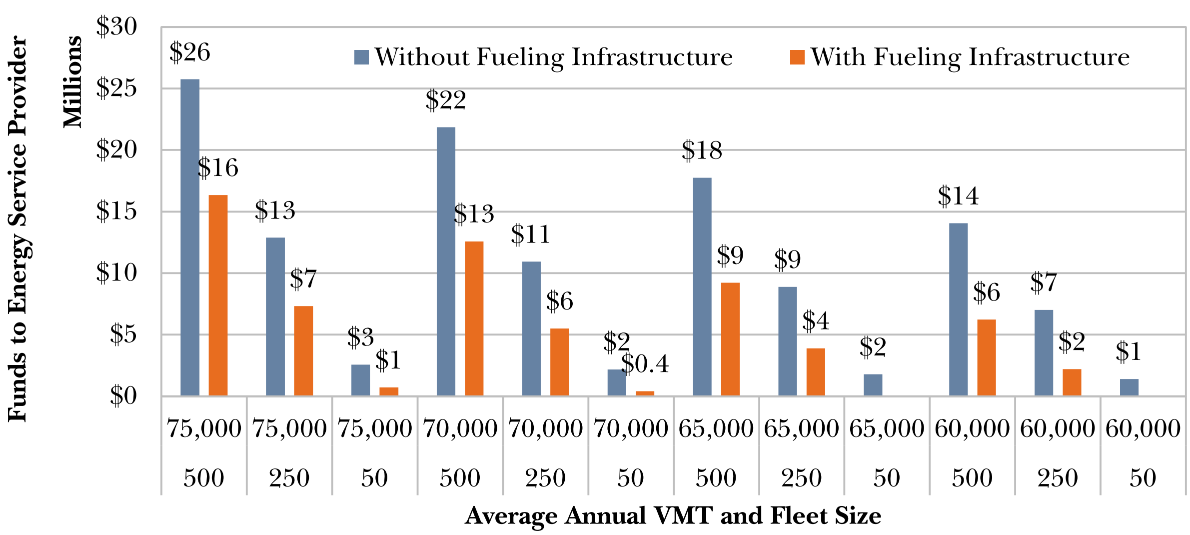
FIGURE 20: Light-Duty Vehicle Fleet with New Investment in Fueling Infrastructure Scenario Analysis Results



This figure shows the financial performance for delivery trucks, passenger cars, and light-duty trucks. Payback is not achieved under any scenario. The project lifetime is 6.5 years for delivery trucks and 7.4 years for light-duty trucks and passenger cars. The legend denotes the annual VMT for each vehicle in the fleet.

Source: C2ES Analysis, U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0.

FIGURE 21: Available Net Fuel Cost Savings from Scenario Analysis for Tractor-Trailer Fleet Operators to Purchase Services from an Energy Service Provider



This figure illustrates at least 90 percent of a project's annual fuel cost savings that a fleet operator could spend to procure services from an energy service provider. The funds spent on services from the energy service provider are discounted at a rate of 6 percent.

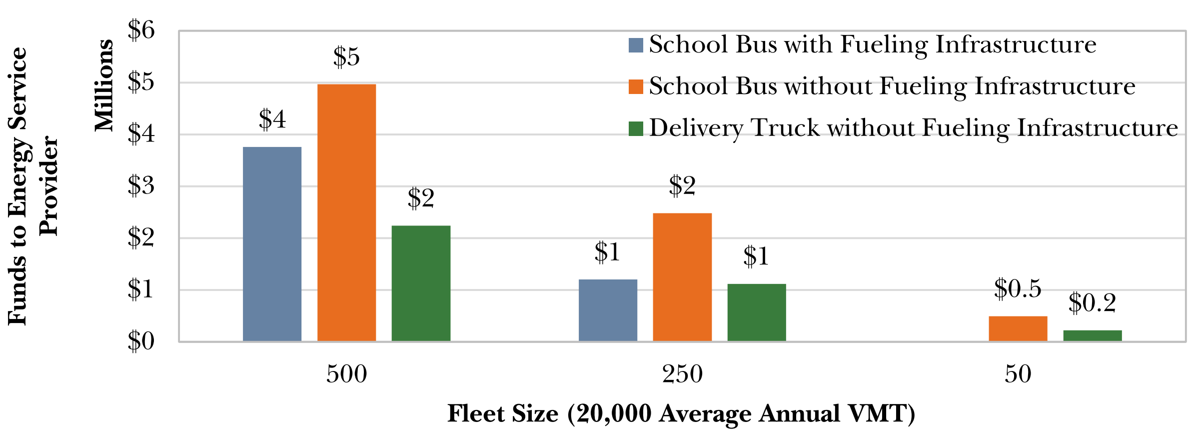
Source: C2ES Analysis, U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0."

An energy service provider can help fleet managers deploy NGVs, but the potential savings from NGV fleet conversions may dictate the level of service. Fleet managers that forecast a net profit from converting to NGVs could share a percentage of their annual fuel cost savings with energy service providers in exchange for services. Based on the illustrative examples above, tractor-trailer fleet managers could be the most likely to generate cost savings through NGV vehicle conversions under several scenarios, and therefore would be able to procure the most ESCO-like services from energy service providers. As illustrated by **Figure 21**, over the life of a seven year project, tractor-trailer fleets could yield a net cost savings ranging between $50,000 for a fleet with 50 vehicles (averaging 60,000 miles per year) and more than $25.7 million for a fleet with 500 vehicles (averaging 75,000 miles per year).

The analyses also show that the only school bus fleets that achieve net cost savings are fleets that travel at least 20,000 miles per year. The only light-duty vehicle fleets that achieve net cost savings are delivery truck fleets that travel at least 20,000 miles per year and do not require fueling infrastructure. All analyses and associated ranges of net cost savings assume that a fleet manager spends at least 90 percent of a project's annual fuel cost savings on the provision of energy services, though the percentage of annual fuel cost savings that a fleet manager may actually spend on the provision of energy services may vary.

School bus and light-duty vehicle fleets can afford more ESCO-like services when projects do not require new fueling infrastructure. Only the scenarios in which fleets achieved net cost savings through converting to CNG would allow for fleet managers to procure energy services (see **Figure 22**). Based on the illustrative example, the larger school bus fleets of 250 or 500 vehicles that require fueling infrastructure investments could achieve a net cost savings exceeding $1.2 million, whereas the smallest fleet in the example analysis, consisting of 50 vehicles, did not achieve net cost savings. In contrast, all CNG school bus projects that do not require new fueling infrastructure could achieve net cost savings. Delivery trucks are the only light-duty vehicle evaluated in the analysis that achieved a net cost savings, and only under the scenario that did not require new fueling infrastructure. In those examples, a delivery truck fleet could receive ESCO-like services ranging from $224,000 to $2.24 million (see **Figure 22**).

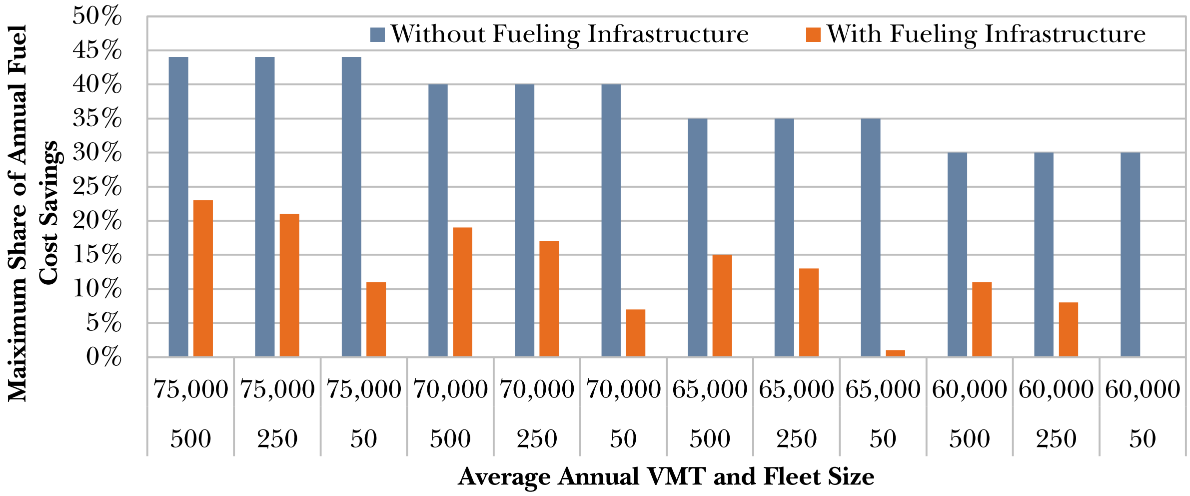
FIGURE 22: Available Net Fuel Cost Savings from Scenario Analysis for School Bus and Light-duty Vehicle Fleet Operators to Purchase Services from an Energy Service Provider



This figure illustrates at least 90 percent of a project's annual fuel cost savings that a fleet operator could spend to procure services from an energy service provider. The funds spent on services from the energy service provider are discounted at a rate of 6 percent.

Source: C2ES Analysis, U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0."

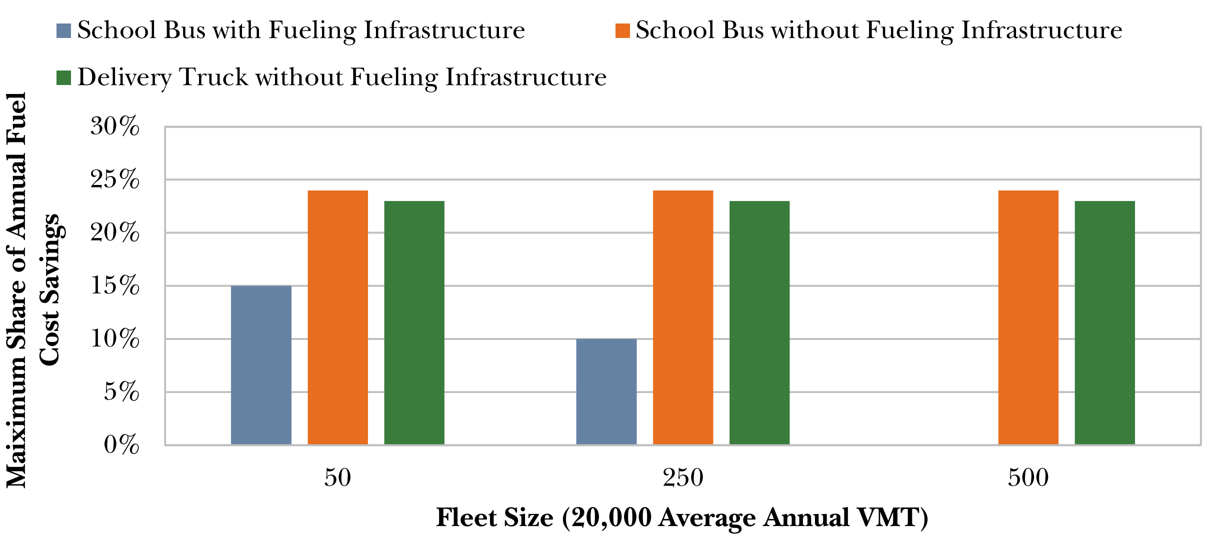
FIGURE 23: Using Nearly All Net Fuel Cost Savings for Tractor-Trailer Fleets from the Scenario Analysis



This figure illustrates the approximate maximum share of annual fuel cost savings that a tractor-trailer fleet manager can spend on services from an energy service provider and still result in a net cost savings over the life of the project.

Source: C2ES Analysis, U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0."

FIGURE 24: Using Nearly All Net Fuel Cost Savings for School Bus and Light-duty Vehicle Fleets from the Scenario Analysis



This figure illustrates the approximate maximum share of annual fuel cost savings that can be spent on services from an energy service provider and still result in a net cost savings over the life of the project.

Source: C2ES Analysis, U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0."

When projects do not require new fueling infrastructure, the share of annual fuel cost savings that fleet managers can apply towards ESCO-like services depends only on annual VMT. When new fueling infrastructure is needed, both VMT and fleet size affect the maximum share of annual fuel cost savings. In this scenario, larger fleets provide a higher percentage of savings because the cost of providing fueling infrastructure decreases as fleet sizes increase (see **Figure 23** and **Figure 24**).

Total annual fleet VMT is a key factor in identifying the maximum funding that a fleet manager can pay an energy service provider, since annual cost savings depend mostly on overall fuel use. The total annual vehicle miles traveled of a fleet is the product of fleet size and average annual VMT per vehicle. For tractor-trailer projects that do not require new fueling infrastructure, energy service providers could earn more from the fuel costs savings of a 500-vehicle fleet traveling 60,000 miles per year on average (30 million total miles) than from a 250-vehicle fleet averaging 75,000 miles per year (18.75 million total miles). When including fueling infrastructure costs, however, the fuel cost savings benefit of increasing the number of vehicles in a fleet diminishes because increased fuel consumption also increases operating and maintenance costs (see **Figure 21**).

A fleet manager must weigh the costs of the services that energy service providers offer against the benefits of those services. An energy service provider's fee could cost a fleet the vast majority of fuel cost savings. For example, a 10 percent energy service provider fee would consume more than 90 percent of a project's fuel cost savings for a hypothetical 250-vehicle school bus fleet with new fueling infrastructure. This additional cost, however, could be justified if the benefit requirements of the fleet are met. For instance, if greenhouse gas reductions are desired by a state agency, the benefit requirements of the agency may be met as long as these reductions are achieved and the cost of energy service provider is covered by the fuel cost savings.

Summary: Net Cost Savings from NGV Fleet Conversions

The financial performance of converting from diesel- or gasoline-powered vehicles to NGVs depends on five key factors:

1. **Price difference between diesel and CNG:** The price difference between diesel and CNG is the single most important factor in determining the financial performance of a conversion project. A large price difference between traditional petroleum fuels and less expensive CNG can greatly improve the project financial performance.
2. **Fuel economy**: Conventional vehicles with lower fuel economy present opportunities to reduce fuel costs because these vehicles use large quantities of fuel, which could use less-expensive natural gas as a substitute. However, NGVs generally have a relatively low fuel economy compared to their conventional vehicle counterparts, which can offset the potential fuel cost savings of switching to NGVs.
3. **Total average annual fleet VMT**: Fleets with a higher average annual VMT present a greater opportunity for fuel cost savings because the total fuel consumed is higher than average. The total average annual fleet VMT accounts for both the size of a fleet and the number of miles the fleet's vehicles drive per year.
4. **Vehicle lifetime**: The incremental cost of an NGV compared to a diesel or gasoline vehicle must be earned back within the useful life of a vehicle. Vehicles with long life expectancies have more time to accumulate fuel cost savings, which can result in a net cost savings over the life of the project.
5. **Fueling infrastructure**: Projects that require investment in dedicated refueling infrastructure provide lower net savings than projects that do not require fueling infrastructure investments because fleets must recoup additional upfront investments and pay for maintenance. However, fleet ownership of fueling infrastructure may enable fleet operators to acquire natural gas fuel for less than retail prices.

Hypothetical fleets of tractor-trailers, school bus fleets, and light duty vehicles were analyzed. Each fleet type can provide net cost savings from NGV deployment projects under some conditions, but only private tractor-trailers provide net cost savings under a wide range of conditions. For tractor-trailers, all scenarios evaluated achieve a net cost savings, with the exception of a fleet of 50 vehicles that travel 60,000 miles annually and require new fueling infrastructure. For school buses, only fleets that have a high annual VMT can achieve net cost savings. If new fueling infrastructure is required, then only relatively large fleets of 250 or 500 vehicles yield net cost savings. For light-duty vehicles, only delivery truck fleets that do not require fueling infrastructure investments achieve a net cost savings.

The ESCO business model requires that project benefits and cost savings be large enough to provide value for the energy service provider and the fleet manager. A positive financial performance is consequently a necessary criterion for successful implementation, but net cost savings may not necessarily be sufficient to enable a fleet manager to afford a full suite of the energy service providers' services. Hypothetical tractor-trailer fleet conversion projects yield a number of scenarios with sizeable business opportunities for energy service providers. For hypothetical school buses and light-duty vehicles, however, only a narrow set of conditions would allow an energy service provider to offer ESCO-like services in exchange for a share of the project's net cost savings.

The next section identifies key considerations regarding the role of energy service providers in NGV fleet projects.

QUESTION 4. WHAT ARE THE KEY CONSIDERATIONS REGARDING THE USE OF ESCO-LIKE SERVICES IN NGV FLEET PROJECTS?

The findings in this section summarize considerations for fleet managers and energy service providers regarding the provision of ESCO-like services in natural gas fleet projects. The section also includes findings on the role of government in enabling and facilitating these projects.

Building off the financial analysis presented previously, there are several scenarios where school bus and tractor-trailer fleets can achieve a net cost savings by switching from diesel to natural gas. In these cases, energy service providers can facilitate the transition to natural gas and earn a share of the fuel cost savings.

Applying the ESCO model to school bus and private tractor-trailer fleets could help transition these fleets to natural gas powered vehicles, as explained below:

- **Public School Bus Fleets:** Energy service providers could work with one or more school districts to deploy natural gas school buses and associated fueling infrastructure. Services would likely include identification and evaluation of cost or emissions savings opportunities, provision of technology performance guarantees, management of the technology transition, and bundling projects into a portfolio.
- **Private Tractor-Trailer Fleets**: Energy service providers could work with private vehicle fleets to deploy fueling infrastructure and to support the adoption and conversion of natural gas Class 8 truck fleets, or heavy-duty tractor-trailer fleets. Services would likely include identification and evaluation of cost or emissions savings opportunities, provision of technology performance guarantees, management of the technology transition, alternatives to equipment ownership, and partnership facilitation. One unique challenge to applying the ESCO model to tractor-trailer fleets is structuring alternatives to fleets owning natural gas fueling stations, since many of them do not return to a central location daily and instead must rely on publicly available fueling infrastructure.

This section makes some extrapolations and draws upon applicable real-world examples whenever possible to present critical considerations in applying the valuable ESCO-like services to natural gas fleet conversion projects. The findings below provide examples of how ESCO-like services apply to NGV fleet conversion projects, and then identify barriers, and potential solutions, to the provision of energy services to NGV fleet conversion projects.

Applying ESCO-like services to natural gas fleet conversion projects

As outlined in the C2ES report, *Applying the Energy Service Company Model to Advance Deployment of Fleet Natural Gas Vehicles and Fueling Infrastructure Barriers*, an energy service provider could offer the following services to public and private fleets:

1. Identification and evaluation of project opportunities
2. Management of technology transition
3. Alternatives to equipment ownership
4. Fuel cost savings and technology performance guarantees
5. Bundling projects into a portfolio
6. Partnership facilitation

The section below presents findings on the potential services that energy service providers could offer fleet managers of NGV conversion projects. For more information on how each of ESCO-like services might be administered, consult *Applying the Energy Service Company Model to Advance Deployment of Fleet Natural Gas Vehicles and Fueling Infrastructure Barriers*. See also Appendices E-G for more information on the pros, cons, and uncertainties around providing ESCO-like services to each fleet type considered in this guide.

1. Identification and evaluation of project opportunities

Similar to the way they identify and evaluate project opportunities in the building sector, energy service providers could assist fleet managers in assessing the benefits of a transition to natural gas. For buildings, some clients may already be familiar with energy cost saving technologies, but they still value ESCO-like services because the providers have extensive experience with the scope of technological solutions.[59] Providers can offer authoritative assessments on the suitability of new technologies as well as the estimated cost savings from the use of a new technology.[60]

Energy service providers have been successful primarily in public and not-for-profit markets because these entities use existing energy use reduction goals as a driver to enter into long-term energy performance contracts[61] and additional opportunities may exist for NGVs. Fleet operators may be generally aware of the cost saving potential of natural gas as a fuel, but most lack direct experience with NGVs. Expert advice on the potential cost savings and project implementation details could increase the chances that an NGV project would be considered.[62]

The public and institutional sector accounted for more than 85 percent of ESCO revenues in 2011, including 64 percent from municipal, university, school, and hospital (MUSH) clients.[63] Similarly, government and institutional fleet projects could potentially make up the majority of the demand for ESCO fleet services because they tend to have a higher tolerance for projects with longer payback periods, may be seeking societal benefits like greenhouse gas or pollution reductions rather than maximized investment return, and may face many bureaucratic hurdles where an ESCO can help.

In addition, many government and institutional clients are already familiar and comfortable with the ESCO model, and financial institutions are familiar with applications of the ESCO model in these sectors. For instance, energy service providers already partner with school districts on building energy efficiency projects and could bundle school bus conversion projects with these existing projects.

Traditional ESCOs have had limited success in the commercial building energy efficiency markets[64] and may be similarly challenged to make an impact in commercial vehicle fleet markets. Private sector companies in the United States typically desire capital expenditures for energy projects to have short payback times, which may not be conducive to financial viability of energy efficiency upgrades. Similarly, the application of the ESCO model to vehicle projects may be hampered by the tendency of fuel cost savings contracting to work best for projects with longer payback periods.[65]

2. Management of technology transition

Energy service providers may have more experience with new technology and can help fleet operators implement NGV conversion pilot projects. Managers of public or private fleets may see a transition to a new technology as too risky or staff intensive to undertake on their own. Businesses that have scarce management time to devote to vehicle conversion projects, such as small fleet operations or businesses that are not primarily concerned with fleet vehicles, may value having an energy service provider manage their NGV technology transition. This service can be especially valuable to fleet operator who desire to have a third-party handle vehicle maintenance for the entire term of the vehicle lease, as is commonly done in vehicle leasing markets.[66]

Small public and private fleets, however, may not yield a net cost savings unless fueling infrastructure is already available, according to the analyses completed for this guide. As a result, energy service providers may want to consider directing their technical assistance toward small fleets that already have access to fueling stations (e.g., shared use or retail stations). On the other hand, public fleet managers may be more willing to invest in an energy service provider's technical assistance in a NGV conversion project because of the public benefits of increased NGV use.

3. Alternatives to equipment ownership

Energy service providers may be able to own the NGVs or fueling infrastructure and lease it to fleet managers. Avoiding equipment ownership can benefit public budgets if it lets fleet managers avoid upfront capital outlays. Often public fleet managers are unable to use funds from their operating budgets for capital expenditures, which can make it difficult to fund the large upfront capital outlays that vehicle and fueling infrastructure can require. For public entities that must borrow funds for fleet projects through bond issuances, the higher capital outlays and increased risk of NGV projects could deter interest in NGVs if the project negatively effects the terms of future bond issuances.[67] Shifting equipment ownership to an energy service provider can allow a project to be "off-balance-sheet," so that operational savings can be realized from a project's outset in order to minimize technology risk and upfront capital.

Fueling needs and leasing arrangements may also make avoiding equipment ownership attractive for some private fleets. For example, tractor-trailers fleets may require access to fueling stations several hundred miles away from a central location due to long travel routes, so contracts that prioritize fueling station access over ownership could be advantageous. In addition, many fleets already lease their vehicles using existing commercial fleet management companies and may structure their operations and capital budgets to favor leasing.

In some cases, truck-leasing projects can resemble the operations of an energy service provider because they can offer ESCO-like services that add value to a typical leasing arrangement. For example, Willow Run Foods, Inc. leased 15 heavy-duty CNG trucks from the management company Ryder System, Inc. in New York. Willow Run Foods benefited from Ryder's existing knowledge of natural gas, maintenance network, and experienced technicians to ensure the safe operation, maintenance, and fueling of the leased NGVs.[68]

4. Fuel cost savings and technology performance guarantees

Performance contracting, where the savings associated with the project helps to fund the project, is often a feature used by energy service providers who complete energy efficiency upgrades, and a variation of this approach using fuel costs savings could be applied to NGV projects. A performance contract for building projects is predicated on measurable, predictable energy use savings from improvements in energy efficiency technology. For NGV projects, two variables that influence a project's fuel cost savings certainty are the manner in which a fleet uses its NGVs and the vehicle technologies.

All else being equal, energy service providers may be more likely to provide cost savings guarantees for fleets that travel on fixed, predictable routes and for technologies with better performance history. Fleets with predictable routes may be more likely to receive a guarantee because there is more certainty about the potential fuel cost savings. School bus fleets, for example, travel the same routes daily and typically operate in similar daily traffic conditions, consuming a predictable amount of fuel. An energy service provider could offer a guarantee to a school bus fleet manager to help overcome the manager's risk aversion of trying a new vehicle technology.

Similarly, technologies with a known performance track record may be better positioned to receive a performance guarantee than new technologies would be. For example, the Cummins 12-liter CNG tractor-trailer engine has only been on the market since early 2013 and has not demonstrated its performance over a vehicle's lifetime.[69] The performance risk of an unproven technology will reduce the expected value of its use and may harm the financial viability of an NGV project. Scenario analysis can help reduce this risk and provide a fleet manager an understanding of the project's financial viability under differing assumptions including performance, VMT, and overall fuel cost savings. **Figure 21** through **Figure 24** in the preceding section highlight how scenarios can be used to illustrate the range of annual net cost savings and overall savings that could be available for an energy service provider.

Energy service providers and fleet managers can, however, construct contracts to account for the cost savings approach of NGV conversion projects and provide cost protection for both parties. For example, the parties could agree on a baseline fuel price and an expected change in fuel price over time, which could be combined with the fleet's anticipated fuel use to calculate the expected cost savings. Contracts can also account for driver behavior in some cases by incorporating driver feedback software in a project, for example, or specifying driving techniques and routes. For fleets that use both private, on-site fueling infrastructure and more expensive publicly available fueling infrastructure, contracts could include stipulations that require the fleet to use a certain share of fuel at the on-site station.

5. Bundling projects into a portfolio

Integrating vehicle projects into other type of energy efficiency projects may reduce investment risk and offer other benefits. Because vehicle projects may have relatively low and uncertain savings, bundling fleet NGV conversion projects with more profitable building energy efficiency projects can make vehicle projects more attractive to investors. As energy service providers gain more experience working with vehicle fleets, they will be able to more tightly integrate NGV projects into existing energy efficiency portfolios. Including NGV projects in facility-wide ESCO portfolios from the outset can allow the vehicle projects, which tend to be riskier and offer lower returns compared to building projects, to be incorporated with more familiar, less risky investments that offer a higher return (see **Box 3**).

The potential for additional cost savings through bundling could depend on the building's location and its proximity to fleet operations. For example, if a building project has access to natural gas, project developers could also install an onsite NGV fueling station at a lower cost than for a standalone NGV fueling station. This optimization would require the fleet to be located in close proximity to the building, which may work for some types of fleets but not all. For example, a school bus fleet is often stored off school property and not close to buildings so this may not be an option for them. Refueling facilities may face siting restrictions, which could also present a barrier to project bundling. For instance, for many years New York City prohibited LNG stations within the city limits (in early 2015 that ban was overturned).[70] Policy options to promote alternative fuel vehicle adoption is explored later in this section.

Box 3. Bundling Building and Fleets Projects in Pennsylvania

In 2012, Johnson Controls, Inc. helped Rose Tree Media School District in Pennsylvania deploy a fleet of CNG school buses by bundling the bus project with their existing energy efficiency project. Johnson Controls identified an opportunity to use a $500,000 state grant from the state's NGV Development Program to fund the fleet conversion. Johnson Controls identified the opportunity for the fleet conversion, provided a performance guarantee, managed the technology transition, and bundled the project with their existing building energy efficiency contract for Rose Tree.

Bundling projects helped Rose Tree transition to NGVs in several ways. First, Rose Tree could rely on Johnson Controls as a trusted source of information, since the company had already established a relationship through their building energy efficiency contract. Second, bundling the CNG school bus project with a building efficiency project that offered shorter payback periods helped reduce risk for Rose Tree. Third, sharing the costs of natural gas access and storage for the buildings and vehicle fleet resulted in a reduction of projected project costs. Finally, bundling the projects helped justify the transaction costs of entering into a fleet energy service contract, considering Rose Tree had fewer than 100 vehicles in its fleet.[71]

6. Partnership Facilitation

Energy service providers could leverage public-private partnerships that encourage the shared use of fueling stations to improve the financial performance of NGV projects. Some fleet applications, such as tractor-trailers, may rely on expansive network of publicly available fueling stations that can accommodate vehicles that travel several hundred miles daily and do not return to a central location on a daily basis.

Sharing of fueling infrastructure can reduce project managers' expenses by eliminating the need for redundant fueling infrastructure and by increasing the throughput at any required new stations, thereby reducing costs and improving revenue streams. Leveraging existing fueling infrastructure, especially privately owned and operated stations, can be a significant cost-sharing measure for fleet managers. Nationwide, 53 percent of currently installed CNG stations are privately owned, and a further 25 percent of planned CNG stations will be private as well.[72] Energy service providers could arrange partnerships between public and private infrastructure operators and NGV fleet managers.

Multiple CNG infrastructure partnerships have been attempted in the United States in recent years. As mentioned previously, Colorado's ALT Fuels Program funds public-private partnership projects, which encourage the shared use of stations with fleets that would require station use daily or very often (referred to as anchor fleets). In addition, Pennsylvania's Public and Private Partnerships for Transportation Act, signed by Governor Corbett in September 2012, enabled private companies and public transportation authorities to participate in CNG infrastructure partnership projects.[73] In September 2014, Pennsylvania's Public-Private Partnership Board approved a CNG project that sought a public-private partnership in building, operating, and using CNG fueling stations. The private partner will design, install, finance, and operate the fueling stations at up to 37 public transit facilities, which will be accessible for public transit and privately-owned CNG vehicles. Additionally, a 2012 NYSERDA report suggested expanding a contract between the New York State Office of General Services and natural gas producer Clean Energy to make more fueling stations publicly available.[74] However, the relevant stations in operation are outdated and not conducive for use by large trucks like tractor-trailers, which would benefit significantly from shared use stations.[75]

Policy options that can facilitate the use of ESCO-like services for NGV deployment

State policies and programs can act as barriers or incentives to encourage fleets to increase the use of NGVs through ESCO-like services. All states have policies and programs that encourage greater use of alternative fuels in transportation for environmental, energy security, or economic reasons. A comprehensive database of these policies and programs is available at the U.S. Department of Energy Alternative Fuel Data Center at http://afdc.energy.gov.

At the same time, because government procurement must often follow a strict set of guidelines including the competitive solicitations for goods and services, competitive bidding requirements may make fuel cost savings contracting more difficult to pursue, even when such contracts would save public agencies money.[76] For example, while many states allow public agencies to enter into ESCO contracts that improve building energy efficiency, thereby reducing energy use, some states are unable to include vehicle projects in ESCO-like contracts because these projects reduce energy costs rather than energy use.

Government agencies can work to incorporate vehicle conversion opportunities into new and existing programs that assist state and local fleet managers with the ESCO-like projects. For example, Colorado enacted a law in 2013 that expanded the state's existing utility cost-savings measures law to allow state agencies to enter into a vehicle fleet maintenance and fuel cost-savings contract.[77] The law requires the energy cost savings of a project to pay for the entire NGV cost, rather than the incremental cost compared to a gasoline or diesel vehicle. The financial burden created by this requirement can make projects financially infeasible. In addition, the law requires a net savings for each year of the project, which makes projects with longer payback periods more challenging to complete. The Colorado State Senate postponed considering a proposed bill to alter these requirements in February 2015.[78] Utah enacted a law similar to the 2013 Colorado law for cost savings contracting in March of 2015 that excludes the restrictive language of

Colorado's legislation.[79]

Local and state incentives and related policy priorities can reduce risk and help overcome cost barriers for NGV fleet projects. Targeted financial incentives for NGV projects can improve the net cost savings of a fleet conversion project and enable projects to move forward. In the Willow Run Foods Inc. example previously discussed, Willow Run received a $1 million grant from NYSERDA to cover approximately 75 percent of the cost difference between a diesel and CNG truck. The project is expected to reduce greenhouse gas emissions by approximately 500 tons annually, or the equivalent of taking 100 cars off the road, by reducing diesel consumption by 175,000 gallons annually. The reduction in diesel consumption is estimated to save about $100,000 annually in fuel costs after paying for upfront vehicle costs. The vehicles will be able to travel up to 500 miles before refueling, allowing drivers to travel long distances while returning to a central fueling location, which limits the need to use more expensive public infrastructure.[80]

In some cases, leadership priorities could result in state agencies focusing incentives on particular technologies. In 2014, governors from 16 states signed a memorandum of understanding to purchase light-duty CNG vehicles if vehicle manufacturers made them available. Seven other states joined a request for a proposal to make NGV purchases issued by all memorandum signatories except one, which resulted in 111 dealers from four automakers agreeing to offer at least one NGV model for use in state fleets.[81] State policy priorities may also draw attention away from the NGV market. In 2014, eight states signed a memorandum of understanding to collaborate on the advancement of zero emission vehicles, which could result in NGVs competing with other technologies for limited state resources.[82] Connecticut and Vermont participate in both efforts.

TABLE 5: Issues and Options for the use of Energy Service Providers

ESCO-LIKE SERVICE	DESCRIPTION	BARRIER(S) ADDRESSED
1. Identification and evaluation of project opportunities	Leverage energy service provider's extensive experience with the scope of technological solutions. Provide authoritative assessments on the suitability of new technologies.	Lack of Experience
2. Management of technology transition	Manage NGV technology transition to address fleet resource constraints. Especially useful for fleets that already lease vehicles.	Project Risk, Limited Resources
3. Alternatives to equipment ownership	Help public fleets avoid upfront capital outlays by avoiding equipment ownership in order to benefit public budgets. In some cases, construct contracts that prioritize fueling station access over ownership.	Budget Constraints, Public Fueling Dependency
4. Fuel cost savings and technology performance guarantees	Use scenario analysis to reduce risk and provide a fleet manager an understanding of the project's financial viability. Construct contracts to account for cost savings approach of NGV conversion projects and provide cost protection for both parties.	Project Risk
5. Bundling projects into a portfolio	Bundle fleet NGV conversion projects with more profitable building energy efficiency projects to make vehicle projects more attractive to investors.	Project Risk
6. Partnership facilitation	Leverage public-private partnerships that encourage shared use of fueling stations to improve financial performance.	Financial Performance

Summary: Issues and Options for Energy Service Providers with NGV Fleet Projects

Energy service providers have a number of considerations when it comes to providing ESCO-like services to fleets for NGV projects. School bus fleets and tractor-trailer fleets may be able to afford a broad range of ESCO-like services (see **Table 5**). As with traditional ESCOs and building energy efficiency projects, however, the primary market for applying the ESCO model to NGV fleet projects will likely be public and not-for-profit organizations.

Energy service providers could assist fleet managers in many ways, though the specific services that could be offered may depend on the project's fueling infrastructure needs, the fleet size, and the technical capacity of the fleet. The ESCO-like services that energy service providers could offer fleet managers may help managers get accustomed to the new technology, identify the project's greatest savings potential, reduce their financial risk, and maximize their financial payoff. Some of these services may depend upon the different needs of public and private fleets and the different needs of the fleet type.

The differences between vehicle and building energy efficiency projects that could inhibit successful vehicle projects can be reconciled in part through the conditions of a contract between a fleet and an energy service provider. Whereas traditional ESCO contracts prioritize energy use reductions, a fleet contract could account for the cost savings approach of NGV projects by addressing drivers of energy cost savings and the uncertainty of predicting vehicles' energy performance. The contracts could also influence driver behavior to some extent, which would partially reduce the uncertainty of predicting fleet vehicles' fuel consumption.

State and local governments can play a key role in enabling and encouraging the application of the ESCO model to NGV fleet projects. For example, legal barriers may prohibit applying the model to public fleet projects. State governments can revise regulations to allow the provision of ESCO-like services, as the Utah legislature did in 2015. Government agencies can also work to incorporate vehicle conversion opportunities into new and existing programs that assist state and local fleet managers with ESCO-like projects, such as Colorado has made available through enabling legislation for utility cost-savings contracts. Finally, local and state incentives and related policy priorities can help overcome NGV fleet conversion risks and cost barriers. For example, a nearly $1 million New York state grant that successfully helped convert the Willow Run delivery truck project to NGVs.

III. CONCLUSION

This guide demonstrates that converting vehicle fleets to natural gas has many potential benefits, but the conversion process can be complex. Energy service providers can help ease the transition, maximize the benefits that NGV fleets offer, and improve the likelihood of a project's success by providing services similar to ESCO services in the building energy efficiency market. Fleets that anticipate a net cost savings from purchasing NGVs compared to gasoline or diesel vehicles could also afford energy service providers' assistance.

Converting fleets to natural gas would have the immediate effect of reducing petroleum use. The extent of petroleum use reduction depends upon the type of vehicles, the number of vehicles, and the miles that each vehicle in the fleet travels each year. Replacing petroleum fuel with natural gas could reduce a fleet's greenhouse gas emissions and help reduce most criteria pollutant emissions. Benefits from criteria pollutant reductions, however, will continue to decrease over time because of stricter emission controls for gasoline and diesel engine. As a result, in the longer run, reductions in criteria pollutant emissions through the adoption of natural gas fleets could be limited.

Switching fleets to natural gas fuel may also reduce fleet managers' net costs because of the potential to save on fuel costs. From 2012 to early 2015, natural gas maintained a price advantage over gasoline or diesel fuel of more than $1.40 per gasoline gallon equivalent. While the 2014 drop in petroleum prices reduced and in some cases even eliminated the price advantage of using natural gas, the U.S. EIA forecasts that natural gas will have a price advantage over petroleum and that this advantage will exist for many years. In addition, the volatility of petroleum prices can also leave fleet managers exposed to prices fluctuations, whereas the relative stability of natural gas prices may provide fleet managers with a better level of fuel cost certainty. Fuel cost savings and reduced price volatility that result from switching to NGVs from diesel or gasoline powered vehicles could be important conditions for many fleet managers, even when there are environmental or energy security benefits offered by natural gas over petroleum.

Conversion of tractor-trailer fleets to NGV under a wide array of scenarios, for example, may offer significant potential for petroleum use reduction and net cost savings. These vehicles have a low fuel economy and tend to travel many thousands of miles per year and, therefore, both small and large fleet managers are constantly looking for ways to lower fuel costs. By switching to natural gas, these fleet managers have an opportunity to lower overall operating costs by between $50,000 and $25.6 million depending on the fleet size, annual VMT, and the need for fueling infrastructure. One key challenge with tractor-trailer fleets is the potential dependency on publicly available fueling infrastructure since these vehicles often travel great distances and do not return to the fleet's home base daily.

School bus fleets are another fleet type that could have lower operating costs by converting to natural gas. Unlike tractor-trailers, school bus fleets require a very high annual VMT in order to achieve a net cost savings according to the analysis completed for this guide. Like tractor-trailers, the low fuel economy of these vehicles and high annual miles traveled create an opportunity for school bus fleets to lower operating costs by between $500,000 and $5 million depending on the fleet size, annual VMT, and the need for fueling infrastructure.

Light duty vehicles, also explored in this guide, offer a much narrower set of conditions to achieve net cost savings, and near term opportunities may be modest compared to the potential of the other vehicle types because few light-duty NGV models are currently commercially available.

For fleets that could achieve a net cost savings by switching to NGVs or for those that value the environmental or energy security benefits of using natural gas, fleet managers may choose to use an energy service provider to help with the technology transition. These providers can reduce the risks of fleet conversions and ease the transition to a new technology by offering the following six services:

1. **Identification and evaluation of project opportunities**: Leverage energy service provider's extensive experience with the scope of technological solutions. Provide authoritative assessments on the suitability of new technologies.
2. **Management of technology transition**: Manage NGV technology transition to address fleet resource constraints. Especially useful for fleets that already lease vehicles.
3. **Alternatives to equipment ownership**: Help public fleets avoid upfront capital outlays by avoiding equipment ownership in order to benefit public budgets. In some cases, construct contracts that prioritize fueling station access over ownership.
4. **Fuel cost savings and technology performance guarantees**: Use scenario analysis to reduce risk and provide a fleet manager an understanding of the project's financial viability. Construct contracts to account for cost savings approach of NGV conversion projects and provide cost protection for both parties.
5. **Bundling projects into a portfolio**: Bundle fleet NGV conversion projects with more profitable building energy efficiency projects to vehicle projects more attractive to investors.
6. **Partnership facilitation**: Leverage public-private partnerships that encourage shared use of fueling stations to improve financial performance.

NGV fleet conversion projects have the potential to reduce petroleum use and to reduce fleet managers' costs. Energy service providers can play a valuable role in facilitating NGV projects. In situations where fleets can achieve net cost savings, energy service providers may enhance the value of the projects. Even in these situations, government agencies may be critical partners to enable a successful partnership between fleet managers and energy service providers.

APPENDIX A: ADDITIONAL RESOURCES

More Information Related to Reductions in Petroleum Use and Greenhouse Gas Emissions from NGVs Use

The following resources provide additional information related to the potential for NGVs to reduce petroleum use and greenhouse gas emissions.

- **Lifecycle emissions of transportation fuels**: The Argonne National Laboratory produces the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model to allow users to evaluate the energy and environmental impacts of advanced vehicle technologies and new transportation fuels. See https://greet.es.anl.gov.
- **Vehicle statistics**: The U.S. Department of Transportation's Highway Statistics Series provides state-level data on light-, medium-, and heavy-duty vehicles operated by the public and private sectors. See http://www.fhwa.dot.gov/policyinformation/statistics.cfm.
- **Study on converting U.S. heavy-duty fleet to natural gas**: The University of California at Davis recently completed a study on economic and environmental effects of converting the U.S. heavy-duty fleet to natural gas. See http://news.ucdavis.edu/search/news_detail.lasso?id=11153.
- **Study on the climate impacts of heavy-duty natural gas trucks**: The Environmental Defense Fund has published a journal article in 2015 that details the potential climate benefits of natural gas trucks and the role of reducing emissions across the natural gas value chain. See: http://www.edf.org/energy/climate-impacts-heavy-duty-natural-gas-trucks.
- **Status of NGVs**: Argonne National Laboratory prepared a white paper on the status and issues for NGVs for the U.S. DOE's 2015 Clean Cities Strategic planning meeting. See http://www1.eere.energy.gov/cleancities/pdfs/2015_strategic_planning_natural_gas.pdf.

More Information Related to Integrating NGVs in Fleets

The following resources provide additional information related to integrating NGVs in fleets.

- **Publicly available fueling infrastructure**: The U.S. Department of Energy Alternative Fuel Data Center has an interactive map of the publicly available natural gas fueling infrastructure in the United States. The database is updated monthly. See http://www.afdc.energy.gov/locator/stations.
- **A guide on CNG infrastructure**: The American Gas Association has produced a CNG infrastructure guide for the prospective CNG developer that covers business models, station construction and configuration notes, and other economic points of interest. See http://www.aga.org/sites/default/files/sites/default/files/media/cng_infrastructure_guide.pdf.
- **Integrating CNG in refuse fleets**
  - Argonne National Laboratory produced a 2014 study on CNG refuse fleets. See http://www.afdc.energy.gov/uploads/publication/casestudy_cng_refuse_feb2014.pdf.
  - NYSERDA produced a guidebook for CNG refuse fleets in New York state in 2012. See http://www.nyserda.ny.gov/-/media/Files/EIBD/Research/CNG/cng-refuse-fleets.pdf.
- **Fleet & fueling consulting**: The Natural Gas Vehicle Institute offers consulting services for NGV fleet conversion projects, with technical expertise and analysis for fueling and vehicle questions. See: http://www.ngvi.com/fleetfueling_consulting.html. Clean Energy also provides financing, engineering, and other services to help fleet managers transition to NGVs. See

http://www.cleanenergyfuels.com/customer-solutions/heavy-duty-trucking/#more.

More Information Related to Improving the Financial Performance of Converting Fleets to Natural Gas

The following resources provide additional information related to integrating NGVs in fleets.

- **Financial tools**: The U.S. DOE offers helps fleet managers estimate the financial outcomes CNG fleet conversion projects. See the AFLEET tool (https://greet.es.anl.gov/afleet) and the VICE Model (http://www.afdc.energy.gov/vice_model).
- **Applying the ESCO model for NGV fleet deployment**: As part of this project, C2ES wrote a report on applying the ESCO business model to advance NGV fleet vehicle and infrastructure deployment. See http://www.c2es.org/publications/applying-energy-service-company-model-advance-deployment-fleet-natural-gas-vehicles-fue.
- **Local gasoline and diesel prices**: AAA provides gasoline and diesel prices update weekly by state and local markets. See http://fuelgaugereport.aaa.com/todays-gas-prices.
- **Regional natural gas prices**: The DOE provides quarterly alternative fuel price reports by regional markets. See http://www1.eere.energy.gov/cleancities/toolbox/price_report.html.
- **CNG infrastructure cost considerations**: NREL and New West Technologies has compiled a report that lists the factors for fleet managers to consider in the implementation of fueling stations and equipment. See http://www.afdc.energy.gov/uploads/publication/cng_infrastructure_costs.pdf.
- **CNG fuel savings calculator**: The American Gas Association created a Natural Gas Fleet Savings Calculator, a spreadsheet tool that helps fleet owners conducting a preliminary analysis of the total cost of ownership of converting a fleet to NGVs. See http://www.aga.org/natural-gas-fleet-savings-calculator.
- **State gasoline tax reports**: The American Petroleum Institute tracks state, local, and federal gasoline and diesel taxes. The maps and reports are updated quarterly. See http://www.api.org/oil-and-natural-gas-overview/industry-economics/fuel-taxes.

APPENDIX B: FLEET DATA

TABLE 6: Market Size and Energy Use Comparison

FACTORS	PUBLIC SCHOOL BUS FLEETS	PUBLIC LIGHT-DUTY FLEETS	PRIVATE TRACTOR-TRAILER FLEETS
Number of applicable vehicles	480,000	3,263,699	2,469,094
Transportation energy consumption (million gasoline-gallon equivalent/year)	935	2,326	27,926

The table provides estimates of the market potential of each fleet type by using the number of applicable vehicles on the road and current transportation energy consumption per year. Annual energy consumption was calculated for public light-duty fleets based on the energy consumption for all light-duty vehicle and commercial light trucks, assuming public and private vehicles have the same VMT. Energy consumption in gasoline gallon equivalent for private tractor-trailers is for all combination trucks on the road in the United States.

Source: American School Bus Council. "Environmental Benefits"; U.S. Energy Information Administration. "Freight Transportation Use, Reference case"; U.S. Department of Transportation, Federal Highway Administration, "Highway Statistic Series 2012 – January 2014 Table MV-7"; U.S. Department of Transportation, Federal Highway Administration, "Highway Statistic Series 2012 – January 2014 Table VM-1"; U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0."

TABLE 7: Vehicle Lifespan Comparison

FACTORS	PUBLIC SCHOOL BUS FLEETS	PUBLIC LIGHT-DUTY FLEETS			PRIVATE TRACTOR-TRAILER FLEETS
		DELIVERY TRUCK	LIGHT TRUCK	CAR	
Expected Vehicle Lifetime (years)	15	6.5	7.4	7.4	7

The table provides estimates of the average vehicle lifespan for each fleet type.

Source: U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0."

TABLE 8: Per-Vehicle Energy and Environmental Impact Criteria Comparison

FACTORS	PUBLIC SCHOOL BUS FLEETS	PUBLIC LIGHT-DUTY FLEETS			PRIVATE TRACTOR-TRAILER FLEETS
		DELIVERY TRUCK	LIGHT TRUCK	CAR	
Per-vehicle average petroleum use displacement (GGE/year)	1,912	2,041	642	452	12,722
Per-vehicle Fuel Cost Savings ($/year)	$3,482	$3,544	$1,115	$786	$25,018
Per-vehicle GHG Savings (lbs/year)	4,480	2,124	668	471	52,109
Per-vehicle CO Savings (lbs/year)	-2,224.33	-2.83	0.00	0.00	-4,762.81
Per-vehicle NOx Savings (lbs/year)	48.99	155.49	0.00	0.00	712.92
Per-vehicle PM2.5 Savings (lbs/year)	10.48	4.29	0.00	0.00	105.20
Per-vehicle VOC Savings (lbs/year)	-40.00	2.98	0.38	0.39	0.00

This table provides estimates of the energy and environmental impact of each fleet type using per-vehicle average petroleum use displacement estimated in gallons per year, per-vehicle fuel cost savings measured in dollars per year, and per-vehicle avoided greenhouse gas and local air pollutant emissions measured in pounds per year for each fleet type. Per-vehicle average petroleum use displacement was calculated from annual average fuel economy and VMT for each vehicle type. Per-vehicle fuel cost savings was calculated by multiplying the per-vehicle average petroleum use displacement and average fuel price difference between CNG and diesel/gasoline. Per-vehicle greenhouse gas savings was calculated by multiplying per-vehicle average petroleum use displacement by the difference in greenhouse gas emissions between CNG and diesel/gasoline. Per-vehicle avoided local air pollutant emissions was from the Argonne National Laboratory's GREET model.

Source: U.S. Department of Energy –Argonne National Laboratory Transportation Technology R&D Center. "The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation Model"; American School Bus Council. "Environmental Benefits"; U.S. Energy Information Administration. "Freight Transportation Use, Reference case"; U.S. Department of Transportation, Federal Highway Administration, "Highway Statistic Series 2012 – January 2014 Table MV-7"; U.S. Department of Transportation, Federal Highway Administration, "Highway Statistic Series 2012 – January 2014 Table VM-1"; U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0."

TABLE 9: Upfront Cost Criteria Comparison

FACTORS	PUBLIC SCHOOL BUS FLEETS	PUBLIC LIGHT-DUTY FLEETS	PRIVATE TRACTOR-TRAILER FLEETS
Incremental cost per vehicle ($)	31,376	6,300-15,000	60,000-65,000
Fueling infrastructure cost ($)	590,960-3,393,890	355,464-3,705,119	2,259,969-20,083,987

This table estimates the incremental cost of a vehicle and the cost of fueling infrastructure. The fueling infrastructure cost was estimated based on the installation cost of a fast-fill CNG station. Using the VICE model, the low end of the range was based on the costs of accommodating a fleet size of 50 and the high end was for a fleet size of 500. For the low end of light-duty fleets, the table uses the estimate for 50 passenger cars based on the gasoline taxi vehicle type in the VICE model. For the high end, the calculation was based on 500 delivery trucks using the delivery truck vehicle type in the VICE model. The average incremental vehicle cost for a school bus was based on the VICE model. For the low end of the public light-duty fleets, the table uses the incremental cost of Ford F-150 pickup truck and the high end was based on the delivery truck vehicle type in the VICE model. The range of incremental vehicle cost for tractor-trailers was for Class 8 vehicles using CNG based on a previous C2ES report.

Source: U.S. Department of Energy Alternative Fuels Data Center. "VICE Model 2.0"; Frades, Matt. 2014. "Applying the Energy Service Company Model to Advance Deployment of Fleet Natural Gas Vehicles and Fueling Infrastructure. Center for Climate and Energy Solutions. http://www.c2es.org/publications/applying-energy-service-company-model-advance-deployment-fleet-natural-gas-vehicles-fue.

APPENDIX C: FINANCIAL PERFORMANCE ASSUMPTIONS

The following table assumptions used in the financial analysis that were different from the default assumptions in the VICE model.

PARAMETER	ASSUMPTION	SOURCE
Tractor Trailer		
Incremental Cost	$65,000 per unit	Stiff, Justin, and Jim Tilley. "Natural Gas Vehicles (NGV) and Fueling Options."
Average VMT	66,161 miles per year	FHWA Highway Statistics 2012
Average Vehicle Life	7 years	C2ES Assumption
Fuel Economy	5.8 mpg	FHWA Highway Statistics 2012
CNG Fuel Economy Loss	5.3%	VICE Model (Delivery Truck)
Light Truck		
Average VMT	11,882 miles per year	FHWA Highway Statistics 2012
Fuel Economy	18.5%	Transportation Energy Data Book 33rd Ed.
Passenger Car		
Average VMT	11,265 miles per year	FHWA Highway Statistics 2012
Fuel Economy	24.9%	Transportation Energy Data Book 33rd Ed.
Fuel Prices		
CNG Fuel Price with Station	$1.67 per GGE	U.S. EIA AEO 2014
CNG Fuel Price without Station	$2.13 per GGE	U.S. EIA AEO 2014
CNG Price Increase	2.9%	U.S. EIA AEO 2014
Diesel Fuel price	$3.73 per gallon	U.S. EIA AEO 2014
State Diesel Excise Tax	$0.191 per gallon	API
Gasoline Fuel Price	$3.50 per gallon	U.S. EIA AEO 2014
State Gasoline Excise Tax	$0.205 per gallon	API

APPENDIX D: FINANCIAL PERFORMANCE RESULTS

TABLE 10: Tractor-Trailer with Fueling Infrastructure

FLEET SIZE	60,000 ANNUAL VMT	65,000 ANNUAL VMT	70,000 ANNUAL VMT	75,000 ANNUAL VMT
50	-$213,365	+$102,487 (6.9)	+$418,728 (6.5)	+$735,357 (6.1)
250	+$2,385,733 (6.3)	+$4,062,112 (6.0)	+$5,748,203 (5.6)	+$7,444,006 (5.4)
500	+$6,432,698 (6.1)	+$9,818,639 (5.8)	+$13,205,226 (5.5)	+$16,592,459 (5.2)

Where possible, payback in years is noted in the figure. The project lifetime is 7 years.

TABLE 11: Tractor-Trailer without Fueling Infrastructure

FLEET SIZE	60,000 ANNUAL VMT	65,000 ANNUAL VMT	70,000 ANNUAL VMT	75,000 ANNUAL VMT
50	+$1,431,401 (4.6)	+$1,821,518 (4.3)	+$2,211,635 (3.9)	+$2,601,752 (3.6)
250	+$7,157,007 (4.6)	+$9,107,591 (4.3)	+$11,058,175 (3.9)	+$13,008,759 (3.6)
500	+$14,314,015 (4.6)	+$18,215,183 (4.3)	+$22,116,351 (3.9)	+$26,017,519 (3.6)

Where possible, payback in years is noted in the figure. The project lifetime is 7 years.

TABLE 12: School Bus with Fueling Infrastructure

FLEET SIZE	5,000 ANNUAL VMT	10,000 ANNUAL VMT	15,000 ANNUAL VMT	20,000 ANNUAL VMT
50	-$2,145,749	-$1,639,393	-$1,132,453	-$624,929
250	-$6,392,021	-$3,842,722	-$1,278,824	+$1,299,672 (13.0)
500	-$11,686,722	-$6,544,328	-$1,343,538	+$3,915,648 (12.1)

Where possible, payback in years is noted in the table. The project lifetime is 15 years.

TABLE 13: School Bus without Fueling Infrastructure

FLEET SIZE	5,000 ANNUAL VMT	10,000 ANNUAL VMT	15,000 ANNUAL VMT	20,000 ANNUAL VMT
50	-$1,051,514	-$534,229	-$16,943	+$500,343 (10.4)
250	-$5,257,572	-$2,671,143	-$84,715	+$2,501,713 (10.4)
500	-$10,515,143	-$5,342,287	-$169,430	+$5,003,427 (10.4)

Where possible, payback in years is noted in the table. The project lifetime is 15 years.

TABLE 14: Delivery Truck with Fueling Infrastructure

FLEET SIZE	5,000 ANNUAL VMT	10,000 ANNUAL VMT	15,000 ANNUAL VMT	20,000 ANNUAL VMT
50	-$1,248,534	-$1,081,405	-$914,017	-$746,371
250	-$3,578,468	-$2,735,079	-$1,885,240	-$1,028,951
500	-$6,485,079	-$4,778,951	-$3,047,022	-$1,289,291

Where possible, payback in years is noted in the table. The project lifetime is 6.5 years.

TABLE 15: Delivery Truck without Fueling Infrastructure

FLEET SIZE	5,000 ANNUAL VMT	10,000 ANNUAL VMT	15,000 ANNUAL VMT	20,000 ANNUAL VMT
50	-$506,363	-$262,726	-$19,089	+$224,548 (4.4)
250	-$2,531,814	-$1,313,629	-$95,443	+$1,122,742 (4.4)
500	-$5,063,629	-$2,627,258	-$190,887	+$2,245,484 (4.4)

Where possible, payback in years is noted in the table. The project lifetime is 6.5 years.

TABLE 16: Passenger Car with Fueling Infrastructure

FLEET SIZE	5,000 ANNUAL VMT	10,000 ANNUAL VMT	15,000 ANNUAL VMT	20,000 ANNUAL VMT
50	-$1,068,224	-$1,013,139	-$958,032	-$902,905
250	-$2,447,757	-$2,171,699	-$1,895,115	-$1,618,003
500	-$4,171,699	-$3,618,003	-$3,062,199	-$2,504,287

Where possible, payback in years is noted in the table. The project lifetime is 7.4 years.

TABLE 17: Passenger Car without Fueling Infrastructure

FLEET SIZE	5,000 ANNUAL VMT	10,000 ANNUAL VMT	15,000 ANNUAL VMT	20,000 ANNUAL VMT
50	-$326,517	-$253,034	-$179,550	-$106,067
250	-$1,632,584	-$1,265,168	-$897,752	-$530,336
500	-$3,265,168	-$2,530,336	-$1,795,504	-$1,060,672

Where possible, payback in years is noted in the table. The project lifetime is 7.4 years.

TABLE 18: Light-Duty Truck with Fueling Infrastructure

FLEET SIZE	5,000 ANNUAL VMT	10,000 ANNUAL VMT	15,000 ANNUAL VMT	20,000 ANNUAL VMT
50	-$1,149,170	-$1,075,013	-$1,000,819	-$926,586
250	-$2,852,315	-$2,480,389	-$2,107,507	-$1,733,671
500	-$4,980,389	-$4,233,671	-$3,483,136	-$2,728,781

Where possible, payback in years is noted in the table. The project lifetime is 7.4 years.

TABLE 19: Light-Duty Truck without Fueling Infrastructure

FLEET SIZE	5,000 ANNUAL VMT	10,000 ANNUAL VMT	15,000 ANNUAL VMT	20,000 ANNUAL VMT
50	-$401,096	-$302,191	-$203,287	-$104,382
250	-$2,005,478	-$1,510,956	-$1,016,434	-$521,912
500	-$4,010,956	-$3,021,912	-$2,032,868	-$1,043,824

Where possible, payback in years is noted in the table. The project lifetime is 7.4 years.

TABLE 20: Energy Service Provider Service Fee Summary

VEHICLE TYPE	FUELING INFRA-STRUCTURE	FLEET SIZE	ANNUAL VMT	ESCO SHARE %	ORIGINAL PROJECT NPV	ESCO NPV	REVISED PROJECT NPV
Delivery Truck	No	50	20,000	23%	$224,548	$224,146	$402
Delivery Truck	No	250	20,000	23%	$1,122,742	$1,120,731	$2,011
Delivery Truck	No	500	20,000	23%	$2,245,484	$2,241,461	$4,023
School Bus	No	50	20,000	24%	$500,343	$496,594	$3,748
School Bus	No	250	20,000	24%	$2,501,713	$2,482,971	$18,742
School Bus	No	500	20,000	24%	$5,003,427	$4,965,942	$37,484
School Bus	Yes	500	20,000	15%	$3,915,648	$3,761,067	$154,580
School Bus	Yes	250	20,000	10%	$1,299,672	$1,201,850	$97,822
Tractor-trailer	No	500	75,000	44%	$26,017,519	$25,747,708	$269,810
Tractor-trailer	No	250	75,000	44%	$13,008,759	$12,873,854	$134,905
Tractor-trailer	No	50	75,000	44%	$2,601,752	$2,574,771	$26,981
Tractor-trailer	No	500	70,000	40%	$22,116,351	$21,846,540	$269,810

VEHICLE TYPE	FUELING INFRA-STRUCTURE	FLEET SIZE	ANNUAL VMT	ESCO SHARE %	ORIGINAL PROJECT NPV	ESCO NPV	REVISED PROJECT NPV
Tractor-trailer	No	250	70,000	40%	$11,058,175	$10,923,270	$134,905
Tractor-trailer	No	50	70,000	40%	$2,211,635	$2,184,654	$26,981
Tractor-trailer	No	500	65,000	35%	$18,215,183	$17,750,314	$464,869
Tractor-trailer	No	250	65,000	35%	$9,107,591	$8,875,157	$232,434
Tractor-trailer	No	50	65,000	35%	$1,821,518	$1,775,031	$46,487
Tractor-trailer	No	500	60,000	30%	$14,314,015	$14,044,204	$269,810
Tractor-trailer	No	250	60,000	30%	$7,157,007	$7,022,102	$134,905
Tractor-trailer	No	50	60,000	30%	$1,431,401	$1,404,420	$26,981
Tractor-trailer	Yes	500	75,000	23%	$16,592,459	$16,347,915	$244,544
Tractor-trailer	Yes	250	75,000	21%	$7,444,006	$7,313,562	$130,445
Tractor-trailer	Yes	500	70,000	19%	$13,205,226	$12,586,283	$618,942
Tractor-trailer	Yes	250	70,000	17%	$5,748,203	$5,509,216	$238,988
Tractor-trailer	Yes	500	65,000	15%	$9,818,639	$9,211,492	$607,147
Tractor-trailer	Yes	250	65,000	13%	$4,062,112	$3,899,679	$162,433
Tractor-trailer	Yes	500	60,000	11%	$6,432,698	$6,223,464	$209,234
Tractor-trailer	Yes	50	75,000	11%	$735,357	$707,902	$27,455
Tractor-trailer	Yes	250	60,000	8%	$2,385,733	$2,207,810	$177,923
Tractor-trailer	Yes	50	70,000	7%	$418,728	$418,189	$538
Tractor-trailer	Yes	50	65,000	1%	$102,487	$55,132	$47,355

APPENDIX E: CONSIDERATIONS FOR PUBLIC SCHOOL DISTRICT SCHOOL BUS FLEETS

This table summarizes pros, cons, and uncertainties for providing ESCO-like services to school bus fleets.

	PROS	CONS	UNCERTAINTIES
General	• Established practice with public fleet managers because energy service providers have been successful primarily in public and not-for-profit markets. • Lower risk because school bus fleet managers may have experience in estimating value of fleet conversion. • More state and federal incentives exist for using alternative fuels in school buses than for other vehicle types.	• Energy service providers may not be interested because of a weak market opportunity (small market size). • Energy service providers may not be interested because projects are NPV positive in only a few scenarios.	
Identification and evaluation of project opportunities		• School bus fleet managers may already be familiar with fleet conversion opportunities.	
Fuel cost savings guarantees	• A fuel economy guarantee would be valuable to a school bus fleet manager because these projects have a small NPV. • Fuel cost savings guarantees may be relatively feasible for energy service providers to provide because school buses travel on fixed routes.		• Do natural gas school buses perform well enough for energy service providers to have confidence in the technology and provide fuel cost savings guarantees?
Management of technology transition	• Energy service providers can help school bus fleet managers explain the technology transition to the public.		
Alternatives to equipment	• Energy service providers can help with limited budget issues (e.g. limited	• Public incentives may require public agencies to own vehicle and/or	

	PROS	CONS	UNCERTAINTIES
ownership	capital budgets or limited appetite for debt financing in order to maintain favorable bond terms) by letting fleet managers avoid upfront capital outlays.	fueling infrastructure for incentive eligibility. • Public fleet managers are more accustomed to owning their vehicle fleets. • ESCO providers would be less interested in owning vehicles because of weak secondary markets for NGV school buses.	
Bundling projects into a portfolio	• Energy service providers are already engaged with school districts on building energy efficiency projects and can bundle school bus conversion projects with these existing projects. • Bundling vehicle projects with relatively low and uncertain savings together with highly profitable building energy efficiency projects can make vehicle projects more palatable.	• Ability for Energy service providers to reduce total project costs by bundling school bus projects with natural gas building energy projects may be limited because school bus fleets are often located at a great distance from school buildings. • Public agencies with fleets may elect to leave relatively risky vehicle projects out of project portfolios if cost savings is valued much more than petroleum reduction and avoided emissions.	
Partnership facilitation	• Energy service providers may help reduce difficulty coordinating and satisfying the interests of needed project partners (vehicle providers, fueling station service companies, school district officials)		• If school buses fleet managers are more likely to demand "one stop shop" services, does that mean they are less likely to require partnerships with other businesses to complete projects?

APPENDIX F: CONSIDERATIONS FOR PUBLIC LIGHT-DUTY FLEETS

This table summarizes pros, cons, and uncertainties for providing ESCO-like services to public light-duty fleets.

	PROS	CONS	UNCERTAINTIES
General	• Established practice with public fleet managers because Energy service providers have been successful primarily in public and not-for-profit markets.	• Energy service providers may not be interested because projects are NPV positive in only a few scenarios.	
Identification and evaluation of project opportunities	• Market is less developed compared to natural gas school buses, so Energy service providers can help reduce uncertainty about suitability of available NGV equipment for specific application of delivery trucks. • Fleet managers will find the project evaluation services valuable because it may be difficult for them perform themselves, due to the diverse purposes and routes of vehicles in their fleets.		• Will fleet managers work with Energy service providers considering NPV is positive only with certain vehicle types? Can such low NPV and limited opportunities justify the use of an ESCO in the project? • Will there be enough existing fueling infrastructure to make the project viable? (The only successful scenario for light-duty vehicles is the delivery truck vehicle type without fueling station.)
Fuel cost savings guarantees	• Fuel cost savings guarantees will be valuable to delivery truck fleet managers because these projects have a small NPV and could have diverse, variable routes.		• Can ESCO provide accurate estimates for fleet performance if routes are diverse and variable? • If Energy service providers must charge higher fees for their services due to uncertainty, would projects still be viable?

	PROS	CONS	UNCERTAINTIES
Management of technology transition	• Energy service providers can help fleet managers explain the technology transition to the public.		
Alternatives to equipment ownership	• Energy service providers can help with limited budget issues (e.g. limited capital budgets or limited appetite for debt financing in order to maintain favorable bond terms) by letting fleet managers avoid upfront capital outlays.	• Public incentives may require public agencies to own vehicle and/or fueling infrastructure for eligibility. • Public fleet managers are more accustomed to owning their vehicle fleets.	
Bundling projects into a portfolio	• Bundling vehicle projects with relatively low and uncertain savings together with highly profitable building energy efficiency projects can make vehicle projects more palatable.	• Public agencies with fleets may elect to leave relatively risky vehicle projects out of project portfolios if cost savings is valued much more than petroleum reduction and avoided emissions.	• Public delivery truck fleet managers would be more interested in bundling projects with buildings (where the vehicles depart) compared to other fleet types?
Partnership facilitation	• Energy service providers may help reduce difficulty coordinating and satisfying the interests of needed project partners (vehicle providers and government officials).	• Delivery truck scenario only works without fueling infrastructure, so partnership facilitation with fueling station providers may not be valuable.	• Are public fleet managers less likely to require partnerships with other businesses to complete projects because the vehicles are likely to be owned and operated by the government?

APPENDIX G: CONSIDERATIONS FOR PRIVATE TRACTOR-TRAILER FLEETS

This table summarizes pros, cons, and uncertainties for providing ESCO-like services to private tractor-trailer fleets.

	PROS	CONS	UNCERTAINTIES
General	• Strong financial performance (high NPV and short payback period) • Energy service providers can help private fleets pilot NGV deployment, which private fleet managers would not want to "staff up" to do.	• Limited application of the ESCO model in commercial markets • Commercial entities want to maximize their return on investment and may be unwilling to share cost savings with an ESCO • Many tractor-trailer fleets are small in size, so the cost of ESCO services may be too high relative to the cost savings opportunity • Financial institutions are unfamiliar with commercial applications of the ESCO model • For some fleet applications, a network of publicly available fueling stations is needed. This need is not well-addressed by the ESCO model.	
Identification and evaluation of project opportunities	• Energy service providers can help reduce uncertainty about suitability of NGVs for small tractor-trailer fleets that have limited resources.	• Many tractor-trailer fleet managers may already be knowledgeable about project opportunities because their fleet is their primary business.	• Compared to public fleets, private fleet managers may be better equipped with resources and management tools – is there less need for them to depend on energy service providers?
Fuel cost savings and technology performance guarantees	• Small tractor-trailer fleets whose fleet is their primary business may be risk averse to switching a large portion of their vehicle fleet without a technical performance guarantee and/or fuel purchase agreement.	• The role of fuel cost savings and technology performance guarantees may be limited because tractor-trailer fleet projects have a large expected NPV, and uncertainty about this NPV depending primarily on fuel price uncertainty.	

	PROS	CONS	UNCERTAINTIES
Management of technology transition	• Small tractor-trailer fleets or businesses for whom fleets are not their primary business may value technology-transition assistance because they have scarce management time to devote to vehicle conversion projects.		
Alternatives to equipment ownership	• Many tractor-trailer fleet managers depend on publicly available fueling infrastructure and will not want to own fueling stations. • Providing fleet managers with alternatives to equipment ownership is a particularly valuable service for private tractor-trailer fleet managers because of the large upfront costs of switching the vehicles to NGV tractor-trailers and acquiring necessary fueling stations for their long distance fleet. • Even though many scenarios yield a positive NPV, a project may still not meet the fleet manager's internal rate of return requirement for expending financial capital.	• Many tractor-trailer fleets already lease their trucks, so this service may not be as valuable to them.	• What is the appetite among tractor-trailer fleets for leasing vehicles?

	PROS	CONS	UNCERTAINTIES
Bundling projects into a portfolio		• Businesses may be less motived by petroleum reductions and emissions goals, so "subsidizing" riskier or less profitable vehicle projects by bundling them together with more certain energy efficiency projects may not appeal to them. • Cost saving co-deployment of NGV and building projects is not possible for tractor-trailer projects that do not include on-site refueling infrastructure.	
Partnership facilitation			• Will private fleets favor working with individual suppliers or would they value a single point of contact that is responsible for the success of the project?

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[24] These fleet types were identified from research conducted for this project between 2013 and 2014. In particular, a workshop put on jointly by the Harvard Business School and the AFV Finance Advisory Group in 2014 provided insight into which fleet types might be most appropriate for this approach given market conditions and previous experience with NGV fleet deployment. On May 9, 2014, an all-day workshop was conducted in partnership with Harvard Business School to identify promising ESCO service strategies to advance fleet NGV and fueling infrastructure investment that would be attractive to both fleets and services providers. The workshop participants included the AFV Finance Advisory Group, state officials from Connecticut, Maryland, and Massachusetts, as well as faculty and students from Harvard Business School. Workshop breakout groups identified risks with using the ESCO business model to address problems facing fleet managers and ranked them. Groups also identified which ESCO services might be most valuable to a fleet manager. More information on the workshop, including background materials is available upon request.

Other fleet types were considered, but do not face the same adoption barriers as the vehicles included in the guide. For example, nearly 40 percent of new transit buses and 55 percent of new refuse trucks are powered by natural gas, so these vehicle types were excluded from the analysis presented in this Guide, which focuses on fleet types that face serious adoption barriers. Source: https://www.ngvamerica.org/vehicles/for-fleets/transit, https://www.ngvamerica.org/vehicles/for-fleets/refuse.

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The Center for Climate and Energy Solutions (C2ES) is an independent non-profit, non-partisan organization promoting strong policy and action to address the twin challenges of energy and climate change. Launched in 2011, C2ES is the successor to the Pew Center on Global Climate Change.

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