Fuel & Fleet Transformation Plan

City of Raleigh

Prepared by Energetics Incorporated — A Subsidiary of VSE Corporation

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SUSTAINABLE Raleigh

City of Raleigh pursued this project in accordance with recommendations from *A Roadmap to Raleigh's Energy Future: The Climate Energy Action Plan.*

Executive Summary

Sustainability is the cornerstone of Raleigh's vision for the future. This broad, comprehensive vision of sustainability focuses on the interdependence of environmental stewardship, economic strength, and social integrity.

To advance its commitment to sustainability, Raleigh developed *A Roadmap to Raleigh's Energy Future: The Climate Energy Action Plan* (CEAP) in 2012. CEAP provides an integrated framework for Raleigh's continued leadership in energy, climate, and sustainability. By guiding the development of financially responsible projects, CEAP minimizes carbon emissions and maximizes the energy and operational efficiency of City-owned vehicles, facilities, and equipment.

Since fuel is a major expense and a significant contributor to the City's greenhouse gas emissions, CEAP recommends increasing the use of alternative fuels and advanced vehicle technologies in Raleigh's fleet.

In accordance with CEAP, this Fuel & Fleet Transformation Plan evaluates Raleigh's current petroleum-reduction initiatives and identifies additional cost-effective strategies for transitioning Raleigh's fleet to an even greater use of alternative fuels and advanced transportation technologies.

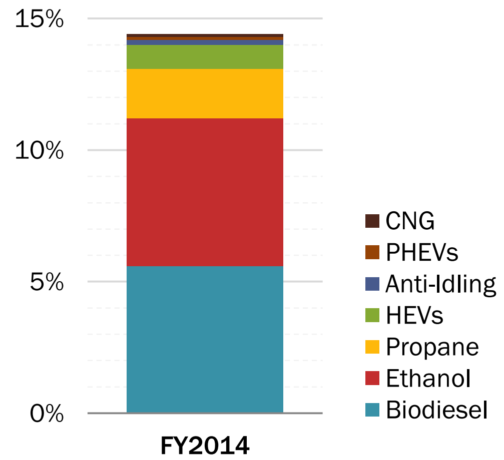
1 City of Raleigh displaced 14.4% of its petroleum consumption in FY2014

Raleigh's current petroleum reduction initiatives include using **biodiesel** blends (B20) in heavy-duty vehicles; consuming low-**ethanol** blends (E10) in gasoline vehicles; converting 49 police sedans to bi-fuel **propane** (LPG); using 86 hybrid-electric vehicles (**HEVs**) in passenger applications; installing **anti-idling** systems on 29 police vehicles; operating 5 neighborhood electric vehicles and converting 8 vehicles to plug-in hybrid-electric vehicles (**PHEVs**); and using 11 compressed natural gas (**CNG**) vehicles.

FIGURE ES.1 shows how current initiatives contribute to Raleigh's total achieved petroleum reduction.

Note: This calculation computes petroleum consumption avoided or displaced through the use of alternative fuels and advanced transportation technologies, as opposed to using a prior year as a baseline.

[FIGURE ES.1] In Fiscal Year (FY) 2014, Raleigh displaced 14.4% of its fuel consumption.



2 Raleigh could displace up to 42.9% of its petroleum consumption

If Raleigh enacts the strategies identified in this report at the recommended penetration rates, the City's total petroleum displacement could increase by an additional 28.5% — to a total of 42.9%. To maximize its petroleum displacement, Raleigh would need to:

- Procure HEVs for all new sedan purchases;
- Install anti-idling technology in 35% of police patrol vehicles;
- Convert 70% of light- and medium-duty trucks to propane;
- Use CNG in all automated side-loading refuse trucks; and
- Switch 72% of current diesel use to B20 and 34% of gasoline currently used by flex-fuel vehicles to E85

3 Raleigh will benefit from establishing a fleet steering committee

This committee, headed by the City's Fleet Superintendent with representation from all departments, will help the fleet gain buy-in from its internal clients. The committee should assist with the process of centralizing all vehicle and maintenance data and revising its policies and procedures, such as those regarding:

[FIGURE ES.2] Raleigh could double its propane use by assigning all propane bi-fuel patrol cars, like the one pictured, to a location with propane fueling available and by encouraging officers to refuel using propane.

- Vehicle replacement evaluation criteria
- Vehicle replacement capital fund
- Vehicle procurement procedure
- GPS tracking and vehicle analytics
- Take-home vehicles

4 Raleigh would maximize its current alternative fuel initiatives by reassigning alternative fuel vehicles to locations where they can refuel

Raleigh could double its propane use — saving up to $40,000 per year and reducing petroleum consumption by an additional 2% — by increasing propane use in its existing bi-fuel police patrol cars [FIGURE ES.2]. All bi-fuel cars should be assigned to a location with propane readily available, and officers should be encouraged to refuel using propane as often as possible. Similarly, all CNG passenger vehicles should be assigned to locations with CNG readily available and assigned to functions with high utilization.

Additionally, almost 25% of Raleigh's diesel is purchased from public gas stations; the cost savings from refueling exclusively at City-owned stations would more than offset the higher cost of using biodiesel (B20).

5 Raleigh's fleet management system should capture all data needed to manage the fleet's operations

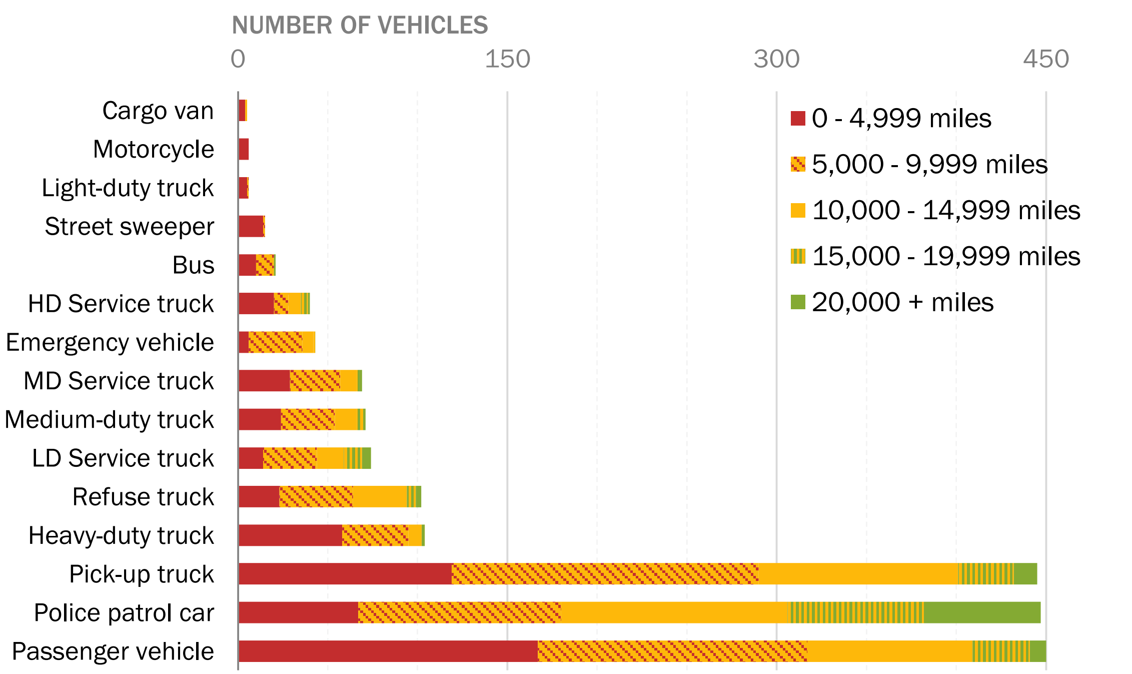
Capturing accurate data enables better analytics and smarter decision-making. All vehicles using City-owned fueling stations should have an automotive information module (AIM) installed to enable automatic fuel and vehicle data-recording. Also Vehicle Fleet Services (VFS) should conduct quality control on all data entered manually.

VFS should ensure that its current fleet management software can collect and provide the information needed to properly evaluate vehicle and driver performance metrics, as recommended in this report. Periodically assessing alternative fleet management systems is also advised.

6 Conducting regular fleet analyses will help Raleigh to identify underutilized vehicles and right-size its fleet

As shown in FIGURE ES.3, 30% of Raleigh's vehicles drove less than 5,000 miles in FY2014 and 65% drove less than 10,000 miles.

[FIGURE ES.3] Number of vehicles by type and level of utilization. Utilization, based solely on annual mileage, is classified as very low (< 5,000 miles), low (5,000 – 9,999 miles), typical (10,000 – 14,999 miles), high (15,000 – 19,999 miles), and very high (> 20,000 miles).



Conducting monthly analyses will help Raleigh determine the best applications for owning vehicles, using motor pool vehicles, renting vehicles, or using personal vehicles.

Generating these analyses requires resources not currently available within VFS; savings from using the analytics to right-size the fleet should offset the cost for the additional position to do these analyses on an ongoing basis.

In addition, VFS — or the proposed fleet management steering committee — needs the authority to re-assign vehicles that are underutilized, unneeded, or not the most efficient type for the current assignment.

7 Hybrid-electric sedans are the most cost-effective solution for reducing the fleet's petroleum consumption

Mid-sized HEV sedans, such as the hybrid Ford Fusion and Toyota Camry Hybrid, are most cost-effective; small HEV sedans like the Toyota Prius are cost-effective with higher resale values.

Since the average payback period on HEV SUVs exceeds the vehicle's lifetime, HEV SUVs should only be procured for high-mileage applications (greater than 10,000 miles per year) where equipment size and/or job function require an SUV.

8 Drivers should receive training on driving best practices at least annually

Regular training encourages more efficient driving, ensures personnel receive timely updates about new fleet procedures, and facilitates the implementation of new policies.

9 Anti-idling systems cost-effectively reduce fuel use in vehicles that remain stationary for extended periods

The battery-based anti-idling system currently installed in 29 police vehicles has not met Raleigh's expectations. Other anti-idling systems on the market may prove more capable of meeting Raleigh's needs; these systems should be tested to determine which is most effective.

10 Converting some trucks to propane may be cost-effective

Converting Raleigh's medium- and light-duty trucks to bi-fuel propane will be cost-effective if these trucks use propane for at least 65% of their annual fuel use.

The Parks, Recreation, and Cultural Resources department operates most of the City's medium- and light-duty trucks [FIGURE ES.4]. The department already has propane available at its Marsh Creek location, and another station will open soon at the Northeast Remote Operations Center.

Some highly utilized pick-up trucks may also be good candidates for conversion to propane. ■

[FIGURE ES.4] Converting Raleigh's medium- and light-duty trucks to bi-fuel propane will be cost-effective if the trucks make propane at least 65% of the fuel they use anually. Certain highly utilized pick-up trucks may also be good candidates for conversion to dedicated propane.

Introduction

CHAPTER ONE

Fuel is a major expense for the City of Raleigh. In FY2014 (July 1, 2013 – June 30, 2014), City of Raleigh's 2,000 on-road vehicles consumed 2.15 million gallons of fuel at a cost of $6.6 million. Vehicular fuel consumption also accounts for 14% of the pollution emitted by the City of Raleigh's municipal operations (Greenhouse Gas Emissions Inventory – Municipal Operations, 2010; pp. 21-32).

Responsibility for keeping the City's fleet operating safely and efficiently rests with Vehicle Fleet Services (VFS), a division within Raleigh's Public Works department. VFS has received extensive recognition for its progressive testing and adoption of new alternative fuel and advanced vehicle technologies that prove applicable to the fleet — including three Public Technology Institute awards, a Mobile CARE award, and most recently, recognition as one of the Top 50 large fleets by *Government Fleet* magazine (April 2015).

Using existing tactics, the City of Raleigh displaced 310,290 gallons of diesel and gasoline in FY2014 — a 14.5% reduction. This Fuel & Fleet Transformation Plan identifies additional cost-effective strategies for transitioning Raleigh's fleet to an even greater use of alternative fuels and advanced transportation technologies.

Energetics Incorporated, with assistance from CST Fleet Services and the NC Clean Energy Technology Center, evaluated Raleigh's existing fleet operations, practices, and initiatives; reviewed its fuel and fleet systems; and compared City operations to known best management practices.

This introductory chapter provides background on Raleigh's fleet sustainability efforts, reviews the scope and methodology of this project and Plan, and provides guidance on navigating this report; it also evaluates the effectiveness of Raleigh's existing petroleum-reduction tactics.

1.1. Raleigh's commitment to sustainability

Sustainability provides the cornerstone of Raleigh's vision for the future. This broad, comprehensive vision focuses on the inter-dependence of environmental stewardship, economic strength, and social integrity.

Consistent with this vision, the 2007 City Council created the citizens' Environmental Advisory Board, established an Office of Sustainability, enacted an energy efficiency standard for City facilities, and endorsed the U.S. Mayors' Climate Protection Agreement — agreeing to develop a greenhouse gas emissions reduction strategy for the City.

Subsequently, the Office of Sustainability conducted greenhouse gas emissions inventories for FY2007 (municipal operations) and 2010 (community-wide emissions), identifying vehicular emissions as a major contributor to pollution in Raleigh's air-shed.

In 2012, the Office of Sustainability led the development of Raleigh's Climate Energy Action Plan (CEAP), *A Roadmap to Raleigh's Energy Future*. CEAP provides an integrated framework for exhibiting continued leadership in energy, climate, and sustainability issues. By guiding the development of financially responsible projects, Raleigh expects to minimize carbon emissions and maximize the energy and operational efficiency of City-owned vehicles, facilities, and equipment. Accordingly, CEAP recommends increasing the use of alternative fuels and advanced vehicle technologies in the City fleet.

In particular, CEAP's Fleet Team envisioned a future where the City's fleet would replace conventionally fueled vehicles with a mix of alternatively fueled and hybrid vehicles as existing vehicles reached their optimal lifecycle. To lower both emissions and operating costs, the envisioned decision-support system would comprehensively analyze criteria including the vehicle age, emission factors, lifecycle costs, and replacement schedule to determine when to retire and replace vehicles in favor of cleaner, more efficient alternatives.

CEAP also identifies certain strategies for the City fleet, which this project advances:

- **Become carbon-optimized.** Replace vehicles at the optimal (minimal) point for lifecycle costs and emissions.
- **Invest in alternative fuel infrastructure.** To maintain optimal cost-benefit ratio, invest in alternative fuels when facilities and vehicles are acquired, as opposed to retrofitting afterwards.
- **Adopt 'smart' fleet policies.** Create guidelines for the most appropriate type of equipment based on use; and establish lifecycle cost- and emissions-thresholds that trigger decisions to repair vs. replace.

1.2. Continuous improvement

In addition to testing and adopting new alternative fuel and advanced vehicle technologies, Raleigh's fleet continuously improves its operations.

In June 2012, Raleigh issued the report *Fleet Practices Analysis and Improvement Recommendations*. This report provides a roadmap for improving vehicle and fleet management practices to optimize costs and performance while meeting operational needs and achieving environmental sustainability goals. The report highlights the following needs:

- Assess departmental vehicle take-home policies and develop a formal City-wide policy that supports operational needs and cost-effectiveness
- Strive for cost-efficiency by applying industry best practices, as appropriate, consistently across the organization; e.g.,
  - Improve tracking of costs and performance through enhanced data management
  - Unify service delivery model
  - Integrate staff skill development and strategic outsourcing plans
  - Refine administrative practices
- Align long-term fleet management strategies to environmental sustainability and other ongoing City-wide efforts

Then, in December 2012, VFS and Public Utilities conducted an Interactive Business Processes review. This review intended to align processes with the goal of presenting proposals to City decision-makers in a consistent, balanced format that facilitates the evaluation, comparison, and prioritization of competing initiatives.

Following a benchmarking exercise, the team conducting this Interactive Business Processes review recommended:

- Public Utilities create a fleet liaison position to improve coordination with VFS
- VFS develop an employee incentive program to encourage its staff to acquire industry-standard certifications for maintenance training and proficiency; the same incentives would be available to Public Utilities staff charged with vehicle maintenance

1.3. Project methodology

This Fuel & Fleet Transformation Plan lays the foundation for a sustainable fleet by identifying cost-effective strategies for transitioning Raleigh's fleet to greater use of alternative fuels and advanced transportation technologies.

The project's consultants — Energetics Incorporated, the North Carolina Clean Energy Technology Center, and CST Fleet Services — have successfully completed numerous fleet assessments and implementation plans that incorporate low-emission, cost-saving solutions. In addition to these consultants, the project involved key VFS staff and representatives from the fleet's client agencies, including Public Works; Public Utilities; Parks, Recreation & Cultural Resources; Solid Waste Services; Inspections; Police; Fire; Budget & Management; and Sustainability.

To produce this Plan, the project team collected all available reports and data (including those conducted by specific departments), analyzed current fleet practices, assessed fueling infrastructure, and reviewed fleet policies. The team also conducted interviews with City of Raleigh staff in order to understand existing practices and obstacles to implementing new solutions (See Appendix A for interview summaries).

Fleet characteristics analyzed include vehicle make, model, year, initial cost, engine, fuel specification, and VIN; operational characteristics, such as mileage, quantity of fuel dispensed to each vehicle, and department assignment; and procurement schedule (expected lifetime).

Fleet operations were assessed against best practices to identify fleet management processes needing improvement. The project team also investigated the fleet's existing performance measures to determine if these effectively capture the objectives of Raleigh's fleet.

The team also evaluated the benefit of GPS telematics that could track vehicle operations and notify the Fleet Superintendent of any issues in real time. Advanced telematics would also enable a more accurate determination regarding when alternative fuels, vehicle technologies, or management practices (e.g., right-sizing or right-typing) might be effective.

Finally, the project team investigated whether the current new equipment purchasing policy prevented the acquisition of alternatively fueled vehicles or advanced transportation technologies, and reviewed replacement criteria to determine whether vehicle turnover supports Raleigh's goal of obtaining a "carbon-optimized" fleet.

To evaluate potential solutions, the project team reviewed operational impacts and, to the maximum extent possible, quantified the benefits, costs, and risks for each (e.g., environmental, social, and financial factors).

In addition to this report, the team delivered an Excel-based cost-benefit tool containing the assumptions, calculations, and inputs used in this analysis. Modifying the spreadsheet's inputs will allow staff to assess a proposed solution more accurately as additional information becomes available (e.g., quoted costs; see Appendix B for additional information on this cost-benefit tool).

1.4. Effectiveness of current petroleum-reduction initiatives

On April 17, 2007, the City Council adopted a resolution recommending that the City of Raleigh reduce its fossil fuel consumption by 20% from 2006 levels.

In an attempt to achieve this aggressive target, VFS used a variety of strategies, such as identifying, testing, evaluating, and, where effective, implementing innovative technologies, policies, and programs; developing innovative partnerships and financing methods; and cultivating pilot / demonstration projects.

VFS also focused on vehicle right-typing; positioning remote operations centers strategically; stocking alternative fuels; allocating budget based on fuel consumption (rather than dollars); testing technologies, such as propane fueling and anti-idling battery systems; and sharing vehicles through the motor pool.

The remainder of this section will review the utilization and cost-effectiveness of Raleigh's existing petroleum-reduction strategies.

1.4.1. BIOFUELS

Blending biofuels — biodiesel and ethanol — into traditional fuels (i.e., diesel and gasoline) reduced Raleigh's petroleum consumption by a total of 10.2% in FY2014.

[FIGURE 1.1] Refuse trucks fill up with a 20% biodiesel blend (B20) at Solid Waste Service's Wilders Grove facility.

The City of Raleigh began blending biodiesel into petroleum diesel in 2002. Currently, the City dispenses a 20% biodiesel blend (B20) from three locations: VFS, Solid Waste Services [FIGURE 1.1], and the Heavy Equipment Shop. In FY2014, Raleigh used 608,216 gallons of B20 — displacing 121,643 gallons of petroleum diesel — at a cost of only $0.05 more per gallon than petroleum diesel.

Gasoline purchased and dispensed by the City of Raleigh — as with most gas stations — contains 10% ethanol (E10) as a result of Federal Renewable Fuel Standard (2006). Thus, Raleigh's fleet consumed 124,432 gallons of ethanol in FY2014.

Ethanol, a renewable fuel most commonly produced from corn in the U.S., contains less energy than gasoline. As a result, E10 reduces vehicle fuel economy by approximately 3%;[1] despite the reduced miles per gallon, E10 reduces greenhouse gas emissions by at least 19% compared to gasoline over ethanol's complete lifecycle.[2]

1.4.2. PROPANE

Using grant funds, VFS converted 10 police patrol cars to bi-fuel propane as a pilot project in 2011. The bi-fuel system consumes propane (also referred to as Liquefied Petroleum Gas [LPG]) first, when available, and gasoline secondarily.

The pilot proved successful and the Police Department now operates 49 bi-fuel patrol cars. To support these vehicles, the City installed propane fueling stations at the North District Police Office [FIGURE 1.2], the Southeast District Police Office, and at Parks, Recreation, and Cultural Resources' Marsh Creek facility (access to this location

[1] U.S. Department of Energy, "Fuel Properties Comparison," (2014).

[2] U.S. Department of Energy, "Ethanol Vehicle Emissions" (2014).

[FIGURE 1.2] The propane fueling station at the North District Police Office on Six Forks Road

is limited to daytime hours). An additional propane fueling station will come online in 2015 at VFS's Northeast Remote Operations Center.

In FY2014, these 49 bi-fuel police patrol cars consumed 57,130 gallons of LPG and 53,533 gallons of gasoline. Since one gallon of propane contains 73% of the energy in one gallon of gasoline,[1] the average fuel economy of bi-fuel LPG vehicles (8.6 mpg) is 17% lower than all-gasoline vehicles (10.4 mpg).

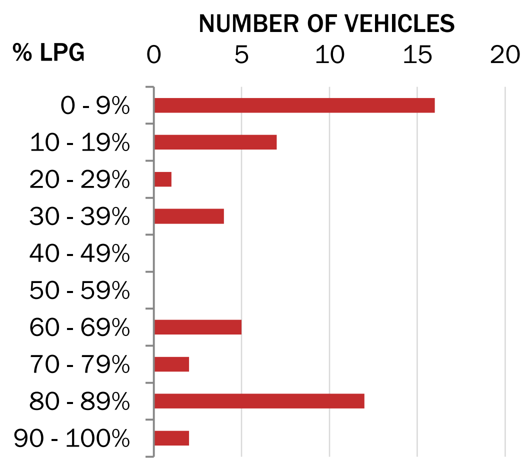
Accounting for LPG's lower energy content, the 49 bi-fuel propane police vehicles displaced 41,705 gallons of gasoline with an annual cost savings of $40,425, or $825 per vehicle. On average, the conversions cost $5,900 per vehicle,[3] meaning it will take 7.2 years to recoup the initial conversion cost.

[3] A contractor converted the first ten vehicles and trained VFS maintenance staff; then these City staff performed all subsequent conversions in-house.

However, as shown in **FIGURE 1.3**, below, certain bi-fuel vehicles primarily used propane while others used hardly any. If every bi-fuel vehicle used 90-100% LPG, savings would increase to $2,853 per vehicle per year and the payback for patrol car conversions would decrease to 2.1 years.

Leveraging the availability of LPG at Marsh Creek, the Parks, Recreation, and Cultural Resources department purchased some propane-operated off-road equipment and mowers in late 2014. Early performance results are promising, but data were not available yet as of the date of this report.

[FIGURE 1.3] In FY 2014, 21 bi-fuel police patrol cars consumed mostly propane (>60% LPG) while 28 bi-fuel vehicles consumed little propane (<40% LPG).



1.4.3. COMPRESSED NATURAL GAS

The City of Raleigh operates 11 vehicles on compressed natural gas (CNG): six Honda Civics, one Ford F-150 pick-up truck, one Dodge 2500 van, one bi-fuel (CNG / gasoline) Ford E-450 van, and two Autocar refuse trucks.

From 1999 to 2006, Honda charged $4,600 more for CNG Civics than the gasoline version; the 2013 CNG Civic currently costs $8,150 more than the comparably equipped gasoline model. At the time of purchase, the CNG Ford F-150 truck and Dodge 2500 van cost $3,150 more than gasoline versions of the same vehicles.

These vehicles primarily fill up at the Heavy Equipment Shop [**FIGURE 1.4**; next page]; some also use PSNC's CNG station in North Raleigh. In total, these vehicles consumed 1,088 gasoline-gallon equivalents (gge) during FY2014.

TABLE 1.1, next page, calculates the payback for these vehicles, assuming an average savings of $1.41 per gasoline-gallon equivalent. The various scenarios consider 1) the average annual mileage of Raleigh's CNG vehicles, 2) highest current utilization among Raleigh's CNG vehicles, and 3) the average annual mileage of comparable gasoline vehicles from Raleigh's fleet.

As shown in **TABLE 1.1**, Raleigh's dedicated CNG vehicles do not receive sufficient mileage to provide a return on investment during their useful life.

One obstacle preventing higher utilization is convenient fueling. Any vehicles based downtown, such as at VFS, must drive to the Heavy Equipment Shop to refuel. To be successful, CNG vehicles should 1) have regular, reliable daily routes that use nearly all CNG stored in the vehicle's tank; and 2) return to a base location where CNG fueling is readily available. As a result, larger vehicles with lower fuel economies that operate long periods each day, such as refuse trucks, are better candidates for CNG than motor pool vehicles.

Solid Waste Services began a pilot testing two CNG refuse trucks in November 2014. If the refuse trucks consume the 6,800 gge expected, the payback on the $38,300 incremental cost will be 4.5 years. CNG fueling is not currently available at Wilders Grove and the Heavy Equipment Shop's system is too small to fuel trucks quickly, which may limit these vehicles' utilization.

[TABLE 1.1] Payback period calculation for Raleigh's CNG sedans & pick-up trucks in 3 scenarios: 1) current utilization, 2) highest current CNG vehicle utilization, and 3) average utilization of comparable gasoline vehicles. This analysis excludes two vans that did not register any miles or fuel use in FY2014 and two CNG refuse trucks that were delivered to City of Raleigh in FY2015.

	HONDA CIVIC SEDANS	FORD PICK-UP TRUCK & DODGE VAN
Incremental cost*	$4,600	$3,150
SCENARIO 1 > CURRENT AVERAGE UTILIZATION		
Average annual mileage	3,305 miles	1,256 miles
Annual fuel consumed (CNG)	119 gge	119 gge
Annual fuel cost savings	$168	$168
Payback period	**27.4 years**	**18.8 years**
SCENARIO 2 > HIGHEST CURRENT CNG VEHICLE UTILIZATION		
Annual mileage	5,523 miles	1,412 miles
Annual fuel consumed (CNG)	194 gge	139 gge
Annual fuel cost savings	$274	$196
Payback period	**16.8 years**	**16.1 years**
SCENARIO 3 > UTILIZED EQUAL TO COMPARABLE GASOLINE VEHICLES		
Average annual mileage	8,800 miles	8,300 miles
Annual fuel consumed (CNG)	317 gge	741 gge
Annual fuel cost savings	$447	$1,046
Payback period	**10.3 years**	**3.0 years**

* Additional cost for CNG versus comparably equipped gasoline vehicles at time of purchase

AT LEFT
[FIGURE 1.4] The compressed Natural Gas (CNG) filling station at the Heavy Equipment Shop

AT RIGHT
[FIGURE 1.5] A CNG Honda Civic assigned to Raleigh's Motor Pool

1.4.4. ELECTRIC & HYBRID-ELECTRIC

Raleigh's fleet contains several types of electrified vehicles, including light-duty and specialized hybrid-electric vehicles, plug-in hybrid-electric vehicles, and neighborhood electric vehicles.

LIGHT-DUTY HYBRID-ELECTRIC VEHICLES

Raleigh's fleet contains 86 light-duty Hybrid-Electric Vehicles (HEVs); models include Toyota Camry Hybrid (42), Toyota Prius (9), Honda Civic (3), Toyota Prius C (2), Ford Fusion (1), and Ford Escape Hybrid (29; 25 with 4-wheel drive).

The hybrid-electric sedans average 34 mpg, compared to 17.2 mpg for the City's gasoline sedans. The hybrid-electric SUVs average 23.9 mpg, versus 15.5 mpg for the City's gasoline SUVs. The increased fleet fuel economy displaced 19,507 gallons of gasoline in FY2014.

[TABLE 1.2] Payback period calculations for Raleigh's light-duty hybrid-electric vehicles 1) as currently utilized (average) and 2) if utilized at the highest level among all HEVs in its class.

	HEV SEDANS	HEV SUVS
Incremental cost*	$2,604	$6,169
SCENARIO 1 > CURRENT AVERAGE UTILIZATION		
Average annual mileage	8,865 miles	8,171 miles
Annual fuel cost savings	$773	$559
Payback period	**3.4 years**	**11.0 years**
SCENARIO 2 > HIGHEST CURRENT HEV UTILIZATION		
Annual mileage	24,200 miles	20,081 miles
Annual fuel cost savings	$2,111	$1,373
Payback period	**1.2 years**	**4.5 years**

* Additional cost for HEV versus a comparably equipped gasoline-only vehicle

On average, HEVs cost $2,604 more than comparable gasoline sedans and $6,169 more than comparable gasoline SUVs. TABLE 1.2 calculates payback, assuming an average cost of $3.04 per gallon of gasoline. Since the HEVs receive more annual miles than their gasoline equivalents in Raleigh's fleet, the two scenarios depict 1) the current average utilization of Raleigh's HEVs, and 2) the highest current HEV utilization.

As shown in TABLE 1.2, the HEV sedans recoup their higher initial costs within the vehicles' lifetime, while HEV SUVs only recoup their incremental cost in high mileage assignments.

PLUG-IN HYBRID ELECTRIC VEHICLES

In 2007, the City of Raleigh converted one Toyota Prius HEVs into a Plug-in Hybrid Electric Vehicle (PHEV) using an aftermarket kit containing batteries, controls, and a plug-in port; subsequently, seven more Toyota Prius HEVs were converted to PHEVs in 2010.

The City paid $1,100 for the conversion kits. Toyota now offers a PHEV model of the Prius at a cost of $5,800 over the HEV model. The city also purchased one Chevrolet Volt which cost $13,000 more than the Toyota Camry Hybrid.

[FIGURE 1.6] Two Ford Escape Hybrids next to a Toyota Camry Hybrid in Raleigh's motor pool

The PHEVs average 42.8 mpg, 26% higher than the HEVs and 148% higher than the City's gasoline sedans. As a result, PHEVs displaced 1,662 total gallons of gasoline.

TABLE 1.3 compares payback calculations for the PHEVs to both conventional gasoline vehicles and HEVs. The calculations assume an average cost of $3.04 per gallon of gasoline. The various scenarios consider the current average utilization of Raleigh's PHEVs, and best use of a PHEV.

As shown in **TABLE 1.3**, PHEVs do not perform considerably better than the HEVs currently in Raleigh's fleet. PHEVs achieve their best payback when routes are mostly completed in electric mode; this generally requires the PHEV be driven for short durations and fully recharged prior to each trip.

[TABLE 1.3] Payback period calculations for Raleigh's plug-in hybrid-electric vehicles compared to the average gasoline sedan in Raleigh's fleet and against standard HEVs in Raleigh's fleet. The scenarios consider 1) the PHEVs current average annual utilization and 2) highest current utilization of Raleigh's PHEVs.

	PHEV VS. GASOLINE	PHEV VS. HEV
Incremental cost*	$7,000	$1,100
SCENARIO 1 > CURRENT AVERAGE UTILIZATION		
Annual mileage	5,980 miles	5,980 miles
Annual fuel cost savings	$632	$110
Payback period	**11.1 years**	**10.0 years**
SCENARIO 2 > HIGHEST CURRENT PHEV UTILIZATION		
Annual mileage	11,535 miles	11,535 miles
Annual fuel cost savings	$1,219	$212
Payback period	**5.7 years**	**5.2 years**

* The first column indicates the additional cost for a PHEV versus a comparably equipped gasoline vehicle from Raleigh's fleet; the second column considers the additional cost for the conversion kit and installation compared to a standard HEV.

SPECIALIZED HYBRID-ELECTRIC VEHICLES

The City of Raleigh operates two hybrid-electric utility service aerial bucket trucks. The Freightliner trucks have Eaton's Hybrid-Electric Parallel Drivetrain System, enabling the trucks to operate using the diesel engine alone or in combination with the hybrid electric motor. The parallel drivetrain provides additional power to launch the vehicle, improving fuel economy in stop-and-go operations and reducing emissions and operating noise.

The hybrid aerial bucket trucks cost $168,000, 75% more than conventional aerial bucket trucks. Based on FY2014 fueling data, the hybrid bucket trucks did not achieve better fuel economy than the conventional trucks (6.2 mpg vs. 6.3 mpg, respectively).

The hybrid bucket trucks' larger engine (6.7-liter versus 6.4-liter) reduces its expected fuel economy, but fails to explain the discrepancy seen. Instead, fueling and mileage data imply that drivers do not operate the hybrid trucks to optimize the efficiency of the hybrid system, indicating the need for further driver training.

NEIGHBORHOOD ELECTRIC VEHICLES

In the right application, neighborhood electric vehicles (NEVs) could replace a combustion engine vehicle, providing instant return on investment because of NEVs' lower purchase price. However, Raleigh's NEVs average less than 500 miles per year and likely do not replace any conventional vehicles.

1.4.5. IDLE REDUCTION

Anti-idling systems allow vehicles to operate their full electrical system — lights, camera, radio, etc. — with the engine off.

Raleigh's Police Department installed battery-based Energy Xtreme Law

Enforcement anti-idling systems on 29 police vehicles in early 2014. This anti-idling system requires the operator to manually turn off the vehicle's engine; the anti-idling system then powers the vehicle's electrical system until its batteries reach a set threshold, at which point it restarts the vehicle's engine.

The Energy Xtreme system cost $3,995, plus $795 for the data recording module. Police Department staff installs the system in about five hours.

At 3 foot wide by 1 foot deep and 1 foot tall, the Energy Xtreme system noticeably reduces trunk space; additionally, the added weight may affect the performance of some vehicles. As a result, Raleigh upgraded the shocks and springs on some police cars with the system installed.

Unfortunately, the Energy Xtreme system has not provided power for the time duration advertised by the manufacturer. This result may be due to a higher power load than expected, or to insufficient recharge periods. As a result, these systems only reduced idling by an average of 0.65 hours per day.

Assuming the Ford Crown Victoria police cars consume 0.5 gallons per hour while idling and gasoline costs $3.04 per gallon on average, the payback period falls within the vehicle's life. However, RPD reported experiencing some issues with the current system's batteries, which may require further investment.

1.4.6. ASSET TRACKING

In February 2014, Public Works installed Zonar GPS tracking on ten street sweepers to better manage vehicle operations and to provide an electronic inspection solution.

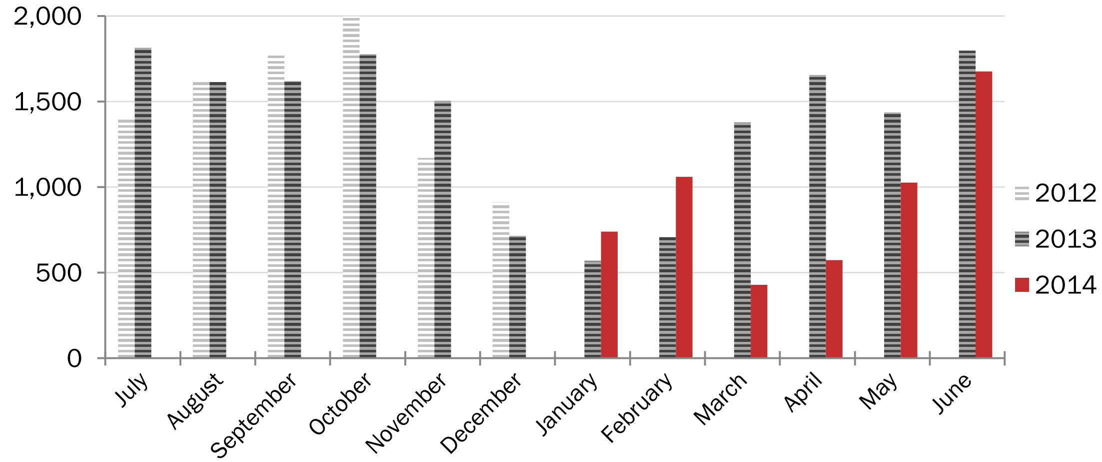
The Zonar ZTRAK, a battery-operated asset tracking device, locates and reports vehicle position. Zonar's Electronic Vehicle Inspection Report (EVIR) system captures, transmits, and records pre- and post-trip inspection, compliance, and maintenance data. The systems cost $1,417 each.

Public Works purchased these systems to make it easier for operators to comply with regulations and to ensure their vehicles operate properly and safely. However, a secondary benefit of these systems includes more efficient use of the vehicles by monitoring operator behavior and optimizing assignments.

Accounting for seasonal differences, the street sweepers used 37% less fuel since installing the GPS tracking systems. It is not clear whether this reduction in fuel consumption is the result of operators changing driving habits, management changing operational assignments, or changes unrelated to the use of the tracking system. FIGURE 1.7 displays fuel use for fiscal years 2013 and 2014.

Public Utilities is currently installing an asset tracking solution on its 404 vehicles and 23 pieces of equipment. The contract with Verizon Networkfleet costs $340 per year per vehicle for the first 3 years, and $235 per year per vehicle for the following

[FIGURE 1.7] Cumulative fuel used by Public Works' street sweepers before and after installing Zonar GPS tracking (February 2014). Even accounting for seasonal effects, fuel consumption dropped 37% in the second half of FY 2014.



two years. Public Utilities expects asset tracking will decrease vehicle miles traveled and subsequently fuel use once implemented.

1.4.7. PETROLEUM REDUCTION

In total, Raleigh's existing alternative fuel and advanced transportation technology initiatives displaced 310,291 gallons of diesel and gasoline in FY2014 — a 14.4% reduction. FIGURE 1.8 itemizes fuel savings by initiative.

This calculation computes petroleum consumption avoided or displaced through the use of alternative fuels and advanced transportation technologies, as opposed to using a prior year as a baseline. Thus, the calculation credits the fleet for actions to reduce petroleum use without penalizing the fleet for growth required to meet the increasing demands of Raleigh's growing population.

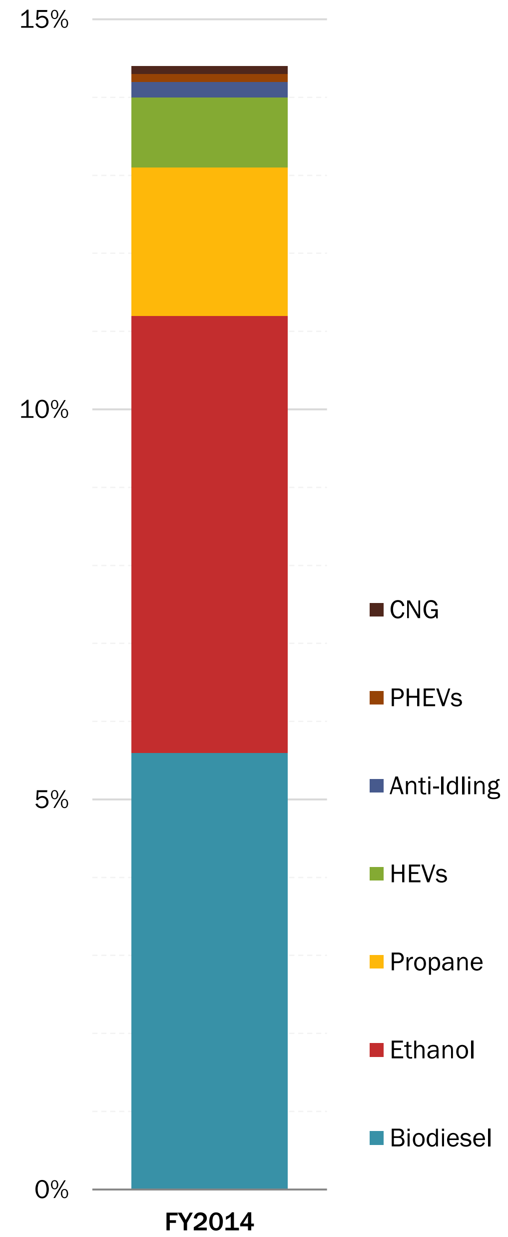
1.5. Navigating this document

This Fuel and Fleet Transformation Plan identifies the steps required for the City of Raleigh to effectively transition to a greater use of alternative fuels and advanced transportation technologies. Analysis and recommendations are grouped into the following chapters:

2. **MANAGEMENT PRACTICES**
   Reviews current practices and presents recommendations for improving fleet operations through policy and procedure.
3. **VEHICLES & FLEET**
   Provides an overview of the current fleet and presents recommendations for improving utilization and fleet composition.
4. **FUEL & INFRASTRUCTURE**
   Analyzes current fuel use and recommends strategies for greater petroleum displacement.
5. **IMPLEMENTATION**
   Prioritizes recommendations and identifies the next steps required for the City to improve its operational efficiency and achieve greater petroleum displacement.

The appendices, available on the common drive at \\corfile\common\Fuel_and_Fleet_Transformation_Plan\, contain supplemental information, analyses, and charts that support the findings of this report. ■

[FIGURE 1.8] In FY2014, Raleigh displaced 14.4% of its fuel consumption using current methods.



Fleet Management

CHAPTER TWO

Effective fleet management is both an art and science. Logistics and economics inform equipment maintenance and replacement schedules; balancing the sizable capital and operating budgets while handling unscheduled repairs and departmental mission needs requires finesse. The best fleet managers sustain a high level of service while striving to improve service performance, increase fleet safety, and minimize fleet costs.

Vehicle Fleet Services (VFS) keeps Raleigh's 2,000+ on-road vehicles operating safely and efficiently. In order to supply City staff with the right vehicle for their job whenever they need it, VFS manages the procurement, maintenance, and replacement of vehicles and the fueling infrastructure needed to support them. VFS must also adhere to federal, state, and City regulations that require retaining records on fleet assets and operations and on every incident involving a vehicle.

Today, fleet management relies on Information Technology (IT) systems to monitor all vehicles and operations. A robust IT system properly captures all information related to vehicle acquisitions, vehicle refueling, fuel deliveries, and maintenance. While these systems continue to evolve, a fleet management IT system is only as good as its data, and only effective when management acts using the generated analyses.

This chapter assesses VFS's current fleet management practices, reviews fleet management best practices, and recommends strategies where opportunities for improvement exist.

2.1. Current fleet practices

Policies, procedures, practices, and processes ensure VFS operates the fleet in a consistent, and generally efficient, manner. To assess Raleigh's current fleet practices, CST Fleet Services interviewed key VFS staff and VFS's clients throughout the City of Raleigh; please see Appendix C for CST's complete report on Raleigh's current fleet management practices.

2.1.1. AUTHORITY OVER DECISIONS

Currently, departments retain more authority for determining vehicle assignments and purchases than VFS. Departments clearly know the most about their respective job functions, and their continued involvement with selecting vehicles will ensure their capabilities are never compromised. However, to successfully implement this Plan, Raleigh will need to take a more balanced fleet management approach.

Several Raleigh departments proactively pursued alternative fuels and/or advanced vehicle technologies within their own sub-fleets. This piecemeal approach is more expensive and creates a challenge for VFS to manage. VFS cannot exchange these specialized vehicles with other fleet vehicles when needed; it also requires VFS to stock new and different parts and adds service and training requirements.

Alternative fuels and advanced vehicle technologies yield the greatest cost efficiencies when deployed department- or City-wide. Economies of scale enable bulk vehicle purchases and make optimal use of fueling/maintenance infrastructure, personnel training, and parts inventory.

In particular, the current delegation of authority over fleet decisions impedes optimal vehicle assignment, replacement, and procurement.

VEHICLE ASSIGNMENT

Because Raleigh's departments operate their sub-fleets independently, VFS cannot reassign underutilized vehicles, or swap vehicles between departments to better suit job functions.

REPLACEMENT OF OLD VEHICLES

Raleigh's Fleet Superintendent currently determines vehicle retirement and replacement as part of the annual budget process. First, the Fleet Superintendent rates the entire fleet on the following 20-point scoring system:

- 1 point for each 20% of useful life (miles or hours) expended, up to a maximum of 5 points; plus
- 1 point for each 20% of useful life (age in years) depleted, up to a maximum of 5 points; plus
- 1 point for each 5% of the purchase price spent on maintenance (excluding accidents), up to a maximum of 10 points.

Vehicles must score at least 15 points to be considered for replacement. Then, the Fleet Superintendent prioritizes the list of vehicles qualifying for replacement.

Next, the Fleet Superintendent completes the Equipment Fund Request Form. Employing another best practice, Raleigh's form prompts the Fleet Superintendent to consider alternative fuel vehicles and/or downsizing to smaller, more efficient vehicles.

PROCUREMENT OF NEW VEHICLES

Raleigh's vehicle purchase policy evaluates new acquisitions on their total cost of ownership — a best practice. The calculation considers purchase price, expected resale (salvage) value, and lifetime fuel and maintenance costs.

However, department directors currently make the final decision on equipment specification and can override the results. Furthermore, the City Council makes the final decision on the budget, approving the number and type of vehicles for purchase. An endlessly constrained budget pressures departments to pick vehicles with lower purchase prices. Thus, this multi-step approval process limits the fleet's ability to transition to alternative fuels and advanced vehicle technology.

2.1.2. MAINTENANCE

The VFS shop at 1014 N. West St. opened more than 60 years ago. Later this year, VFS will move to a new facility and open a separate maintenance shop at the Northeast Remote Operations Center.

The Northeast Remote Operations facility will enable VFS to handle more vehicles, more efficiently. Ample space allows VFS to repair more vehicles simultaneously; and the spacious parts locker makes it easier to locate parts and supplies. Moreover, the reception area provides a better location for interacting with drivers as they bring their vehicles in for service.

In addition to the Northeast Remote Operations Center, a recently added remote maintenance shop at Public Utilities' Field Operations Center brings maintenance closer to where the fleet operates, saving travel time. Decentralizing maintenance locations also builds more rapport between mechanics and drivers, and often leads to more preventative maintenance services being completed at the proper time.

Decentralized maintenance operations sometimes develop redundant equipment and duplicate knowledge as each shop tries to handle every service request. For Raleigh's decentralization strategy to succeed, its mechanics must continue to operate as one group, utilizing all available resources to get the work done in the most efficient manner. For example, when a vehicle requires non-routine maintenance, VFS should transfer that work order to whichever shop specializes in that repair.

VFS currently employs numerous maintenance best practices. For example, VFS uses its centralized database to track mechanic labor — direct and indirect — to vehicles using standard job codes. VFS also updates its fully burdened labor rate annually. **TABLE 2.1** lists additional best practices implemented in Raleigh.

Changes currently underway should improve customers' experience with vehicle maintenance. For example, the

[TABLE 2.1] Inventory of maintenance best practices currently employed by City of Raleigh Vehicle Fleet Services

ADMINISTRATION
» Billing departments for maintenance activity on an occurrence-basis
» Monitoring the ratio of vehicles to mechanics against industry standards
» Using online training for all vehicle types repaired at the shop
PARTS
» Including overhead when billing parts; the markup is currently 25%
» Charging parts to a work order and tracking replacement warranty
» Integrating parts management with work order and ordering system to ensure timely re-orders
» Monitoring parts availability; currently, more than 80% of the times mechanics go to the parts window the needed part is in stock and available
» Inventorying parts, balancing stock, and monitoring slippage on a regular basis; during each inventory, VFS removes obsolete parts
» Adjusting reorder quantities based on usage trends and vehicle purchases / retirements
» Tracking parts efficiently to work orders or indirect codes as they move in and out of the storeroom
FACILITIES
» Siting facilities based on accessibility for most fleet vehicles
» Developing facilities with adequate space, ventilation, etc., to handle most fleet vehicles
» Stocking diagnostic tools for all vehicles in the fleet and utilizing them as appropriate for each job
» Using a computerized shop floor management system
PREVENTATIVE MAINTENANCE (PM)
» Documenting PM schedules, policies, and procedures
» Spot-checking PM for quality assurance
» Scheduling and tracking PM completion through central database
PROCEDURES
» Using a clear and easily understood work order request form and procedure
» Providing customers cost and time estimate for repairs
» Tracking warranty claims in central database
» Monitoring service quality by tracking vehicle re-work and call-backs

small remote maintenance shop at Public Utilities' Lake Woodard facility will better serve this local sub-fleet. And the flow between the offices, shop floor, and parts room at the Northeast Remote Operations Center allows more efficient interactions between vehicle operators and maintenance staff.

The transition to new facilities also provides an opportunity to introduce some new best practices that improve maintenance service, such as

- Assigning / hiring a warranty clerk to track and manage warranty claims and apply for extended warranties after the OEM warranty period expires
- Establishing policies and procedures for currently undocumented work order activities
- Requesting more documentation from drivers requesting service; i.e. pre/post trip inspections, notes regarding when driver first detected the change in vehicle performance
- Recognizing mechanic excellence; e.g., creating a "Wall of Fame"
- Rewarding mechanics / groups of mechanics that achieve certain targets
- Reimbursing mechanics for obtaining certifications useful to their job (with City approval)

2.1.3. PERFORMANCE MANAGEMENT

Operating an effective and efficient fleet requires constant monitoring of fleet operations.

VFS currently monitors fleet performance by tracking all activities and transactions in a centralized fleet management system called FASTER. Automotive Information Modules (AIM) collect vehicle performance and fueling data automatically and record the data in FASTER. Annually, VFS uses FASTER to generate certain performance metrics, such as total cost per mile and average miles per gallon.

However, not all departments use FASTER and not all vehicles have AIM, impeding the accuracy and completeness of the data, and therefore, the reported performance metrics.

VEHICLE DATA COLLECTION

Many Raleigh vehicles have AIM currently installed. AIM both authorizes refueling and collects vehicle data without input from the driver. The modules automatically record fuel consumption, and can be configured to collect a variety of vehicle statistics, such as odometer readings, diagnostic error codes, engine hours, and rapid accelerations or decelerations.

AIM captures much more accurate data than manual entry, enabling better management of vehicle performance. Reviewing Raleigh's fuel transactions for this analysis, it was easy to distinguish vehicles with AIM from those without; vehicles without AIM often reported incorrect information.

AIM is the only way to assure the accuracy of vehicle performance reports, so the City should outfit every pump and vehicle with this system.

VEHICLE TRACKING

Global Positioning System (GPS) technology helps fleets to locate assets, determine optimal routes, and verify data collected by AIM.

Because of these benefits, some departments have begun using GPS in their sub-fleets. For example, Public Utilities is currently installing Verizon's Networkfleet asset tracking solution on its sub-fleet. Public Works currently uses Zonar GPS on ten street sweepers for fleet tracking and electronic inspection. The technologies selected vary in their ability to interface with FASTER, limiting their usefulness for fleet performance management.

FLEET MANAGEMENT SYSTEM

Since all departments do not use FASTER nor all vehicles have AIM, the accuracy and completeness of the data in VFS's fleet management database varies. For example, the Fire Department maintains their fueling and maintenance records in a database that does not integrate with FASTER.

Furthermore, when City vehicles refuel at private gas stations, AIM cannot record the transaction; as a result, the data recorded depends on the accuracy of the information the driver manually enters.

When requesting fleet data for this study, some information was not readily available. VFS reported the data needed to be compiled and verified prior to sending it. This was due, in part, to the difficulty of extracting vast quantities of information in an easily understandable format. However, this also indicates that VFS lacks the resources needed to manage its fleet management system in a way that permits quick and frequent analyses regarding the fleet's performance.

PERFORMANCE METRICS

VFS uses FASTER to generate certain performance metrics annually as part of the budget process. More frequent performance reports would allow VFS an opportunity to proactively address performance issues.

For example, VFS's maintenance team proactively tracks and reports their group performance in great detail; the following metrics, calculated quarterly, address effectiveness of their services as well as efficiency:

- Repairs completed within 24 hours (%)
- Repairs completed within 48 hours (%)
- Vehicles passing emissions test the first time (%)
- Vehicles returned for repair within 30 days (%)
- Vehicles receiving preventative maintenance on schedule (%)
- Percent of mechanics' hours billed to vehicle maintenance and repairs (%)
- Average fleet availability (%)
- Equipment units per mechanic (#)
- Average cost per work order ($)
- Maintenance cost per mile ($/mile)

2.1.4. TAKE-HOME VEHICLES

Certain job-related responsibilities justify allowing City employees to drive their City-owned vehicle home each night. However, over time take-home vehicles have become a job perk more than a necessity.

Vehicle operating costs have risen with fuel prices, and now the additional mileage for employees to drive home City-owned vehicles significantly increases the overall cost to maintain Raleigh's fleet.

2.2. Fleet management best practices

Fleet management best practices improve fleet performance and decrease costs. Implementing the following best practices may benefit the City of Raleigh's fleet.

2.2.1. DRIVER TRAINING

City personnel reported during our interviews that they often receive a vehicle or technology with minimal instructions or guidance.

Driving habits influence fuel consumption more than vehicle technology. Even conventional gasoline and diesel vehicles use less fuel when they are maintained properly and driven less aggressively on properly inflated tires, without unnecessary excess weight. Also, unnecessary idling wastes fuel.

Vehicle operators should understand why their driving habits matter and receive occasional reminders with tips for improving their vehicle's fuel efficiency. Raleigh should host driver trainings and distribute information regarding vehicle operation best practices regularly, as the City does for other workplace practices (safety, health, regulations, etc.).

Aggressive driving negates the benefit of hybrid-electric vehicles; anti-idling devices are ineffective when drivers never engage them. Bi-fuel vehicles provide no benefit when only fueled with gasoline. Thus, it is critically important to provide driver training before introducing any new vehicle, fuel, or technology to the fleet.

2.2.2. ASSET TRACKING

GPS technology helps fleets to locate assets, determine optimal routes, and verify data collected by FASTER. The Public Utilities and Public Works departments are already experimenting with GPS in their sub-fleets.

GPS is most cost-effective when deployed to a large number of vehicles. Widespread

GPS data would help Raleigh to analyze more objectively where, when, and how vehicles are used; additionally, Raleigh could model how departments might share vehicles.

Since it can verify baseline vehicle performance, GPS technology should be considered a precursor to the deployment of alternative fuels and advanced technology solutions.

Alternatively, analysis using AIM data provides a lower-cost method of tracking basic vehicle performance. The FuelMaster AIM installed on Raleigh's vehicles and fuel pumps transmit vehicle data every time the vehicle refuels. This automatic process assures the accurate collection of fueling transaction data as well as the vehicle's odometer reading and any OBD error codes. Because of AIM, the majority of the City's fuel data could easily and accurately be analyzed for this Plan. However, vehicles without AIM frequently logged incorrect mileage data (e.g., extra digits, reversed digits) and required manual correction before analysis.

Regular analysis of the data AIM captures helps identify which vehicles have best — and worst — fuel economy. Frequent analysis, coupled with recognition/reward for the most fuel-efficient drivers — and penalties for the worst — establishes a culture promoting fuel efficiency and raises the fleet's overall fuel efficiency. However, conducting analyses would require additional resources, such as added staff and, potentially, software upgrades.

2.2.3. PERFORMANCE MEASUREMENT

The City has systems in place to capture the data needed to effectively monitor and analyze the fleet and its operations; however, Raleigh fails to use its data for performance management.

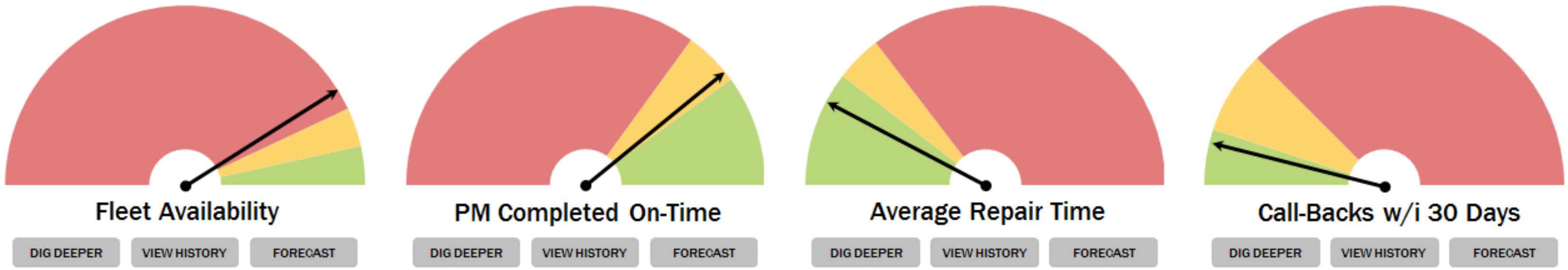
Installing AIM on every vehicle and pump will improve raw data accuracy; adding GPS tracking systems will provide additional information regarding how vehicles are operated. However, this additional data will not add value unless Raleigh has the resources to analyze it and use it to support decision-making.

VFS should ensure that its current fleet management software can collect and provide the information needed to properly evaluate vehicle and driver performance metrics, as recommended in this report. Periodically assessing alternative fleet management systems is also advised.

Raleigh should also monitor all metrics and develop a protocol for action when targets are met (e.g. rewards for good results, consequences for poor results). Certain metrics should be tracked in real time. Statistics and gauges displayed as a visual dashboard with exception alerts allows VFS and its customers to track their critical success metrics and make decisions accordingly [FIGURE 2.1].

Modeling "What If" conditions lends additional insight into the cost and

[FIGURE 2.1] Example of displaying maintenance metrics as a real-time dashboard. A plug-in pulling data from FASTER could automatically display these metrics on monitors at VFS facilities to communicate its progress to all staff and customers.



performance effects of fleet decisions. "What If" models compare performance before and after previous operational changes to determine whether the outcome was positive or negative.

Actual fuel efficiency in miles per gallon (mpg) is the best metric for comparing vehicle performance. Fuel efficiency depends on vehicle type, age, and function; therefore, comparisons require careful selection of baseline vehicles. Fortunately, Raleigh's large fleet encompasses several groups of similar vehicles. Tracking fuel efficiency by vehicle over time allows the City to see the impact of driver training and whether maintenance issues cause fuel efficiency to decrease.

With Raleigh's interest in petroleum reduction, the best fleet metric to track is "Percent of fuel displaced" through the use of alternative fuel vehicles and advanced transportation technologies. **EQUATION 2.1** shows how to calculate this metric.

This metric uses conventional vehicles and trackable statistics as a baseline — as opposed to a previous year; thus, it does not penalize the fleet for growth required to achieve its mission in a growing City.

Alternative fuels' (biodiesel, ethanol, CNG, LPG, and electric) contributions to this metric are easily calculated using gasoline-gallon equivalents. Fuel efficiency improvements — such as from better driving habits — are difficult, but calculable.

Fuel avoided through the use advanced transportation technologies is a function of operating time (anti-idling systems) or fuel economy (hybrids) compared to conventional models. Since these technologies prevented fuel consumption, the quantity of fuel avoided by these technologies must be added to both the numerator and the denominator of the equation.

2.2.4. REPLACEMENT/PROCUREMENT

RETIRING OLD VEHICLES

In many ways, Raleigh's point system for prioritizing vehicles for replacement aligns with best practices: the system accounts for use, age, and maintenance costs; and maintenance costs receive the greatest weighting (10 of the 20 points available).

However, this system also causes certain older and inefficient low-utilization vehicles to remain in the fleet longer than they should. By remaining in the fleet, these vehicles' resale value continues to decline; moreover, their utilization typically decreases further since drivers prefer newer vehicles.

A best practice that would resolve this issue simply removes the maximum points allotted to age. Thus, vehicle age becomes an increasingly more important factor in replacement eligibility, even when utilization and maintenance remain low.

[EQUATION 2.1] Formula for calculating the percent of petroleum displaced through the adoption of alternative fuels and advanced transportation technologies.

$$\text{Petroleum Displaced } (\%) = \frac{\left(N_{\text{Alternative Fuels}} + X_{\text{Advanced Transportation Technologies}}\right) \times 100}{X_{\text{Advanced Transportation Technologies}} + Y_{\text{Fuel Consumed}}}$$

where $N_{\text{Alternative Fuels}}$ is the quantity of alternative fuels purchased — accounting for only the alternative fuel portion of biofuel blends (e.g. 20% of B20) — in gasoline-gallon equivalents (gge);

$X_{\text{Advanced Transportation Technologies}}$ is the quantity of fuel avoided, in gasoline-gallon equivalents (gge), through the use of advanced transportation technologies; and

$Y_{\text{Fuel Consumed}}$ is the sum of all conventional and alternative fuels consumed by the fleet in gasoline-gallon equivalents (gge)

SELECTING REPLACEMENTS

Currently, Raleigh's Fleet Superintendent informally makes vehicle replacement recommendations after reviewing feasible alternatives, including alternative fuel vehicles and downsizing to a smaller, more efficient vehicle. Generally, the Fleet Superintendent recommends a single vehicle model, which the department director must either accept, or counter with a vehicle that will be a better fit. Formalizing this process may result in better vehicle selection.

One best practice presents department directors with five replacement options, with each choice assigned a certain number of points; for example:

1. Down-sized vehicle option
2. Alternative fuel vehicle option
3. More efficient option (e.g., hybrid or downsized engine)
4. Most similar option to retiring vehicle
5. Upsized vehicle option

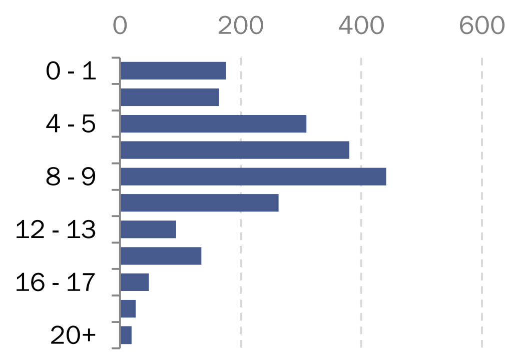
Department directors then select their preferred option, but would be required by VFS to average an established target across all vehicle replacements in a given fiscal year. This approach requires both the Fleet Superintendent and department director to consider all available options and forces the department director to find applications where downsized or alternative fueled vehicles can be used.

VEHICLE ASSIGNMENT

Currently, Raleigh purchases and assigns vehicles to departments; however, there are many applications where this is not the most cost-effective solution. One best practice regularly compares costs for sharing vehicles, renting vehicles, and reassigning vehicles to the total cost of ownership.

Also, the Fleet Superintendent makes vehicle assignment decisions in consultation with an individual department director, leading to inconsistencies across the fleet. Establishing a fleet steering committee, headed by the Fleet Superintendent with representation from all departments, would create a forum for reviewing vehicle utilization and assignments. This committee could review cost models and establish formal guidelines explaining when to purchase, rent, use motor pool vehicles, or reimburse personal vehicle mileage.

[FIGURE 2.2] Number of vehicles in Raleigh's fleet by age. There is a backlog of vehicles more than 7 years old needing replacement.



FLEET FUNDING

Finally, VFS's capital budget must be of sufficient size and consistency to meet vehicle replacement needs. Over the past few years, the capital budget fluctuated greatly, leading to a backlog of vehicles that are well beyond their useful life [FIGURE 2.2].

Even during hard financial times, the City should maintain a more consistent fleet capital budget. Failing to replace vehicles as scheduled simply shifts costs from vehicle purchases to maintenance. Catching up on vehicle purchases creates a challenge both now and in the future, as a bulk of vehicles will need replacement at the same time.

2.2.5. TAKE-HOME VEHICLES

Very few functions today require an employee to respond in-person, with specialized vehicles or equipment, during their off-hours.

In most municipalities, employees making off-hours trips use their personal vehicle and request reimbursement. The few events that may require employees to respond in City-owned vehicle can be forecasted in advance (e.g., snow/ice events); in these select instances, the City Manager or department director could grant special permission to employees to take home a vehicle.

Another approach taken by some municipalities requires employees taking home a vehicle to reimburse the municipality for personal miles and any miles driven outside the city limits. This approach discourages employees from using City-owned vehicles for commuting or other personal uses.

Raleigh should establish clear rules regarding take-home vehicles. Policies should be based on job function — not seniority nor who had a take-home vehicle in the past — to ensure that take-home vehicles relate to job necessity and do not remain a perk.

This policy may need to be phased in over time, grandfathering employees that currently take vehicles home and decreasing the number of take-home vehicles through attrition. The policy should also include a procedure for determining when an extended number of employees may take home a City vehicle because of an impending event, as well as a procedure for reimbursing the City for mileage when employees choose to take home a vehicle although it is not a job requirement.

2.3. Recommendations

Executing the following recommendations will improve the performance of Raleigh's fleet while decreasing its costs.

2.3.1. ESTABLISH A FLEET MANAGEMENT STEERING COMMITTEE

Raleigh will benefit from establishing a fleet steering committee headed by VFS's Fleet Superintendent with representation from all departments. VFS would still retain responsibility for fleet management, with input from the fleet steering committee. This committee will help VFS gain buy-in from departments, such as with decisions about vehicle replacement.

This committee should direct VFS through the process of centralizing all vehicle and maintenance data and revising its policies and procedures. In particular, we recommend VFS revise and centralize its policies regarding:

- Vehicle replacement evaluation criteria
- Vehicle replacement capital fund
- Vehicle procurement procedure
- GPS tracking and vehicle analytics
- Take-home vehicles

For example, Raleigh's procurement procedure should encourage purchasing smaller, fuel-efficient vehicles. Additionally, standardizing models purchased across all departments will increase the cost-effectiveness of VFS's maintenance service. Significant justification should be required to acquire larger, less efficient vehicles and non-standard models. Finally, greater consistency in equipment funding will support more regular fleet turnover, decreasing maintenance and fuel costs.

2.3.2. OFFER DRIVER TRAINING REGULARLY

Drivers should receive training on vehicle operating best practices at least annually and preferably more frequently. Regular trainings encourage more efficient driving, ensure personnel receive timely updates about fleet procedures, and facilitate the implementation of new policies.

Additionally, drivers operating alternative-fuel vehicles and vehicles with advanced transportation technologies should receive specific training to optimize petroleum reduction and address questions and misconceptions.

2.3.3. DEVELOP A SMART FLEET MANAGEMENT SYSTEM

Capturing accurate fueling and maintenance data enables better vehicle and fleet analytics and smarter decision-making.

VFS should ensure that FASTER — its current fleet management system — can collect and provide the information needed to properly evaluate vehicle and driver performance metrics, as recommended in this report. Periodically assessing alternative fleet management systems is also advised.

Additionally, vehicles using City-owned fueling stations should have AIM installed, and VFS should implement a quality-control procedure to ensure the accuracy of data entered manually. ■

SECONDARY RECOMMENDATIONS

The following strategies may create significant incremental costs or burdens on staff time that negate potential savings; thus, these recommendations should be considered as secondary practices to improve service performance and increase vehicle efficiency — once Raleigh successfully implements all primary recommendations.

INSTALL GPS TRACKING ON ALL FLEET ASSETS

GPS tracking will help Raleigh refine its vehicle tracking reports and fleet analysis. While it may not yield significant fuel savings, GPS systems provide significant operational support, such as streamlining pre- and post-trip reporting, tracking response times, and optimizing routes. These operational benefits should be the primary reason for adopting GPS technology.

When departments install GPS vehicle tracking, all should use a platform common to the entire City of Raleigh fleet and integrate with FASTER (or current fleet management software). The data collected from the GPS system should be used to track vehicle efficiency measures and to optimize routes.

NEGOTIATE FUELING COSTS

Raleigh currently purchases almost 25% of the fuel consumed by its fleet from privately owned gas stations — including the majority of the fuel used by the Police and Fire departments. This will likely increase to 40% once the fueling station at the downtown Police Service Center closes.

Raleigh should consider negotiating a discount in exchange for exclusively fueling at specific vendor(s) with locations convenient to where Police and Fire vehicles are stationed. Another advantage of selecting preferred vendors is that the City can encourage the vendors to offer higher biofuel blends (e.g., B5, B10, or B20 instead of diesel; E15 or E85 in addition to E10).

However, if multiple vendors are required, or interested vendors cannot provide fueling data in a manner that easily integrates into FASTER, then the time required to manage this effort may negate the savings.

EVALUATE INSOURCING MAINTENANCE SERVICES

To most cost-effectively operate its large fleet, the City of Raleigh invested in the needed maintenance infrastructure and training to efficiently provide repair and maintenance services. The many smaller local governments surrounding Raleigh maintain much smaller fleets and could not justify this investment in maintenance facilities. Raleigh should consider offering vehicle maintenance services to other local government agencies and evaluate the extent to which the City and potential municipality/agency clients would benefit from such an arrangement.

Vehicles & Sub-Fleets

CHAPTER THREE

City of Raleigh's more than 2,000 on-road vehicles consumed 2.15 million gallons of fuel at a cost of $6.6 million in FY2014. While Vehicle Fleet Services (VFS) retains responsibility for procuring and maintaining these vehicles, the departments to which each vehicle gets assigned determines their day-to-day job function and utilization.

This chapter reviews the types of vehicles in Raleigh's fleet, evaluates the utilization of vehicles in each department's sub-fleet, and suggests strategies for increasing utilization rates based on best practices.

3.1. Fleet assets

Raleigh's fleet of over 2,000 on-road vehicles includes twelve different basic types, or classifications, of vehicles. Most of these vehicles have been up-fit with specialty equipment in order to serve a particular job function; for example, Public Utilities' sewer jet trucks are customized medium-duty trucks.

TABLE 3.1, next page, shows the composition of Raleigh's fleet by vehicle type. Light-duty vehicles — including passenger vehicles, pick-up trucks, light-duty service trucks, and police patrol vehicles — comprise 75% of the City's fleet.

In general, the classifications with the most vehicles drove the most cumulative miles and consumed the most fuel; the one exception is refuse trucks. Refuse, or garbage, trucks have the lowest fuel economy in Raleigh's fleet and consumed more fuel than other vehicles with more cumulative miles.

Appendix D provides individual vehicle performance by vehicle type, along with FY2014 mileage and fuel consumption. The tables and charts indicate wide variation among miles traveled and fuel economy within each classification and vehicle type.

FIGURE 3.1, on the opposite page, plots the twelve vehicle types against total FY2014 fuel consumption and average fuel economy achieved. The size of the bubble denotes the quantity of vehicles.

Vehicle types falling in the lower right corner — highlighted in yellow — are prime candidates for alternative fuels. These have the highest fuel consumption and thus will have the greatest impact on petroleum reduction goals; additionally, these vehicles have the lowest fuel economy, indicating alternative fuels and advanced vehicle technologies (e.g., hybrid-electrics) present the greatest opportunity for improvement.

The average age of City of Raleigh's fleet is 7.6 years, which is in line with other municipalities. For example, Utilimarc's 2011 Municipal Fleet Benchmark Study reported the average fleet is 7.3 years old.[4]

However, as discussed in SECTION 2.2.4, Raleigh has a significant backlog of older vehicles. Failing to replace vehicles as scheduled simply shifts costs from vehicle purchase to maintenance. Furthermore, the fleet must keep more spares on-hand to compensate for the decreased availability of older vehicles.

[4] Utilimarc, "2011 Municipal Fleet Benchmark Study." Similar findings regarding average fleet vehicle age also appear in 1) Fleet Answers, "Municipal Vehicle Replacement Trends," (2010) and 2) Government Fleet, "Fact Book 2012," (2012) pp 34.

[TABLE 3.1] Fleet composition and FY2014 summary statistics

VEHICLE TYPE	QUANTITY[1]	FY14 FUEL CONSUMED	FY2014 MILEAGE[2]	AVERAGE AGE	AVG. FUEL ECONOMY[3]
Police patrol vehicle	485 (479)	589,596	5,492,233	6.1	10.2
Light-duty pick-up truck	481 (469)	356,935	3,898,584	8.1	12.0
Passenger vehicle	476 (469)	213,877	3,464,746	7.9	18.5
Light-duty service truck	89 (86)	107,658	808,640	7.8	8.1
Medium-duty svc. truck	146 (145)	157,580	917,499	9.2	6.1
Emergency vehicle	73 (58)	107,542	354,957	11.5	4.4
Cargo van	5 (5)	3,013	19,271	9.4	6.6
Refuse truck	112 (108)	519,579	940,011	5.2	2.7
Heavy-duty truck	108 (106)	133,554	509,459	8.4	4.6
Heavy-duty service truck	30 (30)	66,394	259,127	8.9	4.2
Bus	22 (22)	17,860	124,480	9.4	6.5
Street sweeper	17 (16)	13,320	35,960	9.5	3.4

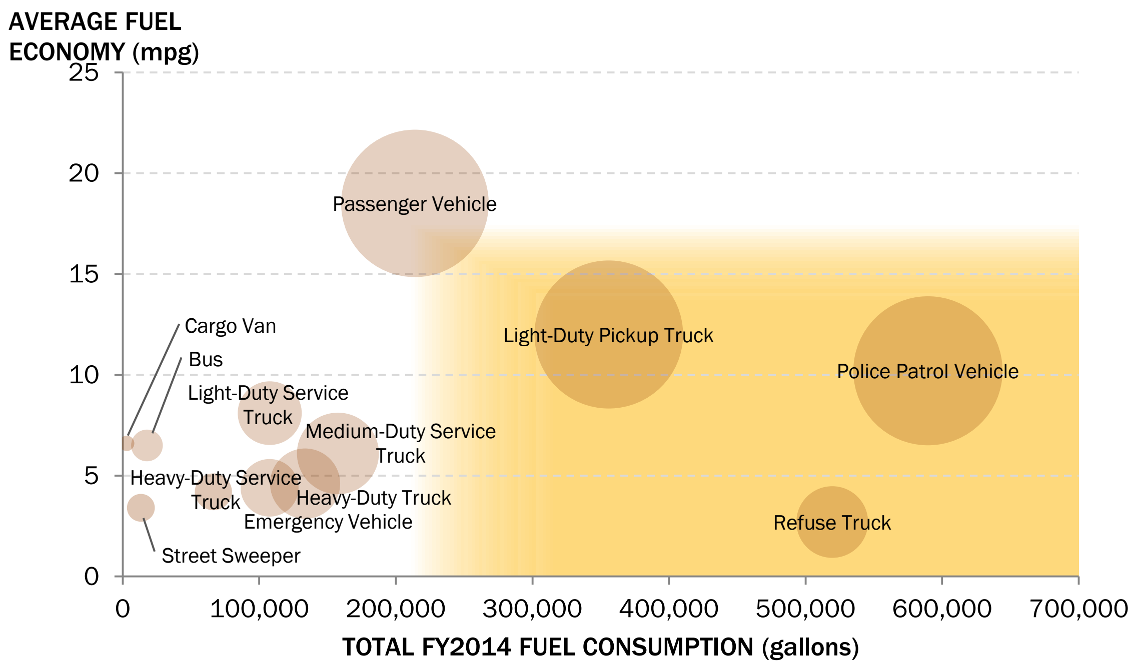
[1] Includes vehicles with at least one fueling transaction during FY2014 (July 2013 to June 2014); parenthetical number indicates the number of vehicles with accurate fuel and mileage records.

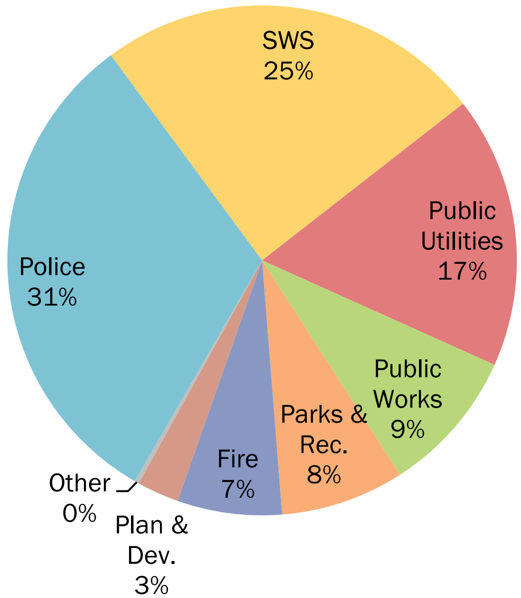
[2] Mileage excludes vehicles with inaccurate data (i.e., not feasible based on fuel transactions) that could not be feasible for the specified vehicle. The number of vehicles reporting accurate fuel and mileage data is provided parenthetically in the Quantity column.

[3] Calculated by determining the fuel economy of each individual vehicle, and then averaged across all similar vehicles; not annual mileage divided by annual fuel consumption.

Catching up on vehicle purchases creates a challenge both now and in the future, as the bulk of vehicles will come due for replacement at the same time.

Besides these on-road vehicles, Raleigh's fleet also includes motorized equipment, such as mowers, tractors, four-wheelers, all-terrain vehicles, backhoes, chippers, and trolleys. This equipment consumes a small percentage of the fleet's fuel use. While there may be some cost-effective alternative fuel or advanced technologies, equipment constitutes such a small part of the fleet that the impact of any changes will be limited. Thus, choosing alternative fuels for motorized equipment should be considered primarily as a means to





[FIGURE 3.1] Plot of the twelve vehicle types against total FY2014 fuel consumption and average fuel economy achieved. The size of the bubble denotes the quantity of vehicles. Vehicle types falling in the lower right corner — highlighted in yellow — are prime candidates for alternative fuels because these have the highest fuel consumption and lowest fuel economy.

[FIGURE 3.2] Distribution of total FY2014 fuel consumption by department. The Police and Solid Waste Services departments use more fuel than all other departments combined.

showcase the City's leadership in environmental stewardship and innovation.

3.2. Department sub-fleets

Categorizing vehicle assets, mileage, and fuel consumed by department sub-fleet provides a different perspective on petroleum reduction opportunities.

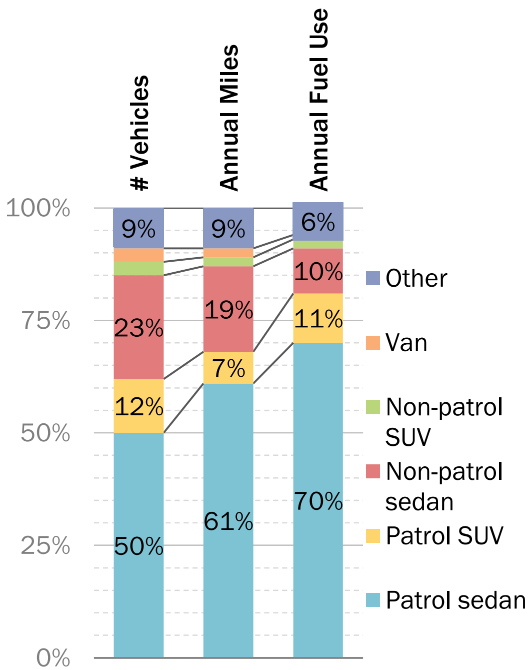
As shown in **FIGURE 3.2**, the Police Department was the largest consumer of fuel in FY2014 (July 2013 to June 2014), followed by Solid Waste Services (SWS) and Public Utilities.

The remainder of this section will review the assets and performance of Raleigh's departmental sub-fleets (excluding CAT). Appendix E provides detailed vehicle statistics and charts by department.

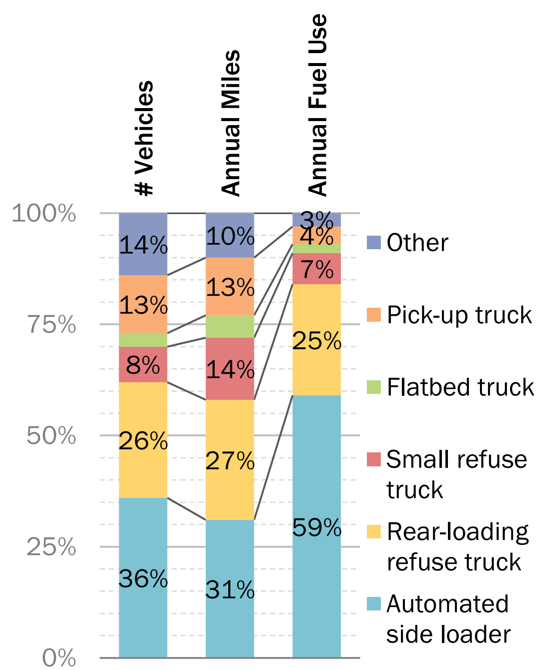
3.2.1. POLICE DEPARTMENT

Patrol cars comprise the majority — approximately 65% — of the Police Department's 769-vehicle sub-fleet. Ford discontinued the Crown Victoria chassis that underpins most of Raleigh's patrol interceptor vehicles; after testing all currently available police patrol chassis, the department will transition to Ford Interceptor Sport Utility Vehicles (SUVs).

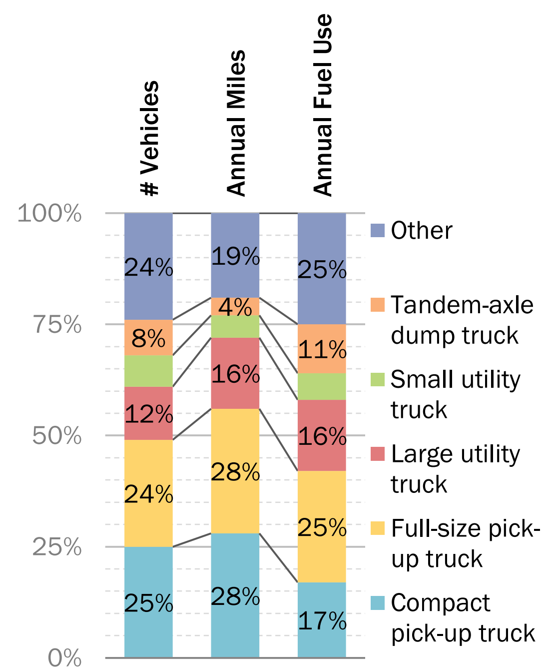
Patrol vehicles (sedans + SUVs) consume more than 80% of the fuel used by the Police Department [**FIGURE 3.3**; next page]. Both total fuel consumption and the percent of fuel used by patrol vehicles will increase as more Interceptor SUVs (8.8 mpg) replace the older Crown Victoria Interceptors (10.2 mpg). Many municipalities report a 15% increase in fuel consumption after switching from a sedan to an SUV chassis. Notably, motorcycles



[FIGURE 3.3] Vehicle count, annual mileage, and annual fuel consumption for the Police Department sub-fleet by vehicle type



[FIGURE 3.4] Vehicle count, annual mileage, and annual fuel consumption for the Solid Waste Services sub-fleet by vehicle type



[FIGURE 3.5] Vehicle count, annual mileage, and annual fuel consumption for Public Utilities' sub-fleet by vehicle type

and hybrid sedans achieve twice the fuel economy of all other non-patrol vehicles in Police's sub-fleet.

3.2.2. SOLID WASTE SERVICES

SWS's 147-vehicle sub-fleet consists primarily of diesel-fueled refuse trucks.[5]

As shown in **FIGURE 3.4**, automated side loaders comprise the largest segment of the sub-fleet and consume as much fuel as the rest of the department combined. SWS's vehicles low fuel economies (average 2.7 mpg) result in the highest per-vehicle fuel consumption in the City (average 2,000 gallons per vehicle).

Notably, utilization rates vary significantly amongst each vehicle type in SWS's sub-fleet.

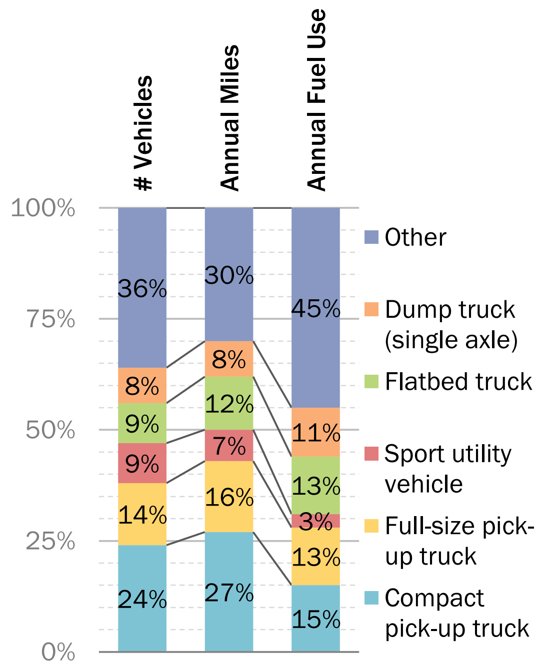
3.2.3. PUBLIC UTILITIES

Pickup trucks comprise the largest segment of Public Utilities' sub-fleet [**FIGURE 3.5**]. The fuel economy of Public Utilities' pick-up trucks differed greatly by vehicle, indicating these trucks perform a variety of job functions (e.g., carrying heavier loads; highway vs. city driving). Notably, the hybrid-electric sedans achieve three times higher fuel economy than the rest of the sub-fleet.

3.2.4. PUBLIC WORKS

Nearly half Public Works' vehicles are classified as light duty. Public Works' sub-fleet (excluding CAT) includes pickup trucks, dump trucks, SUVs, service trucks, and many other vehicle types [**FIGURE 3.6**; opposite page]. A number of vehicle types contain just one or two units, indicating the sub-fleet's composition is customized to the department's service offerings.

[5] Analysis excludes two compressed natural gas (CNG) trucks added in FY2015.

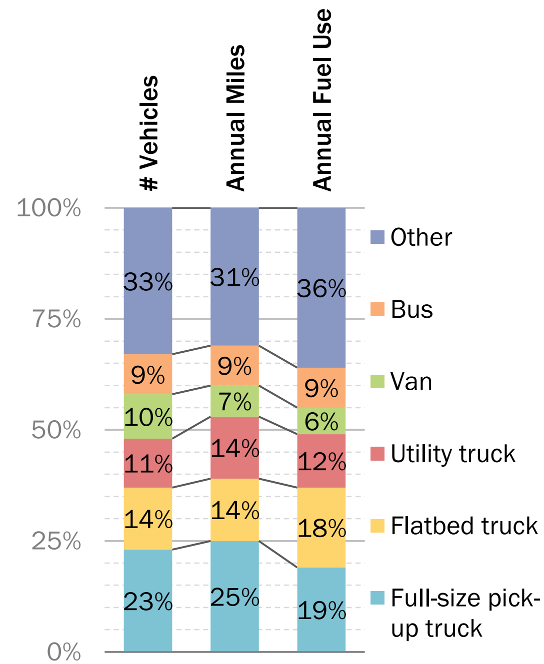


[FIGURE 3.6] Vehicle count, annual mileage, and annual fuel consumption for Public Works' sub-fleet by vehicle type

As with other departments, hybrid-electric vehicles achieve higher fuel efficiencies than all other vehicles. Notably, the fuel efficiency of the passenger vehicles and pick-up trucks vary greatly; also, some vehicles in Public Works' sub-fleet receive very low annual mileage.

3.2.5. PARKS, RECREATION, AND CULTURAL RESOURCES

Parks, Recreation, and Cultural Resources' sub-fleet primarily consists of variously sized trucks. The largest four vehicle types — full-size pick-up trucks, flat-bed dump trucks, light-duty utility trucks, and vans —



[FIGURE 3.7] Vehicle count, annual mileage, and annual fuel consumption for Parks, Recreation, & Cultural Resources' sub-fleet by vehicle type

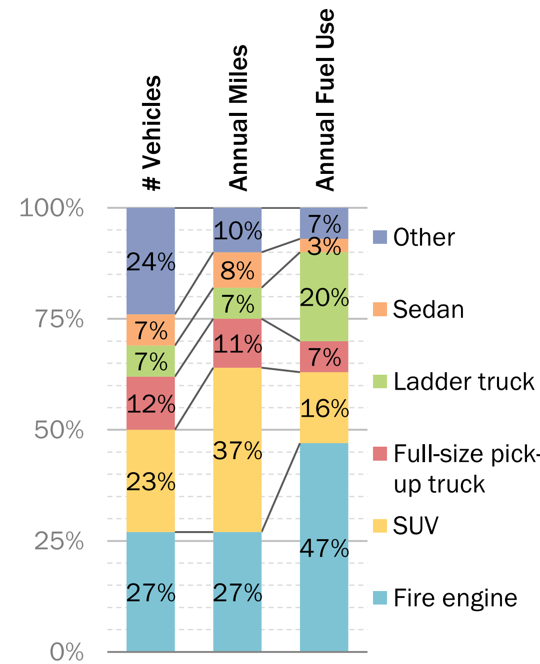
cumulatively account for half of the sub-fleet inventory, miles driven, and fuel consumed [**FIGURE 3.7**].

Again, fuel efficiency and utilization rates vary greatly with hybrid-electric vehicles performing exceptionally well compared to the rest of the sub-fleet.

3.2.6. FIRE DEPARTMENT

While the Fire Department's 147 vehicles serve various functions, all must transport first-responders to emergencies.

As shown in **FIGURE 3.8**, fire engines and SUVs comprise half the vehicles in the sub-



[FIGURE 3.8] Vehicle count, annual mileage, and annual fuel consumption for the Fire Department's sub-fleet by vehicle type

fleet, with SUVs covering the most miles and fire engines consuming nearly half of the sub-fleet's fuel. Fire engines, ladder trucks, and fire rescue vehicles consumed considerably more fuel per vehicle than other vehicles in the sub-fleet.

Notably, fuel efficiency and miles traveled vary greatly across the Fire Department's sub-fleet.

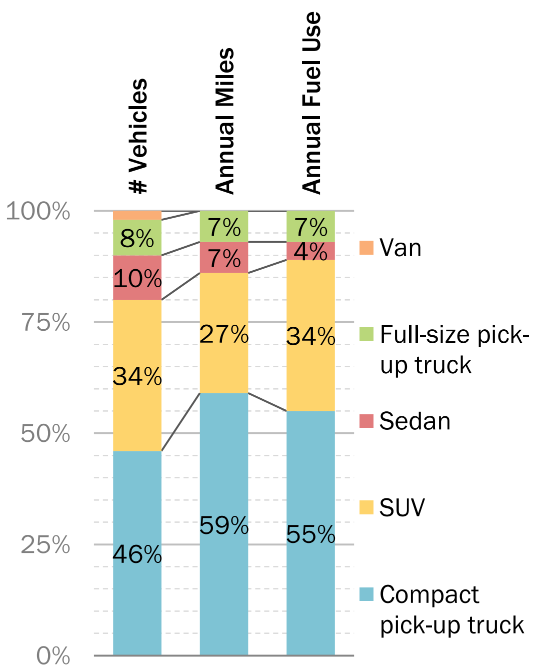
3.2.7. PLANNING & DEVELOPMENT

Planning & Development's sub-fleet includes compact pick-up trucks, SUVs, full-size pick-ups, sedans, hybrid sedans, vans, and one CNG sedan.

As shown in FIGURE 3.9, compact pick-up trucks consume almost two-thirds of the department's fuel in FY2014.

Notably, all vehicles in this department sub-fleet experienced low fuel consumption. Light-duty vehicles — SUVs, sedans (especially the hybrid) — achieve higher fuel efficiencies than the more utilized compact pick-up trucks (no longer available). If they can accommodate required functions, replacing these compact pick-up trucks with light-duty vehicles will make Planning & Development's sub-fleet more efficient.

[FIGURE 3.9] Vehicle count, annual mileage, and annual fuel consumption for the Planning & Development Department's sub-fleet by vehicle type

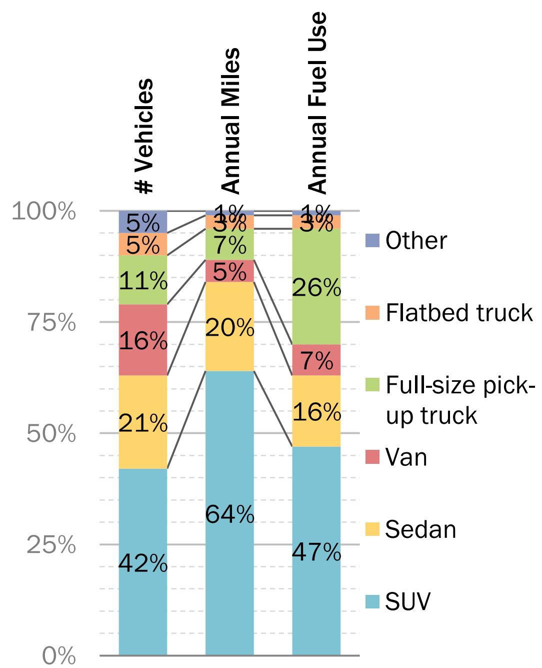


3.2.8. OTHER DEPARTMENTS

All other departments combined — including Budget & Management Services, Emergency Communications, Public Affairs, Emergency Management & Special Events, and the Convention Center — consume less than 1% of the fuel used by the City of Raleigh's fleet.

These departments' sub-fleets consist of light-duty vehicles with relatively low fuel use. As shown in FIGURE 3.10, the proportion of vehicles, annual miles, and fuel use remains relatively constant across all vehicle types.

[FIGURE 3.10] Cumulative vehicle count, annual mileage, and annual fuel consumption for all other department sub-fleet by vehicle type



3.2.9. MOTOR POOLS

Raleigh currently offers three motor pool locations where departments and personnel share vehicles: at the Municipal Building, at Vehicle Fleet Services (N. West St.), and Public Utilities' Lake Woodard facility. These motor pools are entirely automated, allowing personnel to reserve and use any available vehicle.

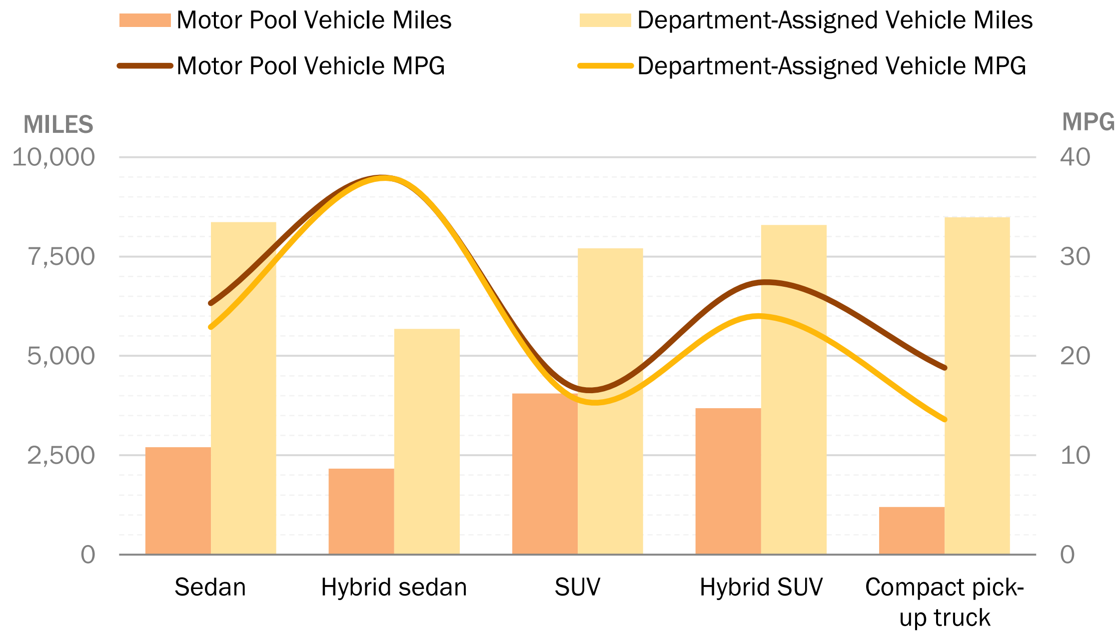
The City currently assigns 15 vehicles to these motor pools — less than 1% of the total fleet. Hybrid-electric vehicles comprise almost half of the motor pool.

Notably, Raleigh's motor pool vehicles receive only 2,762 miles per year on average — 64% fewer miles than vehicles assigned to departments. FIGURE 3.11 (next page) compares the utilization and fuel efficiency of comparable motor pool and department-assigned vehicles.

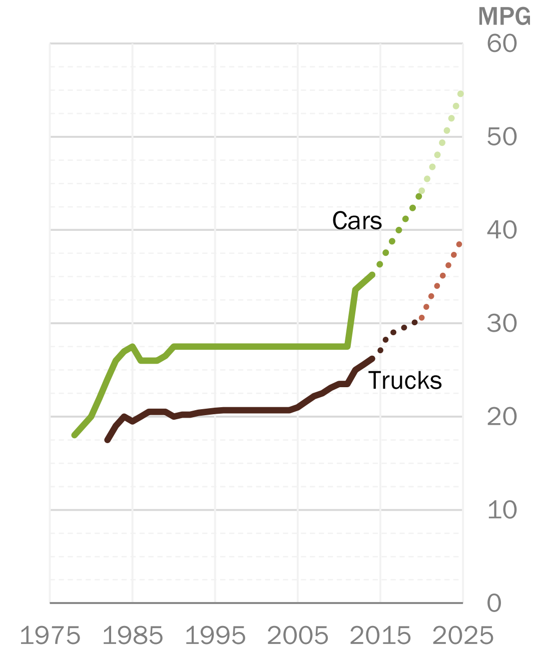
3.3. Fleet composition best practices

Having the right type and quantity of vehicles to complete the mission is critical, while having too many or too large vehicles is not cost-effective.

Fleet composition best practices lower the fleet's operating costs by reducing the number of vehicle assets and decreasing maintenance costs, which indirectly reduces fuel use. The following best practices will improve the City of Raleigh's fleet composition and utilization.



[FIGURE 3.11] Average annual mileage and fuel efficiency (miles per gallon) of vehicles assigned to departments vs. in Raleigh's Motor Pool



[FIGURE 3.12] Federal fuel efficiency standards will continue to increase through at least 2025

3.3.1. NEWER FLEET

As vehicles age, fuel economy typically declines. Increased friction from worn parts, build-up of un-combusted carbon in the engine, and leaky seals all reduce vehicle performance and efficiency.

Additionally, newer vehicles tend to be more efficient: redesigned body styles increase aerodynamics and new engines produce more power with less fuel to meet increasing federal fuel efficiency regulations [**FIGURE 3.12**].[6]

While the average age of Raleigh's fleet — 7.6 years — aligns with most other U.S. municipalities,[7] 7% of its fleet (141 vehicles) is 15 years old or older. Many older vehicles are not heavily utilized yet must be maintained by VFS. See Appendix F for a complete listing of all vehicles model year 2000 or older.

[6] Center for Climate and Energy Solutions, "Federal Vehicle Standards, 1975 – 2025."

[7] The average age of vehicles in U.S. municipal fleets is 7.3 years. Sources: Utilimarc, "Municipal Fleet Benchmark Study," 2011; Fleet Answers, "Municipal Vehicle Replacement Trends," (2010); Government Fleet, "Fact Book 2012," (p. 34).

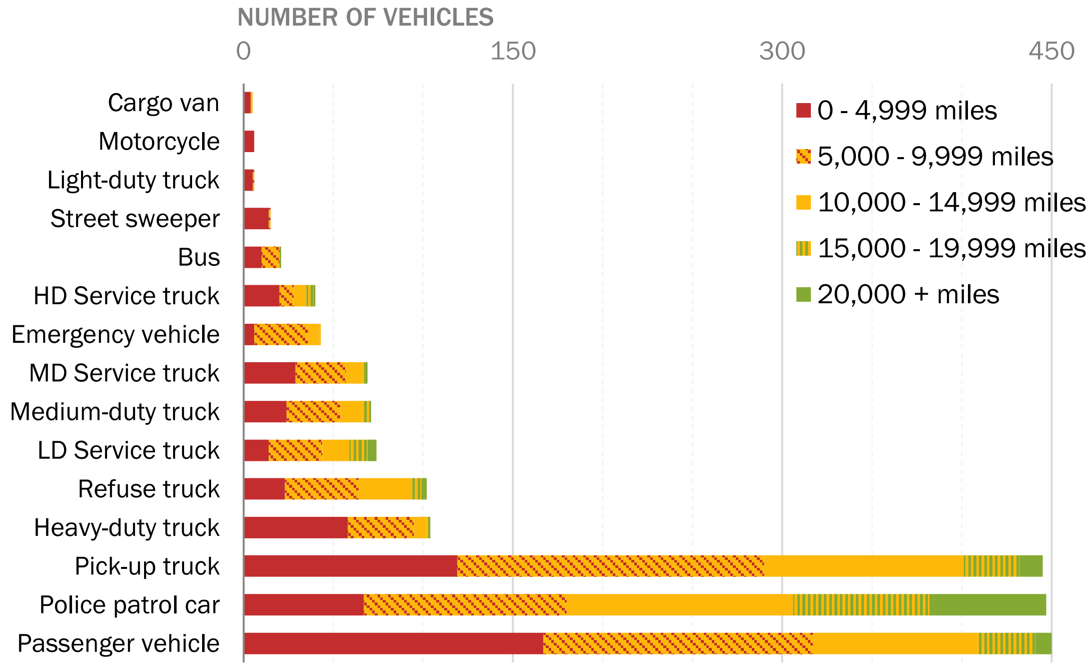
3.3.2. FLEET RIGHT-SIZING

Fleet right-sizing optimizes the fleet size by eliminating vehicles that are no longer required or not used frequently. Combining the duties of several low utilization vehicles in order to decrease fleet size reduces overall fleet capital and operating costs. Increased utilization of remaining vehicles improves the business case for alternative fuels and advanced transportation technologies, as greater fuel savings more rapidly recoup initial incremental costs.

Based on the annual mileage of individual vehicles in Raleigh's fleet [FIGURE 3.13], there appears to be an opportunity to reduce the fleet's size by either modifying vehicle assignments or pooling low-use vehicles.

The best candidates for pooling or re-assignment include light-duty, general-purpose vehicles — such as passenger vehicles and general-purpose pickup trucks — that travel less than 5,000 miles annually. Special purpose vehicles that record few miles but provide an essential and unique function should not be eliminated from the fleet.

Further investigation of vehicles driven less than 5,000 miles will verify the feasibility of right-sizing Raleigh's fleet. Appendix C includes a procedure for fleet right-sizing.



[FIGURE 3.13] Number of vehicles by type and level of utilization. Utilization, based solely on annual mileage, is classified as very low (< 5,000 miles), low (5,000 – 9,999 miles), typical (10,000 – 14,999 miles), high (15,000 – 19,999 miles), and very high (> 20,000 miles).

3.3.3. VEHICLE RIGHT-TYPING

Vehicle right-typing ensures that vehicle type (class, model, drivetrain) fits the functions the vehicle performs.

Vehicle right-typing provides both capital and operating budget savings by generally decreasing the size and increasing the fuel efficiency of selected vehicles. As functions allow, Raleigh's fleet should reduce vehicle size to less expensive, more fuel-efficient models when replacing units. TABLE 3.2, next page, demonstrates possible savings by right-typing vehicle replacements.

Raleigh's current procurement policy incorporates vehicle right-typing by prompting the Fleet Superintendent to recommend the most economic and environmentally sustainable option; however, as discussed in SECTION 2.1.1, the Fleet Superintendent frequently does not know how vehicles will be used, and department heads can circumvent the Fleet Superintendent's recommendation.

3.3.4. MOTOR POOL

Sharing vehicles across departments using a motor pool reduces sub-fleet and overall fleet inventory, increases utilization, and decreases short- and long-term operating costs. A motor pool is most effective when its vehicles receive greater use than department-assigned vehicles.

Motor pools tend not to be effective when 1) the pool contains too few vehicles and 2) motor pool protocols fail to clarify who retains responsibility for refueling, cleaning, reporting maintenance issues, etc. As soon as an employee fails to get the needed vehicle, s/he may speak poorly of the motor pool and insist on getting an assigned vehicle. Similarly, failing to specify responsibility for vehicle refueling, cleaning and maintenance causes vehicle

[TABLE 3.2] Demonstration of potential petroleum and cost savings through vehicle right-typing

CURRENT REPLACEMENT	ALTERNATIVE REPLACEMENT	CHANGE IN INITIAL COST	ANNUAL MILEAGE	ANNUAL FUEL SAVINGS	LIFETIME FUEL COST SAVINGS*	LIFETIME SAVINGS
MODEL / MPG	MODEL / MPG	MORE (LESS)	MILES	GALLONS	COST	TOTAL
Ford Fusion / 20.8	Ford Focus / 29.3	$ (1,899)	8,336	117	$ 2,848	$ 4,747
Dodge Journey / 14.5	Ford Fusion / 20.8	(5,288)	8,331	175	4,259	9,547
Dodge Journey / 14.5	Ford Escape / 19.8	(1,828)	8,331	155	3,764	5,592
Ford F-250 / 9.3	Ford F-150 / 12.0	(4,528)	9,868	237	6,479	11,007
Ford F-350 / 8.4	Ford F-250 / 9.3	(7,410)	9,868	110	3,020	10,430
Ford E-250 / 9.4	Transit Connect / 16.6	1,640	4,568	208	5,697	4,057

* Assumes $3.04 per gallon of gasoline

condition to deteriorate rapidly, making driving motor pool vehicles less desirable.

The City of Raleigh currently offers 15 vehicles in 3 automated motor pool locations. These vehicles average 2,762 miles per year — 36% of the miles of vehicles assigned to specific departments. Such low mileage is not a very cost-effective application for advanced vehicle technologies, yet 7 of these vehicles are hybrid-electrics.

Additionally, some departments operate informal motor pools, where several drivers share one vehicle. This practice undermines the City-wide motor pool by “reserving” low-utilization vehicles that should be pooled, and subsequently reducing the number of vehicles the fleet can eliminate.

Based on the number of City personnel operating out of most buildings/facilities a motor pool should be an effective means of sharing vehicles; however, if Raleigh continues to have a small motor pool with low-utilization vehicles, this strategy will not reduce the number of vehicles in the fleet.

To improve the utilization of its motor pool, Raleigh should expand the size of its motor pool to 10% of its fleet (1% currently) and remove underutilized, non-specialized vehicles from the sub-fleets. Clear policies for motor pool vehicles should be created and enforced. Dedicated VFS staff support may be required to manage the motor pool’s operation. An automated reservation system works well for most fleets, but some personnel need support to reserve and check out a vehicle. This Motor Pool Manager would also retain responsibility for getting motor pool vehicles serviced and cleaned.

Most departments will need some financial incentive or other benefit to encourage use of motor pool vehicles over assigned City vehicle. For example, new vehicles could be assigned to the motor pool initially, and only assigned to individual departments after two years.

3.4. Recommendations

Implementing the following recommendations will improve Raleigh’s fleet composition and vehicle efficiency.

3.4.1. ANALYZE FLEET FREQUENTLY

Conducting regular fleet analyses will help Raleigh to identify underutilized vehicles, and ultimately, to right-size its fleet. Analytics will also help Raleigh determine the best applications for owning vehicles, using motor pool vehicles, renting vehicles, or using personal vehicles. Reports and analysis should be conducted at least quarterly, and preferably monthly; in addition, VFS should have the authority to re-assign vehicles that are underutilized, unneeded, or not the most efficient type for the current assignment.

Generating these reports and analysis will require resources not currently available within VFS. The Fleet Superintendent has requested a new position which would do this work on an ongoing basis. Savings from using the analytics to right-size the fleet and further reduce the fleet's petroleum consumption should offset the cost for the additional position. Alternately, the City could contract with a fleet management consultant to conduct this analysis.

3.4.2. REVISE VEHICLE PROCUREMENT PROCEDURE

Raleigh's procurement procedure should encourage purchasing smaller, fuel-efficient vehicles. Additionally, standardizing models purchased across all departments will increase the cost-effectiveness of VFS's maintenance service. Significant justification should be required to acquire larger, less efficient vehicles and non-standard models. Finally, greater consistency in equipment funding will support more regular fleet turnover, decreasing maintenance and fuel costs.

To minimize the purchase of new vehicles, VFS, or a steering committee comprised of its customer departments, should have the authority to re-assign vehicles that are underutilized, no longer needed, or not the most efficient vehicle type for the current assignment. ■

SECONDARY RECOMMENDATIONS

These recommendations should be considered secondary practices to further optimize the fleet composition — once Raleigh successfully implements all primary recommendations. These strategies will require further analysis to properly implement.

RIGHT-SIZE THE FLEET

In FY2014, 506 vehicles drove less than 4,000 miles; 132 went less than 1,000 miles. Without details about which are specialized vehicles, we cannot recommend removing all of these underutilized vehicles. It is likely that 250 or more of these vehicles can — and should — be removed from the fleet without negatively impacting the City's ability to complete its mission. Duplicate vehicles should be moved to the motor pool. After implementing primary recommendations, the City should conduct additional analysis of its low-utilization vehicles and re-assign or salvage any unnecessary vehicles. Appendix C includes a procedure for fleet right-sizing.

INCREASE THE SIZE OF THE MOTOR POOL

The current size and composition of Raleigh's motor pool does not reduce the overall size of the fleet. There are too few vehicles for departments to rely on a vehicle being available when they need one; this makes departments reluctant to relinquish assigned vehicles. After implementing its primary recommendations, Raleigh should conduct an in-depth analysis on where fleet vehicles are assigned versus where and when they are used to determine the proper size and placement of motor pool(s) so that motor pool vehicles effectively replace a large number of underutilized, department-assigned vehicles.

Fuel & Infrastructure

CHAPTER FOUR

Over the past several years, many Raleigh departments proactively pursued alternative fuels and/or advanced vehicle technologies within their own sub-fleets.

However, this piecemeal approach is more expensive and creates a challenge for VFS to manage. For example, VFS cannot exchange these specialized vehicles with other fleet vehicles when needed; it also requires VFS to stock new and different parts and adds service and training requirements.

Alternative fuels and advanced vehicle technologies yield the greatest cost efficiencies when deployed department- or City-wide. Economies of scale enable bulk vehicle purchases and make optimal use of fueling/maintenance infrastructure, personnel training, and parts inventory.

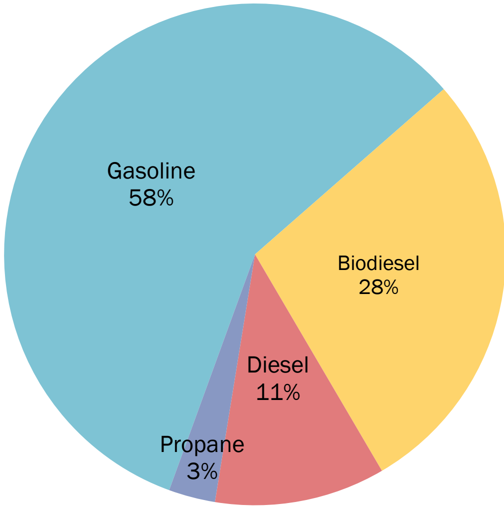
This chapter reviews Raleigh's current fueling infrastructure for both petroleum and alternative fuels and analyzes Raleigh's potential for additional cost savings through a broader, more strategic adoption of alternative fuels and other advanced transportation technologies.

4.1. Fuel consumption

In FY2014 (July 1, 2013, to June 30, 2014), the City of Raleigh's on-road vehicle fleet (excluding CAT) consumed 2.15 million gallons of fuel.

Gasoline (E10) — a blend of 10% ethanol and 90% petroleum gasoline — comprises 58% of the City's FY2014 fuel consumption [FIGURE 4.1; next page]. B20 — a blend of 20% biodiesel and 80% petroleum diesel — and petroleum diesel together comprise 39% of the City's fuel consumption. Propane provides most of the remainder. Compressed natural gas (CNG) provided a negligible percentage of the City's fuel consumption in FY2014.[8]

[8] The City had nine CNG vehicles in the fleet during FY2014 and most were used minimally; two CNG refuse trucks were added in FY2015.

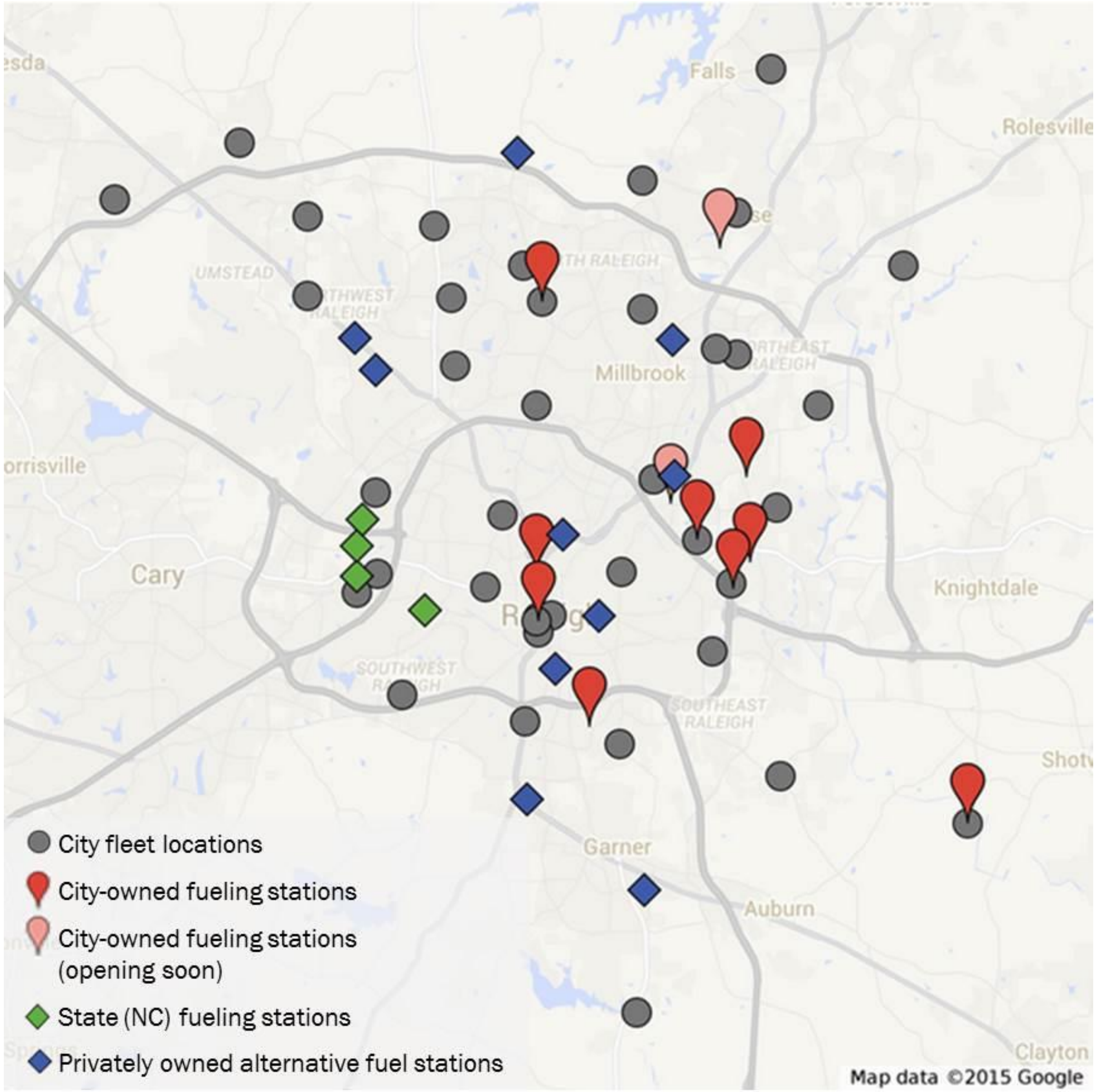


[FIGURE 4.1] Fuel consumption by type for Raleigh's on-road fleet. In FY2014, Raleigh's fleet consumed a total of 2.15 million gallons of fuel (all types).

4.2. Fueling infrastructure

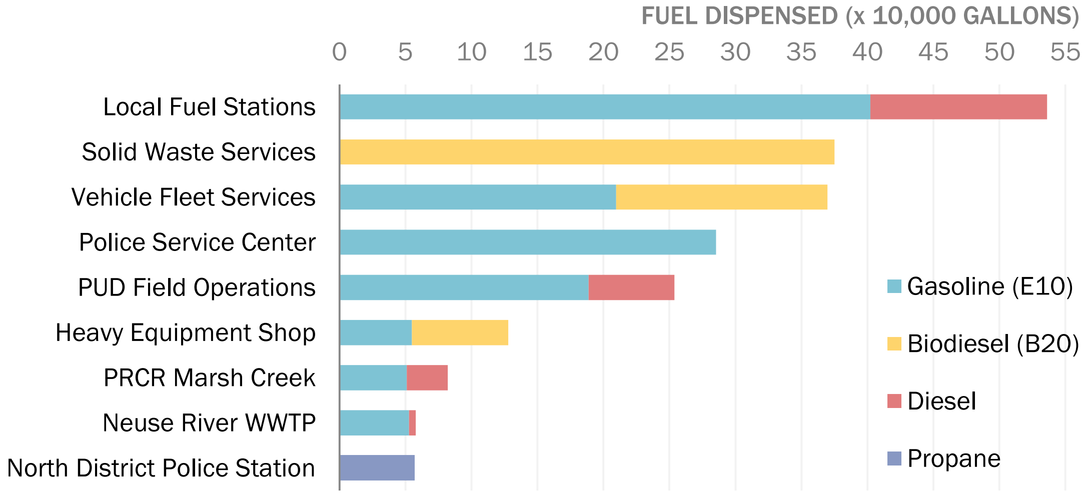
The City of Raleigh maintains the largest network of alternative fuel stations in the Triangle. At the time of this report, Raleigh operates nine fueling stations stocked with traditional and alternative fuels; two additional stations will come online in FY2015/16. FIGURE 4.2 shows these locations. As shown in FIGURE 4.2, many facilities with assigned City vehicles (gray circles) can easily access at least one fueling location (red paddles).

New fueling options added this past year include propane dispensers at Marsh Creek and Biltmore, and multiple fuel offerings at the soon-to-open Northeast Remote Operations Center. Once the new



[FIGURE 4.2] Locations of Raleigh's fuel and fleet infrastructure. Gray dots indicate locations assigned City of Raleigh vehicles. Red paddles indicate current Raleigh fueling infrastructure; lighter-colored red paddles indicate planned or soon to be operational stations. Green diamonds denote State-owned alternative fuel stations, while blue diamonds indicate privately owned alternative fuel stations.

Explore an interactive version of this map with location names, addresses, and fuel types:
https://goo.gl/i3clwn



[FIGURE 4.3] Quantity and types of fuel dispensed from each City-owned fueling station compared to the cumulative amount of fuel purchased from privately owned local fuel stations. Nearly 25% of the fuel consumed by Raleigh's on-road vehicles was dispensed from local fuel stations, not City-owned fueling facilities. The Police Service Center, which dispensed 17% of all fuel dispensed from City-owned facilities, is slated to close soon.

Raleigh Boulevard facility opens, the fueling station at VFS's N. West Street facility is scheduled to close. Additionally, the downtown Police Service Center is scheduled to close soon. Closing these two downtown facilities eliminates convenient fueling locations for City vehicles assigned to downtown.

FIGURE 4.3 displays the quantity and type of fuel dispensed by location. In total, the City purchased more fuel from privately owned local fuel stations than from any one City-owned facility. Police and Fire Department vehicles assigned to locations not convenient to City fueling facilities were the primary users of local fuel stations. The downtown Police Service Center, slated to close soon, dispensed the third largest quantity of fuel; it is expected that the quantity of fuel dispensed from this location will shift to privately owned gas stations once the facility closes.

In addition to Raleigh's fueling stations, NC Department of Transportation, NC Motor Fleet Management, and NC State University stock, or contract with certain providers to supply, alternative fuels at stations in Raleigh (green diamonds; FIGURE 4.2).[9] As shown in FIGURE 4.2, the City has vehicles, but does not currently have fueling facilities, near some of these State-owned or –contracted stations.

Additionally, some of these State-owned facilities offer fuels that the City does not currently provide, such as E85 — a blend of 85% ethanol and 15% gasoline that can be used in flex-fueled vehicles.

4.3. Potential petroleum- and cost-saving strategies

The following analyses quantify and prioritize the potential fossil fuel and cost savings from implementing various petroleum reduction/displacement strategies. All analyses assume Raleigh-specific operations and cost factors, as practicable and available.

Alternative fuels assessed include biodiesel, electric, ethanol, natural gas, and propane; advanced transportation technologies assessed include hybrid-electric vehicles, idle reduction technology, and hydraulic hybrid technology.

The analysis shows that the City of Raleigh has the potential to achieve up to a 43% petroleum reduction/displacement using a combination of alternative fuels and advanced transportation technologies.

4.3.1. BIODIESEL

Biodiesel (B20) accounts for 72% (608,000 gallons) of the fuel consumed by Raleigh's diesel vehicles. In FY2014, B20 cost, on average, $0.05 more per gallon

9 Previous billing issues that restricted the City from purchasing fuel at State-owned facilities have been resolved.

than diesel for large deliveries of fuel. The City of Raleigh currently dispenses biodiesel (B20) from Vehicle Fleet Services, Solid Waste Services, and the Heavy Equipment Shop; additionally, the City dispenses diesel at Public Utilities' Lake Woodard and Neuse River Wastewater Treatment Plant facilities and Parks, Recreation, and Cultural Resources' Marsh Creek facility.

In FY2014, 191 of the City's diesel vehicles fueled exclusively with B20 and 121 vehicles fueled exclusively with diesel. Notably, the distribution of vehicles using each fuel does not vary by vehicle age, which occurs in fleets concerned about using biodiesel blends in older vehicles [FIGURE 4.4].

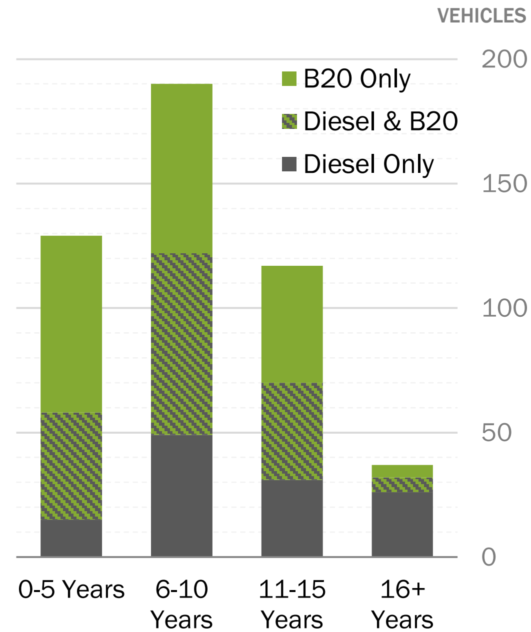
An additional 161 vehicles refueled with both diesel and B20 throughout last fiscal year [FIGURE 4.4]. Mixing fuels is concerning because vehicles that predominantly use diesel may experience fuel filter issues after refueling with B20, incurring additional maintenance costs.

The City of Raleigh could convert most of its remaining diesel to B20. Where vehicle age or periodic vehicle use preclude fueling with B20, off-road diesel tanks could be filled with on-road diesel. Incremental costs of converting to B20 — such as an additional fuel filter change on vehicles currently using diesel — are minimal. TABLE 4.1 presents the economics of switching all diesel-dispensing facilities to B20. However, the Neuse River Wastewater Treatment Plant dispenses only 5,000 gallons of diesel per year and may not turn-over enough to switch to B20.

Two additional methods for increasing petroleum reduction using biodiesel include 1) using higher biodiesel blends (e.g., B30, B50) and 2) using hydrogenation-derived renewable diesel.

Increasing the percent of biodiesel in its fuel would help Raleigh achieve greater petroleum reduction; however, using biodiesel blends above B20 may void engine warrantees and increase the risk of gelling / fuel separation. Furthermore, higher blends are not cost-effective at this time.

[FIGURE 4.4] Number of diesel vehicles fueling solely with diesel, solely with biodiesel (B20), and mixing diesel and biodiesel



[TABLE 4.1] Economic and impact analysis of switching the three facilities currently dispensing Ultra-Low Sulfur Diesel (ULSD) to biodiesel (B20). Initial cost includes one additional fuel filter change per year for all vehicles currently using diesel. Annual fuel cost change assumes B20 continues to cost $0.05 more per gallon. In total, converting remaining ULSD dispensers to B20 could reduce Raleigh's petroleum use by 20,250 gallons.

FUELING STATION	ANNUAL FUEL DISPENSED	PETROLEUM REDUCTION POTENTIAL	INITIAL COST TO IMPLEMENT	ANNUAL FUEL COST CHANGE	COST PER UNIT PETROLEUM REDUCTION	PAYBACK PERIOD	VEHICLE ROI
	(GALLONS)	(GALLONS)	($)	MORE (LESS)	($ / GALLON)	(YEARS)	(%)
Lake Woodard	65,080	13,016	$ 2,828	$ 3,291	$ 0.28	N/A	N/A
Marsh Creek	30,994	6,199	1,347	1,567	0.28	N/A	N/A
Neuse River WWTP	5,179	1,036	225	262	0.28	N/A	N/A

Hydrogenation-derived renewable diesel (HDRD) — also known as green diesel, second-generation biodiesel, or renewable diesel — may be available in the near future at a price competitive with diesel. Using a 100% HDRD blend would significantly reduce the City's petroleum consumption.

EMERGING TECHNOLOGY SPOTLIGHT

Hydrogenation-Derived Renewable Diesel (HDRD)

Like biodiesel, HDRD can be produced from soybean, palm, canola, or rapeseed oil; animal tallow; vegetable oil waste; brown trap grease; and other fats / vegetable oils.

Producing HDRD uses hydrogenating triglycerides to remove metals and compounds with oxygen and nitrogen from biodiesel; thus, HDRD meets the ASTM specification for petroleum diesel. By achieving this standard, HDRD may be used in existing diesel infrastructure and vehicles without system modifications — unlike B100.

HDRD produced from 100% renewable inputs reduces greenhouse gas emissions by 40-90% compared to fossil diesel.

4.3.2. ELECTRIC & HYBRID-ELECTRIC

Several different types of vehicles use electricity as fuel:

1. Battery-electric vehicles (BEVs) only use electric power from a battery pack.
2. Hybrid-electric vehicles (HEVs) use energy recovered through regenerative braking to assist the gasoline-fueled internal combustion engine with accelerating the vehicle.
3. Plug-in hybrid-electric vehicles (PHEVs) use an internal combustion engine to supplement the electric power from a battery pack.

While HEVs simply require refueling, BEVs and PHEVs require recharging. Charging equipment that plug into conventional 20-amp, 110-volt alternating current (AC) outlets — referred to as Level 1 chargers — can fully charge a BEV or PHEV during an overnight period (8-12 hours). Level 1 charging station cost $1,000 each.

Higher-powered Level 2 charging stations recharge vehicles faster (4 hours), but require 220-volt, 40-amp outlets. A Level 2 charging station typically costs $1,500 (basic model without special payment or reporting features); labor and materials to install a 220-volt outlet add ~$3,500, bringing the total installed cost of a Level 2 charging station to $5,000. Despite the higher cost, Raleigh may find Level 2 charging preferable so its BEVs and PHEVs can be quickly recharged as needed.

CASE STUDY

Houston's EV - lution

Spurred by concerns air quality concerns, Houston — the fourth-largest US city and an energy-industry hub — is quickly becoming a giant in the deployment of advanced transportation solutions, including EVs.

Houston operates the nation's third-largest municipal fleet of HEVs and the second-largest municipal fleet of EVs. The City also consolidated its motor pool and expanded EV use through "Houston Fleet Share" — a car-sharing program for city employees developed partnership with Zipcar.

The City began to electrify its fleet in 2009 by converting 15 Prius vehicles to PHEVs. In 2011, Houston procured 25 Nissan Leafs; two more purchased in 2013 were incorporated into the Fleet Share program. Each of these vehicles saves the City $7,000 in fuel and maintenance costs every three years.

With the help of several EV supply equipment manufacturers, Houston also installed 50 charging stations in the fleet garage to support the Fleet Share program. ⌑

SOURCE US Department of Energy, "Houston Energizes Deployment of Plug-In Electric Vehicles" (30 September 2014).

4.3.2.1. BATTERY-ELECTRIC VEHICLES

BEVs' have a shorter driving range (~70 miles per full charge) than gasoline- and diesel-fueled vehicles. Furthermore, BEVs' range can decrease by up to 50% in cold and hot weather due to cabin conditioning loads and decreased battery performance. This makes BEVs ill-suited for job functions that require longer daily trips. However, Raleigh may benefit from replacing certain very-low-mileage vehicles with BEVs.

To evaluate these potential benefits, this analysis assumes Raleigh replaces four of its nine small, general-purpose sedans with BEVs. This analysis compares three BEV models — Ford Focus Electric, Nissan Leaf, and Mitsubishi i-MiEV — to a conventional Ford Focus (MSRP $18,125). **TABLE 4.2** presents the economics of this scenario.

Mitsubishi's i-MiEV is the least expensive BEV and most fuel-efficient (3.9 miles per kilowatt-hour) in this analysis. The i-MiEV is also the smallest vehicle of the three, with the least powerful electric motor and smallest battery pack — yet its driving range is competitive. Notably, the i-MiEV charges more slowly than the other BEVs; while this does not affect overnight charging, it may limit the opportunity for daytime charging. As shown in **TABLE 4.2**, the i-MiEV is the only BEV to potentially provide cost savings over a conventional gasoline vehicle.

In addition to sedans, a few small vehicle manufacturers now offer plug-in hybrid and battery-electric pick-up trucks, cargo vans, and passenger vans; however, these new utility electric vehicles are currently prohibitively expensive ($50,000, compared to $20,000 for a conventional vehicle). At this time, fuel savings from replacing some of Raleigh's trucks will not recoup the high incremental cost within the vehicle's useful life.

Neighborhood electric vehicles (NEV) — small on-road vehicles with a maximum speed of 35 MPH — provide another utility electric vehicle alternative. Two classes of NEVs are currently available through the State contract:

1. **BASIC NEVs.** Similar to golf carts with a small bed for tools or light hauling; offered by Cushman, Global Electric Motorcars, ParCar, and Star for $10,000 - $14,300.
2. **STRONGER NEVs.** E-Ride sells an NEV that is closer to a small truck for $28,500 on State contract.

[TABLE 4.2] Economic analysis of BEV sedan alternatives compared to a conventional Ford Focus sedan

MODEL / RANGE (MSRP)	PETROLEUM REDUCTION POTENTIAL	INITIAL COST TO IMPLEMENT	ANNUAL FUEL COST CHANGE	COST PER UNIT PETROLEUM REDUCTION	PAYBACK PERIOD	VEHICLE ROI
	(GALLONS)	($)	MORE (LESS)	($/GALLON)	(YEARS)	(%)
SCENARIO 1 > LEVEL 1 CHARGING						
Mitsubishi i-MiEV / 62 miles ($22,995)	1,773	$ 23,480	$ (4,079)	$ (0.72)	5.8	130%
Nissan Leaf / 84 miles ($29,010)	1,773	47,540	(3,970)	1.15	12.0	63%
Ford Focus Electric / 76 miles ($36,670)	1,773	78,180	(3,905)	3.49	20.0	37%
SCENARIO 2 > LEVEL 2 CHARGING						
Mitsubishi i-MiEV / 62 miles ($22,995)	1,773	$ 39,480	$ (4,079)	$ (0.27)	9.7	77%
Nissan Leaf / 84 miles ($29,010)	1,773	63,540	(3,970)	1.60	16.0	47%
Ford Focus Electric / 76 miles ($36,670)	1,773	94,180	(3,905)	3.94	24.1	31%

[TABLE 4.3] Economic analysis of replacing a pick-up truck or ATV with a Neighborhood Electric Vehicle (NEV)

CURRENT VEHICLE	REPLACEMENT VEHICLE	% NEV USE VERSUS CURRENT	ANNUAL MILEAGE (MILES)	PETROLEUM REDUCTION POTENTIAL (GALLONS)	INITIAL COST TO IMPLEMENT ($)	ANNUAL FUEL COST CHANGE MORE (LESS)	COST PER UNIT PETROLEUM REDUCTION ($/GALLON)	PAYBACK PERIOD (YEARS)	VEHICLE ROI (%)
ATV	Basic NEV	100%	3,650	183	$ 4,450	$ (418)	$ 0.51	10.7	70%
Pick-up	Basic NEV	40%	3,832	310	5,450	(776)	(0.43)	7.0	107%
Pick-up	Basic NEV	60%	5,748	466	1,450	(1,164)	(2.26)	1.2	602%
Pick-up	Stronger NEV	50%	4,790	388	19,500	(970)	3.99	20.1	37%
Pick-up	Stronger NEV	100%	9,580	776	9,500	(1,939)	(0.97)	4.9	153%

Raleigh currently operates five NEVs, with mixed results (see SECTION 1.4.4). NEVs are most effectively used at the Neuse River Wastewater Treatment Plant, where the NEVs average 3,650 miles per year — 40% of the mileage of pickup trucks and passenger vehicles.

In limited applications, NEVs can perform the same functions of a conventional vehicle; where an NEV can replace a gasoline pick-up truck, it provides a cost-effective solution for reducing petroleum use [TABLE 4.3].

4.3.2.2. HYBRID-ELECTRIC VEHICLES

The City of Raleigh currently operates 86 hybrid-electric vehicles (HEVs). These HEVs achieve significantly higher fuel economy than similarly sized gasoline vehicles in Raleigh's fleet. For example, mid-sized hybrid-electric sedans average 32.4 miles per gallon (mpg), compared to 16.9 mpg for similar gasoline sedans. Small HEV

CASE STUDY

NYC Invests in HEVs

With nearly 27,000 vehicles, New York City (NYC) operates the largest municipal fleet in the US. Over the past 13 years, NYC made a major investment in hybrid-electric vehicle technologies, purchasing 6,880 HEVs, at a cost of $183 million.

The majority of these vehicles have been HEV sedans, such as the Toyota Prius or the Ford Fusion Hybrid. On average, these sedans cost $3,373 more than their gas counterparts; however, the benefits more than offset the incremental cost:

- Right- and down-sized vehicles (e.g., the Toyota Prius is as, or more, compact than the sedans it replaces)
- Improved fuel economy (65% to 130%)
- Reduced maintenance costs
- Increased vehicle availability
- Higher resale value

NYC now spends less on fuel and maintenance and reclaims more money on resale; HEVs are also proving to be more reliable and resilient vehicles. Considering these factors, HEVs save the Big Apple big bucks. ⌑

SOURCE NYC Fleet, "Benefits of hybrid gas-electric cars," (June 2014).

sedans averaged 38.5 mpg; similar small gasoline sedans, 19.1 mpg.

The incremental cost for an HEV varies: The State contract offers a Ford Fusion Hybrid for $23,248 — $5,323 more than a conventional Ford Fusion ($17,925). At $26,790, the Toyota Camry Hybrid costs $3,820 more than a conventional Camry ($22,970). A Toyota Prius ($24,200) costs $6,075 more than a Ford Focus ($18,125).

Raleigh's fleet also contains 29 Ford Escape Hybrids, These HEV SUVs average 24.1 mpg, compared to 16.2 mpg for comparable conventional small SUVs. Originally, these HEV SUVs cost $7,100 more than comparable small SUVs in the fleet.

However, Ford no longer offers the Escape Hybrid. Today, manufacturers tend to offer hybrid options only on luxury and large SUV models — such as the Lexus RX, Porsche Cayenne, and Nissan Pathfinder. The only currently offered HEV comparable to the Escape Hybrid is the Subaru XV Crosstrek, a crossover utility vehicle (CUV).

HEVs may have higher resale value than conventional vehicles. For example, a good-condition 2006 Toyota Prius with 65,000 miles currently sells for $9,029, while a comparable 2006 Ford Focus sells for $5,420. This difference in resale value indicates HEVs retain a portion of their incremental costs; $3,609 is 59% of the difference between the original MSRPs of these vehicles. Thus, the calculations in TABLE 4.4 consider both no difference and an increase in resale value; the higher resale scenario assumes HEVs retain 50% of their initial incremental cost.

TABLE 4.4 calculates the payback period and return on investment for HEVs for small and mid-sized sedans and small SUVs. These calculations show that mid-sized HEV sedans are most cost-effective. Small HEV sedans will be cost-effective with higher resale values. Since the average payback period on HEV SUVs exceeds the vehicle's lifetime, HEV SUVs should only be procured for high-mileage applications (greater than 10,000 miles per year) where equipment size and/or job function require an SUV.

4.3.2.3. PLUG-IN HYBRID VEHICLES

Unlike BEVs, PHEVs are not range-limited; thus, PHEVs could replace Raleigh's 25 conventional, general-purpose sedans and the Police Department's 137 non-patrol sedans.

[TABLE 4.4] Economic analysis of Hybrid Electric Vehicles (HEVs) considering 1) no difference in resale value and 2) higher resale value

QTY	VEHICLE TYPE	ANNUAL MILEAGE	PETROLEUM REDUCTION POTENTIAL	INITIAL COST TO IMPLEMENT	ANNUAL FUEL COST CHANGE	RESALE VALUE	COST PER UNIT PETROLEUM REDUCTION	PAYBACK PERIOD	VEHICLE ROI
(#)		(MILES)	(GALLONS)	($)	MORE (LESS)	($)	($/GALLON)	(YEARS)	(%)
SCENARIO 1 > NO DIFFERENCE IN RESALE VALUE									
9	Small sedan	76,052	2,012	$ 54,675	$ (5,710)	--	$ 0.79	9.6	78%
153	Mid-sized sedan	1,176,602	33,109	699,440	(93,986)	--	(0.02)	7.4	101%
61	Small SUV	401,990	8,076	433,100	(22,925)	--	4.31	18.9	40%
SCENARIO 2 > RESALE VALUE EQUALS 50% OF INITIAL INCREMENTAL COST									
9	Small sedan	76,052	2,012	$ 54,675	$ (5,710)	$ 27,338	$ (1.03)	4.8	128%
153	Mid-sized sedan	1,176,602	33,109	699,440	(93,986)	349,720	(1.43)	3.7	151%
61	Small SUV	401,990	8,076	433,100	(22,925)	216,550	0.74	9.4	90%

[TABLE 4.5] Economic analysis of Plug-In Hybrid Electric Vehicles (PHEVs) where electric power fuels 1) 25% of annual miles for small sedans and 2) 75% of annual miles for mid-sized sedans

QTY	CURRENT VEHICLE	REPLACEMENT VEHICLE	STATION	PETROLEUM REDUCTION POTENTIAL (GALLONS)	INITIAL COST TO IMPLEMENT ($)	ANNUAL FUEL COST CHANGE MORE (LESS)	COST PER UNIT PETROLEUM REDUCTION ($/GALLON)	PAYBACK PERIOD (YEARS)	VEHICLE ROI (%)
SCENARIO 1 > 25% ELECTRIC MILES									
9	Small sedans	Toyota Prius	Level 1	1,313	$ 115,785	$ (3,203)	$ 8.75	36.1	21%
9	Small sedans	Toyota Prius	Level 2	1,313	151,785	(3,203)	10.12	47.4	16%
SCENARIO 2 > 75% ELECTRIC MILES									
153	Mid-sized sedans	Chevy Volt	Level 1	37,520	$ 3,092,895	$ (82,239)	$ 8.46	37.6	20%
153	Mid-sized sedans	Chevy Volt	Level 2	37,520	3,704,895	(82,239)	9.27	45.1	17%

PHEVs cost significantly more than comparable gasoline models. For example, in the compact sedan class, the Toyota Prius Plug-in costs $12,000 more, and the Ford C-Max Energi costs $15,000 more, than a comparably equipped gasoline Ford Focus. Among larger sedans, the Chevrolet Volt and Ford Fusion SE Energi cost $19,000 more than a conventional, gasoline-fueled Ford Fusion.

Most vehicles do not drive the same distance every day; thankfully, PHEVs flexibly accommodate variable ranges — even long distances — by supplementing their battery packs with a fuel-efficient gasoline engine.

On average, Raleigh's passenger sedans travel 7,700 miles annually and consume 450 gallons of fuel. If driven the same distance every day throughout the year (not typical), these vehicles average 31 miles per day. This distance falls within the Chevrolet Volt's electric-only range (38 electric miles per charge; increases to 50 miles starting with 2016 models), but exceeds the electric range of the Toyota Prius Plug-in (11 miles) and various Ford Energi models (21 miles). Thus, the analysis in TABLE 4.5 considers two scenarios, where electric power fuels 1) 25% of a small PHEV's mileage and 2) 75% of a mid-sized PHEV's mileage.

While recharging a PHEV overnight using a Level 1 charger should be sufficient for most applications, the analysis in TABLE 4.5 considers both levels of charging stations.

The calculations in TABLE 4.5 assume the City replaces all conventional passenger sedans with PHEVs; however, PHEVs can be deployed in any quantity. Deploying fewer PHEVs would lower first-year costs, while keeping the same payback and ROI.

However, as shown by this analysis, PHEVs are not cost effective for the city of Raleigh.

4.3.3. ETHANOL

Raleigh's fleet contains 434 Flex-Fuel Vehicles (FFVs) that can refuel using either gasoline or ethanol blends (up to E85). As shown in TABLE 4.6, the Police Department operates the majority of Raleigh's FFVs.

The soon-to-open Northeast Remote Operations Center will be the first City

[TABLE 4.6] Number of Flex-Fuel Vehicles (FFV) by departmental sub-fleet

# FFV	DEPARTMENT
283	Police
59	Public Utilities
35	Public Works
33	Parks, Recreation & Cultural Res.
14	Solid Waste Services
10	All Other Departments

fueling facility to stock E85. While not currently offered at City fueling stations, the NC Department of Transportation facility on Blue Ridge Road and the Crown Mart Express on New Bern Avenue both currently supply E85.

Ethanol blends contain less energy per gallon than gasoline; for example, E85 has approximately 73% the energy content of gasoline. As a result, fueling with ethanol blends lowers FFVs' fuel economy. Thus, E85 must cost at least 25% lower than gasoline (E10) to be cost-effective.

From March through November 2014, the State contract price for E85 averaged \$2.39 per gallon, compared to \$2.74 for gasoline (E10). At the Crown Mart Express, E85 cost \$2.94 per gallon, compared to \$2.95 per gallon of gasoline. While nominally lower, E85 actually costs more per gallon than gasoline after accounting for its lower energy content.

CASE STUDY

How Chicago Encourages Ethanol

The City of Chicago, with 1,860 light-duty FFVs, currently displaces more than 1.2 million gallons of gasoline annually using ethanol (E85).

To maximize its petroleum displacement, Chicago implemented a "lockout" policy in 2011 that required all FFVs use E85 when refueling from city-owned stations. Subsequently, E85 consumption skyrocketed.

In 2012, challenges developed when E85 prices rose higher than gasoline on a gasoline-gallon equivalent (gge) basis. To balance environmental and financial sustainability, Chicago removed the blanket lockout policy and now only deploys the lockout policy when E85 prices fall below gasoline on a gge basis; during "policy-free" periods, fuel choice lies in the hands of individual drivers. ⌑

SOURCE US Department of Energy, "City of Chicago Program Encourages Petroleum Displacement and Collaboration Between Departments," (16 May 2014).

While ethanol does not provide fuel cost savings, using E85 would significantly reduce Raleigh's petroleum consumption. Northeast Remote Operations' fueling station will serve all police vehicles at the Northeast District Office and the majority of FFVs operated by Parks, Recreation, & Cultural Resources. Reserving one of the

[TABLE 4.7] Economic and petroleum-reduction impact of using E85 in Raleigh's Flex-Fuel Vehicles (FFVs).

FUELING STATION	FFVS SERVED	ANNUAL FUEL DISPENSED	PETROLEUM REDUCTION POTENTIAL	INITIAL COST TO IMPLEMENT	ANNUAL FUEL COST CHANGE	COST PER UNIT PETROLEUM REDUCTION	PAYBACK PERIOD	VEHICLE ROI
	(#)	(GALLONS)	(GALLONS)	(\$)	MORE (LESS)	(\$/GALLON)	(YEARS)	(%)
Lake Woodard (new dispenser)	73	76,678	53,876	\$ 10,000	\$ 31,034	\$ 0.59	N/A	N/A
Lake Woodard (new station)	73	76,678	53,876	20,000	31,034	1.05	N/A	N/A
Northeast Remote Operations Center	80	81,705	57,408	--	33,069	0.58	N/A	N/A
Crown Mart Express	24	26,874	18,882	--	24,682	1.31	N/A	N/A

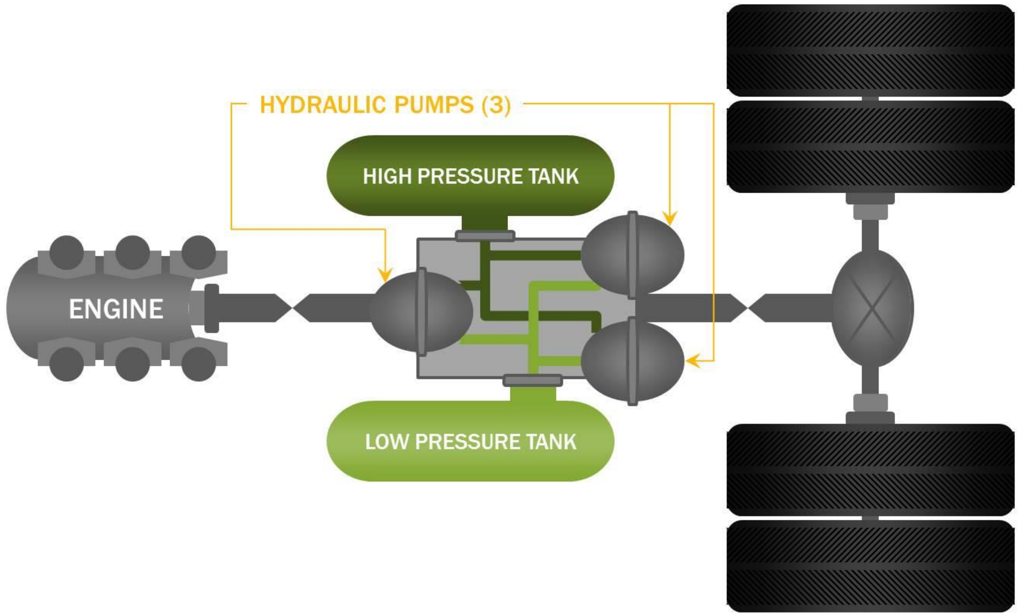
two gasoline (E10) tanks at Lake Woodard for E85 and installing an E85-capable dispenser could fuel most Public Utilities' and Solid Waste Services' FFVs. The Crown Mart Express could potentially serve up to half of Police FFVs based at the Downtown District Office. TABLE 4.7 shows the economics of using more E85 in the fleet.

4.3.4. HYDRAULIC HYBRIDS

Like electric-hybrids common to the passenger vehicle market, hydraulic hybrids capture kinetic energy from braking and use it later to accelerate the vehicle.

As shown in FIGURE 4.5 a hydraulic hybrid vehicle's engine connects to a hydraulic pump that fills a tank with high-pressure hydraulic fluid. Then, this high-pressure hydraulic fluid then flows through another hydraulic pump, turning the vehicle's wheels; when braking, a third hydraulic pump spins in the opposite direction, re-pressurizing the hydraulic fluid to use later. Thus, hydraulic hybrids are most efficient in applications with frequent stops, such as refuse trucks.

Recently, Eaton and Bosch Rexroth discontinued their lower-efficiency parallel hydraulic hybrid lines, leaving Parker Hannifin's series-style RunWise system as the dominant market player. Smaller manufacturers, such as Effenco and Lightning Hybrids, also offer hydraulic hybrid options.



[FIGURE 4.5] A series hydraulic hybrid drivetrain, such as the one in Parker Hannifin's RunWise system. See a summary of RunWise at https://youtu.be/fX7Q2sumz4w

CASE STUDY

Ann Arbor Choses Hydraulic Hybrid

In 2010, Ann Arbor adopted hydraulic hybrid technology for four of its recycling trucks, and the investment is paying off with fuel savings, lower maintenance costs, and increased productivity.

Regenerating refuse trucks' braking energy improves fuel economy by 15%, saving the Michigan city almost 1,800 gallons of fuel each year. Hydraulic hybrids' regenerative braking system also produces huge brake maintenance savings. Normally, trucks that start-and-stop as frequently as refuse trucks require 3-4 brake replacements every year; it took 3 ½ years before Ann Arbor needed to replace the brakes on these hydraulic hybrids — an annual maintenance savings of $12,000.

SOURCE US Department of Energy, "Hydraulic Hybrids: Success in Ann Arbor," (1 October 2011). Supplemented with updated information from a Parker Hannifin case study (dated 2013) provided over email by Angelo Caponi, sales specialist.

Documented fuel savings from Parker Hannifin's RunWise system vary between 35% and 50% depending on route density and operating conditions. Maintenance savings — particularly from the reduced frequency of brake replacements — also contribute significantly to this technology's cost savings. A conventional refuse truck needs its brakes replaced 2-4 times each year, whereas hydraulic hybrid refuse trucks need brakes replaced only once every 3-4 years. At a cost of $1,840 per brake replacement, these maintenance cost savings add up quickly.

Hydraulic hybrid technology can be phased during normal vehicle replacement schedules; the RunWise system costs $100,000 more than a conventional refuse truck. While the improved fuel efficiency helps offset this high incremental cost, the maintenance savings are the key factor in achieving a return on investment [TABLE 4.8; Scenario B]. Because of the high initial cost, hydraulic hybrids are not a cost-effective solution for Solid Waste Service's entire fleet (Scenario 1). As shown in Scenario 2 in TABLE 4.8, the payback period improves when used only on SWS's automated side-loaders, but the trucks must still achieve the highest fuel savings predicted by the manufacturer (55%) to be cost-effective (Scenario 2B).

[TABLE 4.8] Economic analyses of hydraulic hybrid refuse trucks at the various fuel savings ratios documented by early adopters. Scenarios consider 1) replacing all 112 trucks in Solid Waste Service's fleet, and 2) replacing only the 53 automated side-loading trucks; A) without maintenance savings, and B) with maintenance savings from reduced brake replacement frequency.

FUEL SAVINGS	PETROLEUM REDUCTION POTENTIAL	INITIAL COST TO IMPLEMENT	ANNUAL FUEL COST CHANGE	ANNUAL MAINTENANCE COST CHANGE	COST PER UNIT PETROLEUM REDUCTION	PAYBACK PERIOD	VEHICLE ROI
(%)	(GALLONS)	($)	MORE (LESS)	MORE (LESS)	($/GALLON)	(YEARS)	(%)
SCENARIO 1A > REPLACE ALL 112 REFUSE TRUCKS; WITHOUT MAINTENANCE SAVINGS							
35%	192,146	$ 11,200,000	$ (598,947)	--	$ 5.21	18.7	37%
45%	247,045	11,200,000	(770,075)	--	3.36	14.5	48%
55%	274,495	11,200,000	(855,639)	--	2.71	13.1	53%
SCENARIO 1B > REPLACE ALL 112 REFUSE TRUCKS; WITH MAINTENANCE SAVINGS							
35%	192,146	$ 11,200,000	$ (598,947)	$ (505,520)	$ 2.58	10.1	69%
45%	247,045	11,200,000	(770,075)	(505,520)	1.31	8.8	80%
55%	274,495	11,200,000	(855,639)	(505,520)	0.87	8.2	85%
SCENARIO 2A > REPLACE ONLY 53 AUTOMATED SIDE LOADING REFUSE TRUCKS; WITHOUT MAINTENANCE SAVINGS							
35%	126,332	$ 5,300,000	$ (393,794)	--	$ 2.88	13.5	52%
45%	162,426	5,300,000	(506,306)	--	1.54	10.5	67%
55%	180,474	5,300,000	(562,562)	--	1.08	9.4	74%
SCENARIO 2B > REPLACE ONLY 53 AUTOMATED SIDE LOADING REFUSE TRUCKS ; WITH MAINTENANCE SAVINGS							
35%	126,332	$ 5,300,000	$ (393,794)	$ (239,219)	$ 0.98	8.4	84%
45%	162,426	5,300,000	(506,306)	(239,219)	0.07	7.1	98%
55%	180,474	5,300,000	(562,562)	(239,219)	(0.25)	6.6	106%

4.3.5. IDLE REDUCTION

Automotive engines provide power most efficiently at relatively high speeds (55-60 mph) and heavy loads; however, sometimes specific functions and duties require vehicles to idle for extended periods of time. Engines are not optimized for idling and thus consume ½ - 1 gallon of fuel each hour they idle.

Some idle-reduction technologies shut off the engine when it is not needed; other systems provide alternative energy sources (i.e., secondary battery pack, generator) to operate on-board equipment and accessory loads (e.g., air conditioning) for extended periods without using the engine.

Raleigh currently uses the battery-based Energy Xtreme anti-idling system in 29 police patrol vehicles; the Energy Xtreme units provide only 0.65 hours of idle reduction each day. As discussed in SECTION 1.4.5., the performance and durability of these units have not met Raleigh's expectations. ZeroRPM, Vanner, and Navitas, among others, offer battery-based anti-idling systems that may prove more robust and more capable of meeting the needs of Raleigh's police patrol vehicles.

As shown in TABLE 4.9, Raleigh will achieve a favorable return on investment when its anti-idling system prevents 2 or more hours of idling per day. The calculations in TABLE 4.9 assume a new system costs $4,790, installation costs $300, and vehicle upgrades (higher capacity shocks and springs to handle the increase in weight) cost $300; the analysis also assumes the system lifespan is 6.6 years (the same as a new patrol vehicle) and provides for one battery replacement, costing $1,800, at 3.3 years.

While TABLE 4.9 models installing battery-based anti-idling systems in 400 police patrol vehicles, this technology can be deployed in any number of vehicles and should be selected where function requires a vehicle to regularly sit stationary in a location for an extended period of time.

Another type of anti-idling system, known as "automatic stop-start," shuts off the vehicle's engine while idling and restarts the engine as soon as the driver presses the gas pedal. Some systems can even shut off the engine during coasting and/or braking. Many hybrid-electric vehicles utilize this start-stop technology; some car manufacturers also incorporate this technology in conventional vehicles, as well. TABLE 4.10 lists some model year 2014 vehicles with start-stop technology; these, plus additional models, will be offered in model year 2015.

[TABLE 4.10] Some 2014 vehicles using automatic start-stop idle reduction technology

MAKE/MODEL	CITY/HWY	MSRP
Ford Fusion	22/34 mpg	$ 21,900
Chevy Malibu	25/36 mpg	22,140
Ram 1500HFE	18/25 mpg	28,895

[TABLE 4.9] Economic analysis of installing battery-based idle reduction systems in 400 police patrol vehicles, assuming various hours of idle reduction

IDLING TIME REDUCED PER DAY	PETROLEUM REDUCTION POTENTIAL	INITIAL COST TO IMPLEMENT	ANNUAL FUEL COST CHANGE	BATTERY REPLACEMENT COST	COST PER UNIT PETROLEUM REDUCTION	PAYBACK PERIOD	TECHNOLOGY ROI
(HOURS)	(GALLONS)	($)	MORE (LESS)	(ONCE@3.3YRS)	($/GALLON)	(YEARS)	(%)
1	73,000	$ 2,156,000	$ (222,066)	$ 720,000	$ 2.93	13.0	51%
2	146,000	2,156,000	(444,132)	720,000	(0.06)	6.5	102%
3	219,000	2,156,000	(666,198)	720,000	(1.05)	4.3	153%
4	292,000	2,156,000	(888,264)	720,000	(1.55)	3.2	204%

While aftermarket automatic stop-start systems exist, they would only be cost-effective for newer vehicles, vehicles that idle regularly, and large vehicles that consume more fuel when idling.

CASE STUDY

Canyon County Cuts Idle Time

Canyon County Fleet Manager Mark Tolman knew idling Sheriff's Department patrol cars wasted fuel and Treasure Valley Clean Cities finally helped him collect the hard numbers. "It was just shocking," he said. Each patrol car idled up to five hours per day, using one gallon of fuel per hour of idle time.

Canyon County staff installed idle-reduction equipment on nearly all of the 60 patrol cars in the Sheriff's Department, eliminating 36 "ghost miles" per car each day. The idle-reduction system prevents 1.4 million pounds of carbon dioxide emissions every year and improves vehicles' fuel economy by 4 - 6 mpg.

"We're cutting our fuel use, and we're doing it safely — everything runs at peak performance. We're never going to leave our people hanging or compromise their safety," Tolman said. ¤

SOURCE US Department of Energy, "County Fleet Goes Big on Idle-Reduction, Ethanol Use, Fuel Efficiency," (7 April 2011).

4.3.6. NATURAL GAS

Natural gas is a clean-burning fuel composed primarily of methane. Traditionally, natural gas was extracted from underground wells along with crude oil. Today's enhanced extraction methods, such as hydraulic fracturing, have drastically increased natural gas's availability and lowered its price — making it more viable as an alternative fuel for vehicles.

Transitioning to natural gas requires considerable infrastructure investment in fueling and maintenance facilities; once installed, the infrastructure needs to support a multitude of vehicles as soon as possible so fuel cost savings offset the high cost of the infrastructure investment. The following discussion provides an overview of the required fueling and maintenance infrastructure investments before analyzing the economics of various vehicle and fleet options.

FUELING INFRASTRUCTURE

In its standard utility-supplied form, natural gas contains 1,020 British thermal units of energy per cubic foot (Btu/ft^3); gasoline (E10), 15,250 Btu/ft^3. Given fuel tank size constraints, natural gas must therefore be compressed (CNG) or liquefied (LNG) to achieve the energy density needed to fuel a vehicle.

The infrastructure required to compress or liquefy, store, and dispense natural gas as a vehicle fuel costs more, and is far more complex, than conventional liquid fuels. For example, a typical CNG station consists of one or more gas dryers, compressors, and storage tanks per dispenser.[10]

Natural gas supplied by a utility typically contains moisture and other impurities that degrade the operation of CNG compressors and damage vehicles' engines; the CNG station's gas dryers filter out these contaminants.

Then, CNG compressors transform the utility-supplied low-pressure (< 60 pounds per square inch [psi]) natural gas into a high-pressure fuel fit for vehicles (3,600 psi). Natural gas compressors are rated by the quantity of CNG discharged in standard cubic feet per minute (SCFM) and come in a wide array of sizes.

To estimate the quantity of gasoline-gallon-equivalents (gge) a station can produce each hour, divide the compressor's SCFM by its rated inlet pressure (in psi). Based on this rating (gge/hour), CNG stations are classified as fast-fill, time-fill, or limited fast-fill.

Stations that provide CNG at a rate similar to a gas station (180 - 360 gge/hour) are known as fast-fill. In addition to costing more than time-fill stations, fast-fill stations often under-fill vehicles' fuel tanks. The

[10] While the CNG fueling station can operate with just one of each of these components, redundancy prevents downtime when one piece requires service.

speed at which fast-fill stations compress and dispense CNG raises its temperature and pressure, causing the dispenser to read the tank as full prematurely. Once in the vehicle tank, the CNG cools and settles, revealing its true, nearly-but-not-quite-full, level. While today's fast-fill dispensers do a better job of compensating for these temperature effects, under-filling may still occur.

Time-fill stations provide CNG at a much lower rate (< 100 gge/hour), refueling vehicles over a 4 - 12 hour period. Time-fill stations may dispense CNG to multiple vehicles at once and cost significantly less than fast-fill stations, making it ideal for fleet applications where vehicles return to base overnight, such as refuse trucks. Unlike fast-fill stations, time-fill stations can completely fill vehicles' tanks.

Limited fast-fill stations provide CNG at the fast-fill rate until the station's storage tank is depleted, then supply CNG at a time-fill rate.

MAINTENANCE INFRASTRUCTURE

In addition to the special fueling infrastructure, garages and maintenance shops may require upgrades to accommodate CNG vehicles.

According to the National Fire Protection Association,[11] facilities for CNG vehicles differ from other motor vehicles in three ways:

1. **VENTILATION.** Because natural gas weighs less than air, make-up air and air-conditioning systems must introduce air near the floor and exhaust it at the ceiling — the reverse of facilities designed for liquid-fueled vehicles. Installing methane detectors and exhaust fan(s) over the maintenance bays for CNG vehicles may also help meet ventilation requirements. Existing shops that currently provide a minimum of four air-changes per hour (ACH) may not need ventilation system modifications.

2. **HEATING.** While NFPA only prohibits open-flame heaters within the top 18 inches of a bay, best practices recommend that CNG vehicles never be parked below an open-flame heater under any circumstances. Sealed combustion, catalytic, and infrared heaters with a skin temperature below 800°F meet the code requirements for heating systems in CNG vehicle maintenance facilities.

3. **IGNITION SOURCES.** Any potential ignition sources — anything that could arc or spark, including lighting and the motors for roll-up garage doors — must be located more than 18 inches from the ceiling in a CNG vehicle maintenance facility. Traditional lights may be pendant-mounted so that the light fixtures and bulbs hang below the 18 inch threshold. Alternately, equipment and lighting placed within 18 inches of the ceiling must be Class 1, Division2, Group D rated.

VEHICLES

Many manufacturers offer CNG vehicle options. Similar to propane, any vehicle equipped with a gaseous-prep engine may be engineered to accommodate CNG, which burns hotter than gasoline and diesel and does not have the lubricity of liquid fuels. Natural gas engines may be configured as 1) dedicated (runs only on natural gas), 2) bi-fuel (runs on either natural gas or gasoline), 3) dual-fuel (blends natural gas with diesel), and 4) compression ignition (uses a small amount of diesel fuel to ignite, but operates primarily on natural gas). For example, Cummins-Westport sells dedicated-CNG engines (8.9-liter and 11.9-liter) suitable for the medium- and heavy-duty trucks in Raleigh's fleet.

Raleigh currently operates 11 light-duty natural gas vehicles. As discussed in **SECTION 1.4.3.**, the payback period on these existing vehicles exceeds their useful life. While a more convenient fueling station might increase the use of these vehicles, the cost of the station exceeds potential fuel savings. The City's light-duty vehicles do not use enough fuel to support a transition to natural gas; however, larger and heavy-duty vehicles may.

[11] National Fire Protection Association (NFPA), "30A: Code for Motor Fuel Dispensing Facilities and Repair Garages."

CNG is ideal for Raleigh's large vehicles—dump trucks, street sweepers, and particularly, refuse trucks—because the vehicles travel set routes each day and return to a central base each night. These large vehicles also consume a lot of fuel, yielding a shorter payback period on vehicle incremental costs and infrastructure investments.

To pilot this technology, Raleigh purchased two dedicated-CNG automated side-loading refuse trucks in FY2014. These CNG refuse trucks cost $295,570, $38,300 more than similar conventional diesel trucks. These trucks, delivered in December 2014, currently fuel at the City's small CNG station at the Heavy Equipment Shop or at PSNC.

ECONOMIC ANALYSIS

With 112 trucks consuming nearly 550,000 gallons of diesel per year, converting Raleigh's refuse trucks to CNG provides the best potential return on investment.

With a four-day work-week, Solid Waste Services would need a time-fill station rated for 265 diesel-gallon-equivalents per hour (dge/hour) to fill its trucks in 10 hours.[12] A time-fill fueling station of this size costs approximately $1.35 million;[13] a fast-fill

CASE STUDY

Reducing Waste with CNG

Republic Services, one of the largest waste and recycling companies in the country, hauls more than 100 million tons of refuse annually for its 13 million customers. Since the company's founding in 1998, heavy-duty diesel trucks performed the lion's share of this work.

In 2009, with funding from the American Recovery and Reinvestment Act, Republic Services began transitioning its fleet to cleaner and cheaper compressed natural gas (CNG). Clean Cities Coordinator Beth Baird helped Republic Services find this funding opportunity.

"We wouldn't have known about the funding, and we may have gone down this road much more slowly if we hadn't had an advocate," said Rachele Klein, Republic's business development manager.

The company opened a time-fill CNG station in Boise in June 2009, and its first CNG trucks rolled in a few months later. Three additional stations opened in 2011, including two with public access.

The project created a ripple effect, encouraging CNG deployment in Idaho and beyond. Republic Services started with 12 CNG trucks, and now has 87; it plans to convert its entire Idaho fleet operating on CNG within the next five years.

Additionally, a dozen other local fleets began converting to CNG, using Republic's CNG fueling stations.

"Republic Services' shift to CNG was a huge step in advancing the use of natural gas as a vehicle fuel in Idaho," Baird said. ¤

SOURCE US Department of Energy, "Republic Services Reduces Waste with 87 CNG Vehicles," (24 May 2013).

[12] Including the 10.5% fuel efficiency loss from switching to a spark ignition engine

[13] Doubling the cost estimate for the time-fill station on page 17 of this report.

[TABLE 4.11] Economic analysis of replacing all 112 refuse trucks with CNG

SCENARIO	ANNUAL CNG FUEL	INITIAL INFRA-STRUCTURE COSTS	INITIAL VEHICLE COSTS	ANNUAL MAINTENANCE COST CHANGE	ANNUAL FUEL COST CHANGE	COST PER UNIT PETROLEUM REDUCTION	PAYBACK PERIOD	ROI
	(DGE)	($)	($)	MORE (LESS)	MORE (LESS)	($)	(YEARS)	(%)
A	606,633	$3,050,000	$4,289,600	$ 67,500	$ (722,435)	$ 0.25	24.3	62%
B	606,633	1,830,000	4,289,600	67,500	(722,435)	0.11	22.4	75%
C	606,633	3,500,000	4,289,600	90,000	(722,435)	0.35	25.9	57%
D	606,633	2,280,000	4,289,600	90,000	(722,435)	0.21	24.0	67%

station, approximately $1.8 million.[14] Additionally, annual maintenance costs approximately 5% of the station's purchase price.[15]

With a natural gas price of $0.97 per therm and electricity rate of $0.11 per kilowatt-hour, the loaded commodity cost of producing CNG at Wilders Grove will be $1.63 per dge, compared to a total of $3.12 per gallon for diesel and the diesel emission fluid required for modern diesel engines.

In addition to adding a fueling station at Wilders Grove, Raleigh needs a maintenance facility capable of servicing natural gas vehicles. Solid Waste Services' Wilders Grove facility has space available where the City could construct a new garage specifically for CNG vehicles, at an estimated cost of $1.7 million. Alternately, modifying the Heavy Equipment Shop—replacing the heating system, swapping lights, rerouting the electrical, adding methane detectors, and installing a new ventilation system—will cost approximately $40,000 per bay, or $480,000 for the entire facility.

TABLE 4.11 considers the following scenarios for transitioning all 112 trucks in the sub-fleet to natural gas:

A. Install new time-fill fueling station, build new maintenance garage
B. Install new time-fill fueling station, modify Heavy Equipment Shop garage
C. Install new fast-fill fueling station, build new maintenance garage
D. Install new fast-fill fueling station, modify Heavy Equipment Shop garage

As shown in TABLE 4.11, the payback period on a time-fill station is one year shorter than the payback period for a fast-fill station; similarly, modifying the existing Heavy Equipment Shop reduces the payback period by almost two years. However, no scenario produces a return on investment within the 20-year life of the fueling station.

At 6,800 gallons per truck per year, the 53 automated side-loading refuse trucks consume the highest quantity of fuel in Solid Waste Service's sub-fleet. By converting only this sub-group to CNG, Raleigh could reduce the cost of a fueling station to $1.1 million for time-fill or $1.45 million for fast-fill.

As shown in TABLE 4.12, next page, converting only the automated side-loading trucks and upgrading the Heavy Equipment Shop shortens the payback period on the fueling station to within its 20-year expected life.

Since there are fewer CNG vehicles in this scenario, it may also be possible to reduce the cost of upgrading the Heavy Equipment Shop, improving the projected return.

[14] US Department of Energy, "CNG Infrastructure Costs," (DATE).

[15] www.afdc.energy.gov/pdfs/47919.pdf

[TABLE 4.12] Economic analysis of replacing only the 53 automated side-loading refuse trucks with CNG, using the same scenarios as **TABLE 4.11**

SCENARIO	ANNUAL CNG FUEL	INITIAL INFRA-STRUCTURE COSTS	INITIAL VEHICLE COSTS	ANNUAL MAINTENANCE COST CHANGE	ANNUAL FUEL COST CHANGE	COST PER UNIT PETROLEUM REDUCTION	PAYBACK PERIOD	ROI
	(DGE)	($)	($)	MORE (LESS)	MORE (LESS)	($)	(YEARS)	(%)
A	398,847	$ 2,800,055	$ 2,029,900	$ 55,003	$ (474,984)	$ 0.03	21.2	61%
B	398,847	1,580,055	2,029,900	55,003	(474,984)	(0.18)	13.4	81%
C	398,847	3,150,000	2,029,900	72,500	(474,984)	0.16	23.0	54%
D	398,847	1,930,000	2,029,900	72,500	(474,984)	(0.06)	19.9	71%

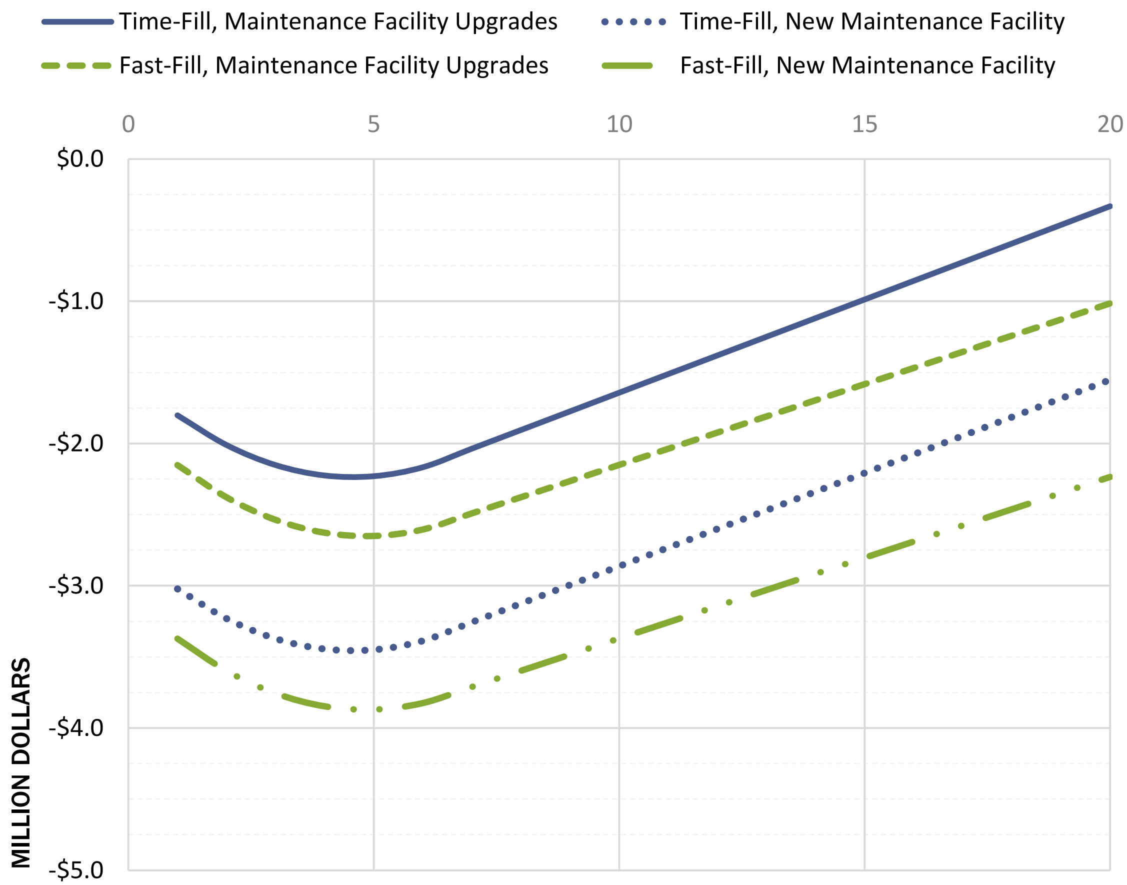
The analyses in **TABLES 4.11** and **4.12** assume all replaced refuse trucks start using CNG the first year. However, it is more likely that Raleigh will purchase CNG vehicles as older trucks retire. Based on the expected service life for Raleigh's automated side loaders, it will take 7 years to convert all vehicles to CNG; since the fleet will use less CNG, this strategy reduces the expected fuel savings for Years 1 – 7, extending the payback period.

FIGURE 4.6 considers a more realistic cash-flow for transitioning to CNG. This scenario assumes that Raleigh installs only one compressor and 30 time-fill posts in Year 1, and a second compressor and additional 30 time-fill posts in Year 3. Again, current fleet practices prevent Raleigh from seeing a return on its CNG investment within the 20-year service life of the CNG fueling station.

4.3.7. PROPANE

Propane — also called Liquefied Petroleum Gas (LPG) or AutoGas — is a clean-burning

[FIGURE 4.6] Cash flow model for transitioning automated side-loading refuse trucks to CNG as vehicles retire



fuel produced as a by-product of natural gas processing and crude oil refining. Like ethanol, LPG contains less energy per gallon than gasoline, resulting in decreased fuel economy; unlike ethanol, propane generally costs less than gasoline per gasoline-gallon-equivalent (gge).

The City of Raleigh Police Department (RPD) currently operates 49 propane bi-fuel Ford Crown Victoria patrol cars. The City currently provides propane fueling at RPD's North District Office, RPD's Southeast District Office, and Parks, Recreation, and Cultural Resources' Marsh Creek location; a new propane station will open soon at the Northeast Remote Operations Center.

Propane is most cost-effective in medium-duty and certain high-mileage, light-duty vehicles. In Raleigh's fleet, the target groups for propane include police patrol vehicles; medium-duty pick-ups and service trucks; and high-mileage, light-duty pick-ups and service trucks.

Manufacturers rarely offer propane — dedicated or bi-fuel — as a factory-direct option; instead, customers specify a gaseous-prep engine when ordering a vehicle and then work with the manufacturer's dealer or their own maintenance shop to install an aftermarket conversion kit.

Ford and General Motors offer gaseous-prep engines that accommodate LPG or CNG for a small added cost ($315); however, General Motors will only sell a gaseous-prep engine if the customer specifies LPG or CNG and agrees to have the conversion kit installed by one of GM's approved providers prior to taking delivery of the vehicle. Ford both allows customers to take delivery of vehicles with gaseous-prep engines and also works with its network of Qualified Vehicle Modifiers to install conversion kits and deliver LPG and CNG vehicles through its dealerships.

CASE STUDY

Kingsport Saves with Propane

Since 2011, Kingsport, Tennessee, has added 43 light-duty propane vehicles to its fleet of 700 vehicles, including forklifts, police cruisers, work trucks, and mowers.

Fleet Manager Steve Hightower wanted whichever technology that best-suited the City's functions at the lowest cost. Recognizing that internal resistance can hurt a project, Hightower obtained support from both the City's leadership and his drivers before beginning the project.

Staff eventually acclimated to propane, but it was tough at first. One barrier encountered during the conversion process was matching current fleet vehicles to available, EPA-certified systems. Vehicle vendors became a barrier when their products were not market ready; Kingsport encountered equipment glitches and other issues when it tried systems that were not EPA-certified.

Hightower ultimately achieved his goal of saving Kingsport taxpayers' dollars. Through 2014, the City saves, on average, $1 per gallon by using propane. In just under three years, the project's savings recouped all project costs and saved an additional $27,000.

In addition to these financial benefits, Kingsport displaced over 36,000 gallons of gasoline, reducing their carbon dioxide emission by 43 tons. Most notably, the police force found it preferred propane vehicles from a performance standpoint, and now specifies propane for their standard cruiser. ¤

SOURCE East Tennessee Clean Fuels Coalition, "Propane Fleet Case Study: City of Kingsport (TN)," (2014).

Many conversion kits for vehicles without a gaseous-prep engine have received EPA certification; however, installing one of these aftermarket kits generally voids the vehicle manufacturer's warranty.

To convert vehicles to propane bi-fuel, a propane tank must be added. The tank can be placed in the vehicle's trunk or truck bed, reducing usable space. In trucks, customers can specify an extra-long bed at a minimal cost ($200) to accommodate this loss of space. Alternately, the tank can be installed where the spare tire typically goes [FIGURE 4.7], decreasing the amount of usable space lost.

The City paid an average of $1.57 per gallon of propane in FY2014. Since propane contains 23% less energy than gasoline, Raleigh paid $2.03 per propane gasoline-gallon-equivalent (gge). On average, gasoline (E10) cost Raleigh $3.04 per gallon in FY2014, meaning propane saves Raleigh approximately $1 for every gge used.

[FIGURE 4.7] Toroidal propane tanks fill the space where the vehicle's spare tire typically goes, whether in the trunk or under the vehicle. (Source: ICOM North America)

The analysis in TABLE 4.13 considers the economics of converting police patrol vehicles (including the Interceptor SUV), pick-up trucks, light-duty service trucks, and medium-duty trucks to propane. The bi-fuel propane conversion kits Raleigh purchased for its police patrol sedans cost $6,000, with installation performed by Vehicle Fleet Services; since bi-fuel

[TABLE 4.13] Economic analysis of propane bi-fuel conversion options by vehicle type and percent of LPG consumed

QTY	TYPE	VEHICLE SERVICE LIFE	ANNUAL FUEL USE PER CAR	TOTAL ANNUAL LPG USE	INITIAL COST TO IMPLEMENT	ANNUAL FUEL COST CHANGE	COST PER UNIT PETROLEUM REDUCTION	PAYBACK PERIOD	VEHICLE ROI
(#)		(YEARS)	(GALLONS)	(GGE)	($)	MORE (LESS)	($/GALLON)	(YEARS)	(%)
SCENARIO 1 > 60% LPG USE									
334	Police patrol SUVs	6.6	1,337	346,211	$ 2,338,000	$ (350,911)	$0.01	6.7	99%
452	Pick-up trucks	8.0	776	271,889	3,616,000	(275,580)	0.84	13.1	61%
89	Light-duty trucks	8.0	1,250	86,223	712,000	(87,394)	0.02	8.1	98%
146	Medium-duty trucks	9.2	1,102	124,661	1,168,000	(126,354)	0.01	9.2	100%
SCENARIO 2 > 90% LPG USE									
334	Police patrol SUVs	6.6	1,337	519,316	$2,338,000	$ (526,367)	$ (0.43)	4.4	149%
452	Pick-up trucks	8.0	776	407,833	3,616,000	(413,370)	0.12	8.7	91%
89	Light-duty trucks	8.0	1,250	129,335	712,000	(131,091)	(0.42)	5.4	147%
146	Medium-duty trucks	9.2	1,102	186,992	1,168,000	(189,530)	(0.43)	6.2	149%

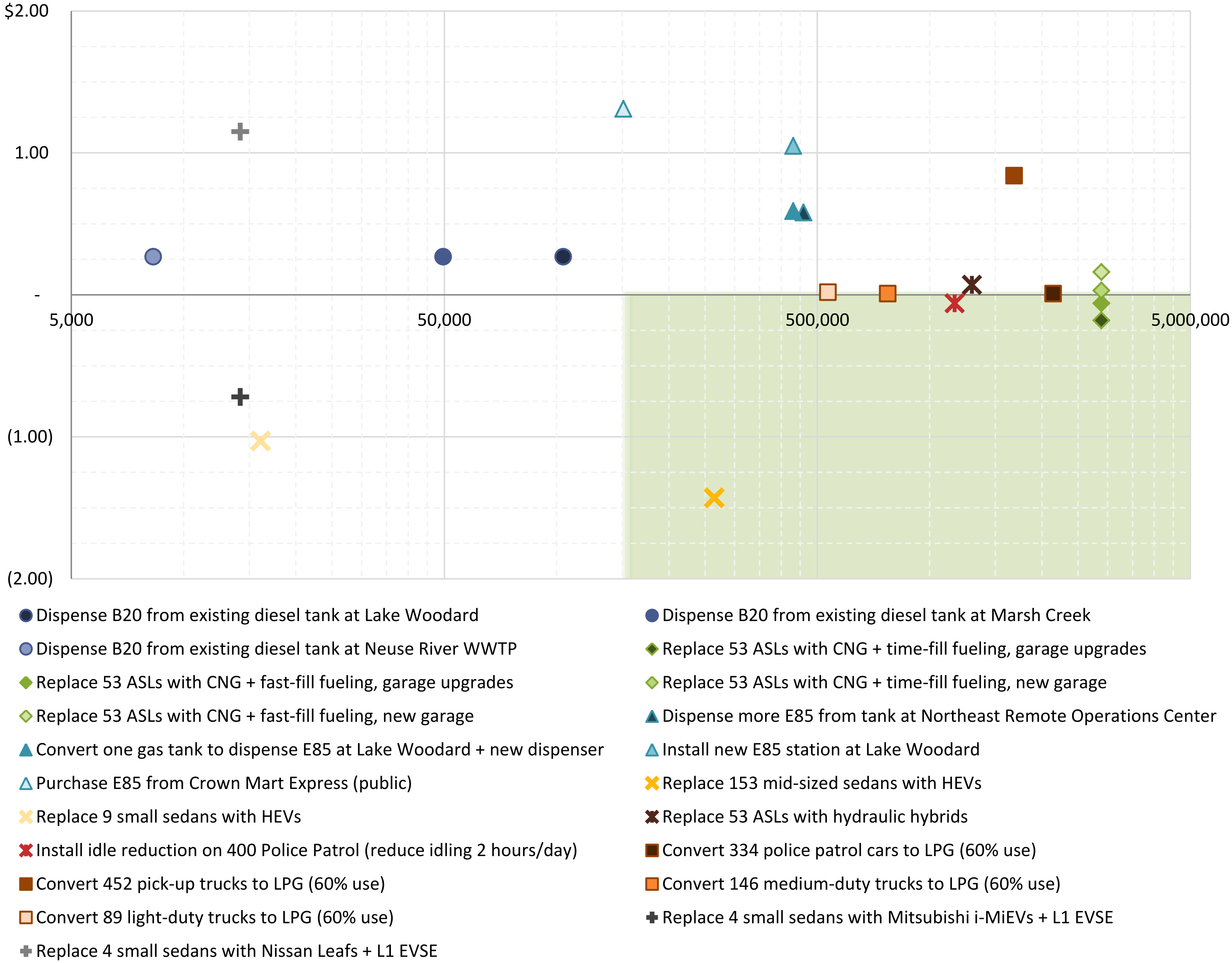
conversion kits for trucks require larger propane tanks, this analysis assumes a cost of $8,000.

Ford recently discontinued its Crown Victoria line. RPD selected the Ford Interceptor SUV to replace the retiring Crown Victoria patrol cars; however, gaseous-prep engines and EPA-certified conversions for this vehicle are not currently available. Alliance AutoGas and Blossman Gas expect to offer EPA-certified aftermarket conversion kits for the Interceptor SUV starting with model year 2016. For this analysis, conversion kits certified for use in the Interceptor SUV are estimated to cost $7,000.

Currently, Raleigh's converted bi-fuel Crown Victorias displace only 45% of their gasoline with propane on average. As shown in TABLE 4.13, police patrol vehicles and medium- and light-duty trucks would need to use at least 60% propane to make the conversion cost-effective, while pick-up trucks require 100% fuel offset — i.e., dedicated propane — to be cost-effective.

[FIGURE 4.8] The propane fueling station at the Raleigh Police Department North District Office. Raleigh's ability to continue or expand LPG use within its Police Department may be limited; however, propane remains a cost-effective alternative for many trucks in Raleigh's fleet.

[FIGURE 4.9] All strategies evaluated plotted as cost-per-gallon of petroleum displaced (y-axis) versus total petroleum reduction potential (x-axis). Strategies in the green-highlighted lower-right quadrant produce the greatest bang for the buck.



4.3.8. PRIORITIZING PETROLEUM- & COST-SAVING STRATEGIES

FIGURE 4.9, previous page, plots most evaluated strategies based on the cost per gallon of petroleum displaced and the quantity of fuel displaced; strategies in the green-highlighted, lower-right quadrant produce the greatest bang for the buck.

TABLE 4.14 provides additional details on the most cost-effective and petroleum-displacing strategies, including the type and number of vehicles affected; potential for reducing Raleigh's petroleum consumption; initial cost to implement; change to annual operating costs (added costs, e.g., station maintenance and replacement parts, minus savings, e.g., fuel, increased resale amount, lower maintenance costs); estimated payback period; staff time required to implement (low, medium, high); and timeframe to implement (<6 months, 6-18 months, or 18-36 months).

[TABLE 4.14] Additional implementation details on the most cost-effective strategies identified by this analysis. The character next to each value indicates whether it ranks as highly beneficial (▲), beneficial (▶), not significantly beneficial (◀), or unfavorable. (▼)

STRATEGY	QTY OF VEHICLES AFFECTED	PETROLEUM REDUCTION POTENTIAL	INITIAL COST TO IMPLEMENT	ANNUAL FUEL COST CHANGE	OTHER ANNUAL COSTS	PAYBACK PERIOD	STAFF EFFORT TO IMPLEMENT	TIME TO ENACT
	(#)	(GALLONS)	($)	MORE (LESS)	MORE (LESS)	(YEARS)	(MONTHS)	(MONTHS)
Replace all sedans with HEVs	162	35,121 ◀	$ 754,115 ▶	$ (99,696) ▶	$(50,274) ▲	3.8 ▲	Low ▲	<6 ▲
Install idle-reduction on police patrol cars	400	146,000 ▶	2,156,000 ◀	(444,132) ▲	109,091 ▼	6.5 ▶	Medium ▶	6-18 ▶
Convert trucks to bi-fuel propane	235	163,225 ▶	1,880,000 ◀	(213,747) ▶	-- ▶	8.8 ▶	High ◀	6-18 ▶
Buy CNG ASL refuse trucks (time-fill fuel; build new garage)	53	360,947 ▲	4,829,900 ▼	(474,984) ▲	55,000 ▼	21.2 ◀	High ◀	18-36 ◀
Buy hydraulic hybrid ASL refuse trucks	53	162,426 ▶	5,300,000 ▼	(506,306) ▲	(239,219) ▲	7.1 ◀	Medium ▶	6-18 ▶
Use B20 in existing diesel tanks	106	20,251 ◀	5,209 ▲	5,120 ▼	-- ▶	N/A ▼	Medium ▶	<6 ▲
Use E85 at NE Remote Ops. Ctr.	80	57,408 ◀	-- ▲	33,069 ▼	-- ▶	N/A ▼	Low ▲	<6 ▲
Add E85 at Lake Woodard (dispenser)	73	53,876 ◀	10,000 ▲	31,034 ▼	-- ▶	N/A ▼	Low ▲	6-18 ▶
Convert pick-up trucks to propane	452	315,663 ▲	3,616,000 ◀	(413,370) ▲	-- ▶	13.1 ▼	High ◀	6-18 ▶
Replace all sedans with PHEVs	162	38,826 ◀	3,208,680 ◀	(85,423) ▶	-- ▶	37.5 ▼	Medium ▶	6-18 ▶

4.3.9. RALEIGH'S PETROLEUM DISPLACEMENT POTENTIAL

In total, Raleigh's existing petroleum-reduction initiatives displaced 310,291 gallons of diesel and gasoline in FY2014 — a 14.4% reduction. Our analysis shows that Raleigh could cost-effectively increase its total petroleum displacement by an additional 28.5% — to a total of 42.9%.

Should Raleigh choose to update its petroleum reduction goal, TABLE 4.15 lists some common targets and identifies a suggested bundle of strategies for Raleigh to achieve each displacement target. Each bundle of strategies provides a blend of cost savings and fuel reduction; however, the City may find different penetration rates more feasible based on the specific nature of each vehicle's job function and the performance of these alternative fuels and advanced transportation technologies.

To achieve the higher levels of cost-effective petroleum displacement [TABLE 4.15; 30%, 35%, 43% targets], Raleigh must commit to CNG. CNG would reduce petroleum consumption more than hydraulic hybrids; however, for CNG to be viable, the City must go "all-in."

4.4. Recommendations

Implementing the following recommendations will advance Raleigh's progress towards its fossil fuel and greenhouse gas emissions goals.

[TABLE 4.15] Potential petroleum-reduction targets and strategies required to achieve each target

TARGET	BUNDLE OF STRATEGIES NEEDED TO ACHIEVE TARGET
20%	**All current strategies plus** » Procure HEVs for all new sedan purchases, » Install anti-idling technology in 25% of police patrol vehicles, and » Convert 40% of light- and medium-duty trucks to propane
25%	**All current strategies plus** » Procure HEVs for all new sedan purchases, » Install anti-idling technology in 35% of police patrol vehicles, » Convert 70% of light- and medium-duty trucks to propane, and » Purchase hydraulic hybrids for 35% of automated side-loading refuse trucks
30%	**All current strategies plus** » Procure HEVs for all new sedan purchases, » Install anti-idling technology in 25% of police patrol vehicles, and » Use CNG in all automated side-loading refuse trucks
35%	**All current strategies plus** » Procure HEVs for all new sedan purchases, » Install anti-idling technology in 25% of police patrol vehicles, » Convert 60% of light- and medium-duty trucks to propane, and » Use CNG in all automated side-loading refuse trucks
43%	**All current strategies plus** » Procure HEVs for all new sedan purchases, » Install anti-idling technology in 35% of police patrol vehicles, » Convert 70% of light- and medium-duty trucks to propane, » Use CNG in all automated side-loading refuse trucks, and » Switch 75% of current diesel use to B20 and 34% of current flex-fuel vehicle gasoline use to E85

4.4.1. MAXIMIZE USE OF EXISTING ALTERNATIVE FUELS

Raleigh could double its propane use — saving up to $40,000 per year and reducing petroleum consumption by an additional 2% — by increasing propane use in its existing bi-fuel police patrol cars. All bi-fuel cars should be assigned to a location with propane readily available, and officers should be encouraged to refuel with propane.

To maximize fuel cost savings, all CNG passenger vehicles should be assigned to locations with CNG readily available and assigned to functions with high utilization.

Finally, almost 25% of Raleigh's diesel is purchased from public gas stations. The cost savings from refueling exclusively at City-owned stations would more than offset the higher cost of filling up with biodiesel (B20).

4.4.2. BUY HYBRID-ELECTRIC VEHICLES FOR PASSENGER SEDAN APPLICATIONS

Hybrid-electric sedans provide the most cost-effective solution for reducing petroleum use in the City's fleet, assuming a higher resale value than conventional vehicles.

4.4.3. INSTALL ANTI-IDLING SYSTEMS ON POLICE PATROL VEHICLES

Anti-idling technology is a cost-effective strategy to reduce petroleum consumption in Police patrol vehicles that are stationary for extended periods even with added costs for better shocks and springs to handle the increase in weight and a battery replacement every 3.3 years. Battery-based anti-idling systems are available from different manufacturers than Energy Xtreme, which the City is currently using. These systems should be tested to determine which is most effective for this application.

4.4.4. CONVERT TRUCKS AND HIGH-MILEAGE PICK-UPS TO PROPANE

Raleigh's medium- and light-duty trucks are good candidates for bi-fuel or dedicated propane conversion. Some highly utilized pickup trucks may be good candidates for propane conversion if the fleet converts its other trucks to propane and invests in additional fueling infrastructure. Bi-fuel conversions prove cost-effective when vehicles use at least 65% propane. The Parks, Recreation, and Cultural Resources department operates most of these trucks, and the department already has propane at Marsh Creek and another station will open soon at the Northeast Remote Operations Center. ■

SECONDARY RECOMMENDATIONS

These recommendations should be considered secondary practices to further optimize fleet fuel consumption — once Raleigh successfully implements all primary recommendations. These strategies will require further analysis to properly implement.

INVESTIGATE COMPRESSED NATURAL GAS (CNG)

Implementing CNG requires considerable infrastructure investment in fueling and maintenance facilities; once installed, the infrastructure needs to support a multitude of vehicles as soon as possible so fuel cost savings offset the high cost of the infrastructure investment. However, Raleigh's procurement policy spreads purchases over vehicles' lifespan.

While this policy reduces annual vehicle capital costs and prevents all vehicles from needing replacement at the same time, it also extends the time required to achieve maximum CNG use and thus, the payback period on the infrastructure investment. Three strategies for improving the economics of CNG include:

1. Delay some vehicle purchases and accelerate others such that Raleigh purchases a large number of CNG vehicles just as the fueling/maintenance infrastructure comes online
2. Procure modular fueling infrastructure, adding only as much infrastructure as Raleigh needs to fuel the CNG vehicles purchased each fiscal year
3. Utilize innovative financial models and partnerships to share infrastructure investment costs

Highly utilized vehicles provide the best payback period. Based on our analysis, CNG will be most cost-effective if Raleigh reduces its Solid Waste Services fleet to 53 automated side loaders and increases the trucks' utilization.

Variation in the cost differential between diesel and CNG significantly affect the economic analysis. Thus, it is strongly recommended that Raleigh further evaluate CNG and the increased financial risks associated with such a large investment before proceeding.

PURCHASE HYDRAULIC HYBRID REFUSE TRUCKS, IF NOT PURSUING CNG

Hydraulic hybrids are a very new technology. Fewer brake changes purportedly produce a significant chunk of the cost savings associated with hydraulic hybrids; fewer trips to the shop also reduce vehicle downtime. If interested in this technology, Raleigh should validate these benefits by testing one truck and inspecting the brake wear.

At 45% fuel savings — the middle of the manufacturers' published range — and a cost of $3.12 per gallon of diesel, hydraulic hybrid refuse trucks will fall just short of paying back the $100,000 incremental cost for an automated side loader. Extending vehicle service life from 7 to 8 years also improves the economic analysis; however, the current decrease in diesel costs reduces the economic benefit of this technology.

The economics of hydraulic hybrids vs. CNG are very close and small changes in input parameters affect whether each technology produces a positive or negative return on investment. CNG would reduce petroleum consumption more than hydraulic hybrids. For CNG to be viable, the City must go “all-in,” which carries higher risk and requires financing that may negate potential savings, whereas hydraulic hybrids could easily be deployed as vehicles are replaced.

EXPAND BIOFUEL USE

While biofuels (B20 and E85) currently cost more than traditional petroleum fuels, they provide a simply implemented and relatively low-cost means of achieving petroleum reduction goals. The most cost-effective methods for expanding Raleigh’s biofuel program include 1) using B20 instead of diesel at Lake Woodard, and 2) using E85 at the Northeast Remote Operations Center. Secondarily, Raleigh should investigate if one of the existing gasoline tanks at Lake Woodard could be reassigned to dispense E85, where the only cost to implement would be an E85-compatible dispenser.

CASE STUDY

Fort Collins' Fleet Adopts All-of-the-Above Approach

Fort Collins, Colorado, operates nearly 700 alternative fuel vehicles (AFVs) in the City's fleet of 1,600. A willingness to explore new technologies and an understanding that there is no one "silver bullet" led Fort Collins to pursue a wide diversity of strategies.

The City's Green Purchasing Policy requires the fleet to consider all AFV options when replacing vehicles. "As long as we can justify the benefits, we aren't afraid of trying new technologies," said Fleet Manager Tracy Ochsner.

Fort Collins' fleet includes a hybrid-electric bucket truck, used to maintain the city's street lights; its remaining heavy-duty diesel vehicles operate on B20, using nearly 300,000 gallons of the fuel annually. The fleet also includes 150 light-duty flex-fuel vehicles running on ethanol blends; 53 propane vehicles, including one Zamboni ice re-surfacer; 40 hybrid-electric vehicles; and six plug-in hybrid-electric vehicles, including Chevrolet Volts and Nissan Leafs. The fleet also operates several neighborhood electric vehicles.

In 2012, Fort Collins' fleet displaced 55% of its total fuel purchases using these alternative fuel and advanced transportation technologies, averting more than 800 tons of greenhouse gas emissions. ⌑

SOURCE US Department of Energy, "Diversity of Fuels Supports Sustainability in Fort Collins," (23 October 2013).

Implementation

CHAPTER FIVE

The previous analysis of potential fuel and fleet transformation strategies focused on cost savings and petroleum reduction benefits; but, it is equally important to consider the operational effects of these changes before proceeding.

This chapter captures the recommendations discussed throughout this Plan, considers potential barriers to their adoption, and outlines possible next steps for Raleigh to transform its fleet.

5.1. Recommendations

Many recommendations suggest expanding Raleigh's current use of alternative fuels and advanced transportation technologies. Additionally, implementing the identified fleet management best practices will yield higher operating efficiencies, better service performance, and greater cost savings.

With the current vehicle turnover rate, it will take eight years for Raleigh to achieve its 20% petroleum displacement goal using the recommended strategies.

5.1.1. ESTABLISH A FLEET MANAGEMENT STEERING COMMITTEE

Raleigh will benefit from establishing a fleet steering committee headed by the VFS Fleet Superintendent with representation from all departments. VFS would still retain responsibility for fleet management, with input from the fleet steering committee. This committee will help VFS gain buy-in from departments, such as with decisions about vehicle replacement and procurement.

This committee should direct VFS through the process of centralizing all vehicle and maintenance data and revising its policies and procedures. In particular, we recommend VFS revise and centralize its policies regarding:

- Vehicle replacement evaluation criteria
- Vehicle replacement capital fund
- Vehicle procurement procedure
- GPS tracking and vehicle analytics
- Take-home vehicles

For example, Raleigh's procurement procedure should encourage purchasing smaller, fuel-efficient vehicles. Additionally, standardizing models purchased across all departments will increase the cost-effectiveness of VFS's maintenance service. Significant justification should be required to acquire larger, less efficient vehicles and non-standard models. Finally, greater consistency in equipment funding will support more regular fleet turnover, decreasing maintenance and fuel costs.

5.1.2. OFFER DRIVER TRAINING REGULARLY

Drivers should receive training on vehicle operating best practices at least annually and preferably more frequently. Regular trainings encourage more efficient driving, ensure personnel receive timely updates about fleet procedures, and facilitate the implementation of new policies.

Additionally, drivers operating alternative-fuel vehicles and vehicles with advanced transportation technologies should receive specific training to optimize petroleum reduction and address questions and misconceptions.

5.1.3. DEVELOP A SMART FLEET MANAGEMENT SYSTEM

Capturing accurate fueling and maintenance data enables better vehicle and fleet analytics and smarter decision-making.

VFS should ensure that its current fleet management software can collect and provide the information needed to properly evaluate vehicle and driver performance metrics, as recommended in this report. Periodically assessing alternative fleet management systems is also advised.

Additionally, all vehicles using City-owned fueling stations should have automotive information modules (AIM) installed, and VFS should implement a quality-control procedure to ensure the accuracy of data entered manually.

5.1.4. ANALYZE FLEET FREQUENTLY

Conducting regular fleet analyses will help Raleigh to identify underutilized vehicles, and ultimately, to right-size its fleet. Analytics will also help Raleigh determine the best applications for owning vehicles, using motor pool vehicles, renting vehicles, or using personal vehicles. Reports and analysis should be conducted at least quarterly, and preferably monthly; in addition, VFS should have the authority to re-assign vehicles that are underutilized, unneeded, or not the most efficient type for the current assignment.

Generating these reports and analysis will require resources not currently available within VFS. The Fleet Superintendent has requested a new position which would do this work on an ongoing basis. Savings from using the analytics to right-size the fleet and further reduce the fleet's petroleum consumption should offset the cost for the additional position. Alternately, the City could contract with a fleet management consultant to conduct this analysis.

5.1.5. MAXIMIZE USE OF EXISTING ALTERNATIVE FUELS

Raleigh could double its propane use — saving up to $40,000 per year and reducing petroleum consumption by an additional 2% — by increasing propane use in its existing bi-fuel police patrol cars. All bi-fuel cars should be assigned to a location with propane readily available, and officers should be encouraged to refuel with propane.

To maximize fuel cost savings, all compressed natural gas (CNG) passenger vehicles should be assigned to locations with CNG readily available and assigned to functions with high utilization.

Finally, almost 25% of Raleigh's diesel is purchased from public gas stations. The cost savings from refueling exclusively at City-owned stations would more than offset the higher cost of filling up with biodiesel (B20).

5.1.6. INSTALL ANTI-IDLING SYSTEMS ON POLICE PATROL VEHICLES

Anti-idling technology is a cost-effective strategy to reduce petroleum consumption in Police patrol vehicles that are stationary for extended periods even with added costs for better shocks and springs to handle the increase in weight and a battery replacement every 3.3 years. Battery-based anti-idling systems are available from different manufacturers than Energy Xtreme, which the City is currently using. These systems should be tested to determine which is most effective for this application.

5.1.7. BUY HYBRID-ELECTRIC VEHICLES FOR PASSENGER SEDAN APPLICATIONS

Hybrid-electric sedans provide the most cost-effective solution for reducing petroleum use in the City's fleet, assuming a higher resale value than conventional vehicles.

5.1.8. CONVERT TRUCKS AND HIGH-MILEAGE PICK-UPS TO PROPANE

Raleigh's medium- and light-duty trucks are good candidates for bi-fuel or dedicated propane conversion. Some highly utilized pickup trucks may be good candidates for propane conversion if the fleet converts its other trucks to propane and invests in additional fueling infrastructure. Bi-fuel conversions prove cost-effective when vehicles use at least 65% propane.

The Parks, Recreation, and Cultural Resources department operates most of these trucks, and the department already has propane at Marsh Creek and another station will open soon at the Northeast Remote Operations Center.

5.2. Transformation challenges

Ultimately, Raleigh's employees affect whether the City will realize the full cost savings and emission-reduction benefits of its petroleum reduction initiatives. Reluctance to drive certain vehicles, driving vehicles in a non-optimal manner, or failing to refuel with alternative fuels will negate any expected petroleum reduction or cost savings. Therefore, the City should proactively address any staff concerns — such as operator constraints, refueling downtime, or maintenance intervals — before implementing changes.

Employee concerns generally fall into three categories:

- » **Safety.** Concerns about personal safety make staff reluctant to use or maintain the vehicle, fuel, or technology
- » **Reliability.** Perception that the vehicle, fuel, or technology limits staff's ability to complete his/her mission
- » **Effectiveness.** When driver habits prevent full realization of the vehicle's, fuel's, or technology's benefits

The following discussion summarizes common operator- and maintenance-related concerns and proposes some solutions for the City of Raleigh to consider.

5.2.1. HYBRID ELECTRIC VEHICLES

Many HEV concerns originate from misinformation and poor experiences with first-generation technologies.

SAFETY

Some drivers feel the on-board battery and electric motor in HEVs may cause a fire, explode, or otherwise put them at risk in a car accident. However, the Insurance Institute for Highway Safety (IIHS) listed several HEVs in its top safety picks for 2015, including the Chevrolet Spark, Chevrolet Volt, Ford C-Max Hybrid, Ford Fusion, Lexus CT 200h, Lincoln MKZ, Toyota Camry, and Toyota Prius.

HEV drivers also sometimes express uneasiness at the lack of engine noise, such as when the vehicle powers on or comes to a complete stop. They may feel that the car malfunctioned or fear that the engine will not restart promptly when needed. Driver training prior to vehicle assignment helps to address these concerns, while driving an HEV quickly alleviates any remaining anxiety.

RELIABILITY

First generation HEVs were much smaller than recent models and increased their fuel economy by downsizing the engine. As a result of these experiences, drivers may equate HEVs with sacrificed cargo space and drivetrain power.

Today's hybrids generally have *more* horsepower going to the drivetrain than basic petroleum models [**TABLE 5.1**; next page]. Similarly, today's HEVs place battery packs in the floorboards and seat backs, preventing the loss of interior or cargo space.

[TABLE 5.1] Drivetrain power and interior space specifications for two common HEVs versus their comparable gasoline models

	GASOLINE	HYBRID
TOYOTA CAMRY LE		
Drivetrain	178 Hp	200 Hp
Cabin space	102.7 ft^3	101.3 ft^3
Cargo space	15.4 ft^3	13.1 ft^3
FORD FUSION SE		
Drivetrain	175 Hp	188 Hp
Cabin space	102.3 ft^3	102.8 ft^3
Cargo space	16 ft^3	12 ft^3

EFFECTIVENESS

Fuel efficiency depends on both vehicle specifications and how the driver operates the vehicle. Rapidly accelerating and braking wastes fuel. In HEVs, hard accelerations rely exclusively on the gasoline engine. Similarly, hard braking bypasses the HEV's regenerative braking system, which would normally capture the car's kinetic energy as electrical energy; instead, it engages the friction brakes.

Training emphasizing gentle acceleration and deceleration helps drivers achieve HEVs' expected fuel efficiency. A more effective program reinforces this training by coupling fuel tracking and driver feedback to ensure HEVs produce the expected return on investment.

5.2.2. IDLE-REDUCTION SYSTEMS

Other municipalities experience success with battery-based idle-reduction systems in police patrol cars. Raleigh should investigate whether other applications — of shorter duration and with lower power requirements — or other manufacturers' products may be more appropriate.

SAFETY

When an idle-reduction system loses its charge quickly and without warning, it may create a hazard for police officers on patrol. To minimize this risk, Raleigh should select systems that automatically restart the engine when the battery power depletes to a set threshold.

RELIABILITY

Some officers worry that the idle reduction system will impair their dash camera; others report that it "feels wrong" to turn off their vehicle during stops. Training on system operation should tackle these concerns and debunk these myths.

Some drivers also express concerns that the system's added weight will affect vehicle handling. Installing better shocks and springs — an additional cost considered in this Plan's economic analysis — ensures handling remains the same.

Additionally, police officers carry lots of equipment today, and idle-reduction systems occupy a significant space. Space-saving packing techniques may help officers adjust to the reduced trunk capacity; alternately, Raleigh could 1) streamline equipment requirements or 2) assign vehicles with idle-reduction systems to duties requiring less equipment.

Finally, the Energy Xtreme system Raleigh Police currently uses cannot sustain vehicles' air conditioning; this interferes with officers' ability to conduct business in the vehicle's cabin during the summer. Again, Raleigh should select a system better suited to its police patrol application or explore whether other applications might be more appropriate.

EFFECTIVENESS

Currently, officers rarely engage the idle-reduction system, eradicating Raleigh's chance to receive a return on its investment. To maximize effectiveness, Raleigh should only install idle-reduction technology on vehicles with assignments that the selected system can support.

Additionally, Raleigh should select an idle-reduction system that automatically engages and stops the engine whenever the vehicle is stationary for a period of time to ensure regular use. Raleigh should also select a system that restarts the engine when the battery becomes depleted to prevent compromising onboard functions. These controls maximize the system's operation and therefore minimize the payback period.

5.2.3. PROPANE (LPG)

The limited availability of gaseous-prep engines or EPA-certified conversions may limit Raleigh's ability to continue or expand LPG use within its Police Department. However, propane may still be a cost-effective alternative for many of the trucks in Raleigh's fleet.

SAFETY

Some drivers fear that LPG carries an increased risk of fire and explosion — particularly during refueling or in the event of an accident.

Propane is widely used as a transportation fuel in law enforcement and other applications across the country. Thorough field testing shows propane tanks safely withstand vehicle collisions as well as incidents involving gunfire.

Driver training is also an effective way to address these concerns, particularly when prospective drivers interact with others who have experience driving LPG vehicles. Nearby agencies using LPG include the Knightdale Police Department, Iredell County Sherriff's Office, and Buncombe County Sherriff Department.

Additionally, a newly designed nozzle — Staubli — allows drivers to refuel LPG vehicles without any special training, procedures, or safety equipment. Staubli also minimizes the hissing sound some drivers find unsettling. Converting vehicles to receive the Staubli nozzle costs $50 per vehicle and takes approximately 15 minutes to install. The nozzle itself may be available as a free upgrade from Raleigh's propane vendor, Alliance Autogas.

RELIABILITY

Police officers carry a lot of equipment today, and propane bi-fuel conversion kits occupy significant space. Space-saving packing techniques may help officers adjust to the reduced trunk capacity. Police SUVs may address the loss of floor space by installing shelves around the tank to make better use of available vertical space. In trucks, purchasing an extended bed will make up for the space occupied by the tank. Alternately, in some vehicles, propane tanks can be installed in the spare tire cavity. Finally, Raleigh should consider whether it can 1) streamline equipment requirements or 2) assign LPG vehicles to duties requiring less equipment.

Some drivers expect propane bi-fuel vehicles to be less powerful than gasoline vehicles — a myth easily debunked after driving an LPG vehicle. Propane vehicles have smooth acceleration and the same horsepower and torque as gas vehicles.

Drivers may also express uneasiness, or concern for vehicle malfunction, because of the delay between turning the key and having the engine start. Not all propane vehicles experience lag, and if they do, the lag is typically very short. Experience and driver training can address these issues.

EFFECTIVENESS

The cost savings — and therefore, effectiveness — of LPG vehicles erode every time a driver opts to run a propane bi-fuel vehicle on gasoline. To maximize return on investment, bi-fuel vehicles should be filled with propane at every opportunity. Raleigh may need additional fueling capacity to accommodate its growing fleet of propane vehicles.

Additionally, Raleigh should consider acquiring dedicated propane vehicles where applications allow. Dedicated propane engines are more efficient than bi-fuel engines; and at 100% gasoline displacement, Raleigh will see a quicker return on its investment (assuming vehicles remain utilized at the current level).

5.2.4. COMPRESSED NATURAL GAS

Flexibility with CNG tank size and placement will minimize concerns about reduced range and increased vehicle weight/length.

SAFETY

Similar to LPG, some drivers fear that CNG carries an increased risk of fire and explosion. Others are wary of breathing gas fumes from potential leaks or using a different type of nozzle to fuel the vehicle.

Training helps assure drivers that CNG vehicles pose no greater danger. Training should increase awareness about the prevalence of fleets using CNG, address concerns about CNG tanks and fueling, and instruct drivers about vehicle operation and fueling. Additionally, some CNG vehicles are longer than their diesel counterparts (depending on tank placement), which may make routes with tight turns more difficult to navigate. Once a driver acclimates to the new vehicle dimensions, they often complete assignments without incident.

RELIABILITY

Since the fuel tank and its protective frame add to a vehicle's weight, some drivers report their vehicle's handling changes after CNG conversion; other drivers notice a loss of power. Drivers typically acclimate quickly to the new weight, dimensions, and/or handling, as they do with any new vehicle the fleet purchases. In rare cases, the added weight of a CNG conversion may affect a vehicle's operational capacity, such as limiting the amount of garbage a refuse truck may collect.

Additionally, some drivers worry whether they can complete their routes before running out of fuel. Fast-filling CNG fills the tank only partially (~75%) and therefore reduces vehicle range. To reduce range anxiety, Raleigh should specify fast-fill (i.e. larger tanks) when converting or ordering vehicles, or install time-fill fueling infrastructure. Training should also teach drivers to stay aware of their fuel level because CNG vehicles cannot pull into any station to refuel, if needed.

EFFECTIVENESS

To maximize CNG vehicles' fuel and maintenance cost savings, drivers should always report any changes in vehicle performance. CNG vehicles sometimes suffer issues with their fuel filter when the gas is not properly "dried." Thus, drivers should receive training on performance issues that indicate a need for preventative maintenance.

5.2.5. HYDRAULIC HYBRIDS

Hydraulic hybrids use hydraulic reservoirs to capture kinetic energy as the vehicle coasts to a stop and then use that stored hydraulic energy to accelerate. Thus, hydraulic hybrids achieve their highest efficiency in stop-and-go applications, such as solid waste collection.

SAFETY

Some drivers worry that hydraulic hybrid vehicles lack responsiveness while decelerating. When a hydraulic hybrid vehicle needs to stop quickly, it engages its back-up friction brakes. Therefore, training should assure drivers that their vehicle will stop without delay or failure, while reminding drivers that the hydraulic hybrid will achieve its maximum fuel economy by coasting to a stop whenever possible.

RELIABILITY

Some drivers express concern about the noise associated with hydraulic hybrid technology. Overall, hydraulic hybrids accelerate more quietly than typical diesel trucks and the brakes do not squeal when decelerating. However, the hydraulic hybrid system produces a quiet but noticeable low-pitch humming sound; most drivers actually prefer the quieter hydraulic hybrid trucks once acclimated.

Hydraulic hybrids require less maintenance because the technology dramatically decreases use of friction brakes. Maintenance technicians should receive training on hydraulic hybrids' extended maintenance schedule to avoid pulling vehicles out of service more frequently than necessary.

Drivers of first-generation hydraulic hybrid vehicles reported handling issues due to the added weight of the hydraulic accumulators; however, newer, light-weight accumulators — made with carbon fiber — add minimal weight to the chassis and do not affect handling.

EFFECTIVENESS

Driving style significantly affects the fuel efficiency of hydraulic hybrid vehicles. Rapid acceleration activates the engine instead of using stored hydraulic energy; and hard braking activates the friction brakes instead of recapturing the vehicle's kinetic energy in the hydraulic fluid. Thus, training should instruct drivers on fuel efficient driving practices to maximize fuel cost savings.

5.3. Proposed next steps

The following table outlines potential next steps Raleigh could take to implement these recommendations. The task duration, staff time, and cost values provided in this table estimate the effort and expense required to implement the recommendations; it is possible actual values will deviate from these estimates.

We recommend the City reassess the effectiveness of these strategies at least once every three years. Once the fleet management best practices are implemented, the City will have the data and organizational capacity needed to evaluate additional petroleum displacement solutions and determine further actions to pursue. ■

1. Establish the fleet management steering committee

ACTION	PURPOSE	DURATION	STAFF TIME	COST
A. Establish committee and its membership	» Identify representatives from each department » Establish rules, norms, and schedule for committee operation	1 month	4 hours	--
B. Hold regular committee meetings	» Meet regularly (at least quarterly) to discuss timely fleet issues; e.g., reviewing analytics, making decisions on fleet policies, procedures, and procurements, exchanging information on fleet initiatives & departmental pilots	Continuous	~250 hours per year	--
C. Revise fleet policies & procedures	» Centralize fleet policies & procedures in consideration of departmental operating guidelines » Review — and, if needed, revise —fleet policies and procedures; for example: – Vehicle replacement evaluation criteria – Vehicle replacement capital fund – Vehicle procurement procedure – GPS tracking and vehicle analytics – Take-home vehicle policy	3 - 6 months per policy	60 – 80 hours per policy	Up to $50,000 per year for consultant to research best practices

2. Offer driver training regularly

ACTION	PURPOSE	DURATION	STAFF TIME	COST
A. Assess training needs and develop training plan	» Determine content needs and best format for presenting content » Work with fleet management steering committee to establish frequency offered & policy regarding frequency of driver training	3 months	40 hours	--
B. Acquire training materials	» Review existing City driver training programs and amend curricula as needed » Alternately, procure consultant to develop and deliver trainings	3 months	40 hours	--
C. Conduct training	» Provide fuel efficient driving training for all licensed staff » Provide specific training for drivers and maintenance staff assigned to alternative fuels and advanced transportation technologies	Continuous	16 hours prep per training + staff time in attendance	$5,000 per training

3. Develop a smart fleet management system and analyze fleet frequently

ACTION	PURPOSE	DURATION	STAFF TIME	COST
A. Analyze data needs & review current fleet management system	» Review data needed for desired fleet management analytics » Assess FASTER's capabilities to determine whether current system meets fleet management needs » Identify staff-training needs to maximize use of FASTER	2 months	80 hours	--
B. Equip all vehicles with AIM	» Purchase and install AIM on every vehicle that regularly fuels at an AIM-equipped pump	6 months	40 hours	$25,000

3. Develop a smart fleet IT system and analyze fleet frequently (cont'd)

ACTION	PURPOSE	DURATION	STAFF TIME	COST
C. Produce monthly fuel reports	» If needed, procure consultant to create report template(s) in FASTER (or other fleet management system) » Generate reports that analyze collected fuel and vehicle utilization data » Review utilization rates and modify vehicle assignments, as needed » Analyze fuel economy, reward best performers, and identify under-performers	Continuous	96 hours per year	$5,000
D. Conduct fleet evaluation	» Hire a consultant to evaluate fleet fuel consumption and vehicle utilization, identify issues, and recommend new strategies at least once every three years » Verify progress towards petroleum-reduction goals	4 months, once every 3 years	250 hours	$15,000

4. Maximize use of existing alternative fuels

ACTION	PURPOSE	DURATION	STAFF TIME	COST
A. Review vehicle assignments	» Determine which vehicles lack easy access to alternative fuels refueling & reassign to locations with refueling available	2 months	40 hours	--
B. Educate drivers about alternative fuels	» Establish a distribution list for all drivers, supervisors using alternative fuel vehicles » Create and distribute a policy regarding refueling with alternative fuels	3 months	48 hours	--

4. Maximize use of existing alternative fuels (cont'd)

ACTION	PURPOSE	DURATION	STAFF TIME	COST
C. Identify & recognize fuel-efficient drivers	» Use fuel reports to determine most and least fuel efficient drivers » Recognize top drivers with certificate & congratulations over distribution list » Remind & enforce fueling policy with those reporting low fuel economy or using a low percentage of alternative fuels	Continuous	48 hours per year	--

5. Use hybrid-electric vehicles for all passenger sedan applications

ACTION	PURPOSE	DURATION	STAFF TIME	COST
A. Institute hybrid-electric vehicle policy	» Develop a policy to purchase hybrid-electric vehicles for passenger sedan applications unless department provides a strong justification for specifying a conventional gasoline vehicle	3 months	80 hours	--
B. Review vehicle models available	» Each model year, review hybrid-electric passenger vehicles against conventional gasoline vehicles using stop-start technology; compare initial costs vs. fuel economy (mpg) to verify most cost-effective model	Continuous	16 hours per year	--

6. Install anti-idling technology in police patrol cars

ACTION	PURPOSE	DURATION	STAFF TIME	COST
A. Research and pilot a new idle-reduction technology	» Research and collect specifications from manufacturers (e.g., Zero RPM, Vanner, Navitas); arrange for demonstrations, if possible » Select the product most suitable to Raleigh's application	6 months	250 hours	--

6. Install anti-idling technology in police patrol cars (cont'd)

ACTION	PURPOSE	DURATION	STAFF TIME	COST
B. Collect and analyze idle time statistics	» Use vehicle computer scanner (OBD II) to record idle time on all police vehicle engines, e.g., when in maintenance for an oil change » Determine which vehicles idle the most	Continuous	4 hours	--
C. Test new idle-reduction system	» Purchase 2-4 systems from the selected manufacturer » Install on the police vehicles incurring the most idling time » Evaluate performance for at least 6 months » Repeat with new vendor if unsuccessful	9 months	40 hours	$15,000
D. Implement successful idle-reduction technology	» Purchase and install the selected idle reduction technology on the 25% of the police vehicles with the highest number of hours idling » Repeat annually until all vehicles with significant annual idle times have an idle-reduction system	6 months per year for 2-4 years	160 hours per year	$600,000 per year
E. Investigate start-stop solutions	» For patrol cars that do not idle frequently or for long periods, investigate whether stop-start solutions might reduce idle time	6 months	40 hours	$5,000

7. Convert medium- and light-duty trucks and high mileage pick-ups to propane

ACTION	PURPOSE	DURATION	STAFF TIME	COST
A. Specify gaseous-prep engines for all new trucks	» As part of the fleet procurement policy revisions, require all new truck purchases specify gaseous-prep engine unless 1) none meets the specified requirements or 2) the department provides a strong justification for not using gaseous-prep	Continuous	< 1 hour	$16,000 per year for upgraded engine

7. Convert medium- and light-duty trucks and high mileage pick-ups to propane (cont'd)

ACTION	PURPOSE	DURATION	STAFF TIME	COST
B. Obtain propane conversion kits	» Develop and publish an RFP for truck propane conversions to verify costs » Review conversion process and verify similarity to police vehicles » Determine whether City maintenance staff will perform conversion or if City will contract with a third party	6 months	80 hours	--
C. Evaluate truck applications & fueling options	» Analyze truck fuel use per day and base locations » Determine whether to convert truck to dedicated LPG vs. bi-fuel » Estimate propane consumption » Re-evaluate economics with updated cost and fuel use inputs	1 month	24 hours	--
D. Test propane conversion system	» Purchase 2-4 conversion kits from selected manufacturer and install on trucks with a gaseous-prep engine that incur high mileage and have easy access to propane fueling » Evaluate system performance for 6 months	9 months	80 hours	$24,000
E. Implement propane conversions	» If trial proves successful, convert the ~40% of truck fleet with easy access to propane as trucks with gaseous-prep engines are purchased	Continuous	600 hours	$1,600,000

Detailed Contents

APPENDICES

Find appendices on the common drive at
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ABOUT THE CONSULTANTS

Our project team's expert knowledge of the state-of-the-art transportation efficiency and alternative fuel technologies yields the best approaches to their implementation. We developed our expertise through previous experience and ongoing work with the U.S. Department of Energy (U.S. DOE), the New York State Energy Research & Development Authority (NYSERDA), and similar organizations.

ENERGETICS INCORPORATED is a full-service technology and management consulting firm with more than 30 years of experience in energy-related fields. Energetics specializes in assisting government agencies and industry with developing new solutions to energy problems. Energetics' engineers have been integral to the success of many demonstrations and evaluations of new transportation technologies in real world performance tests for federal, state, and private sector clients over the past three decades.

THE NORTH CAROLINA CLEAN ENERGY TECHNOLOGY CENTER AT N.C. STATE UNIVERSITY advances a sustainable energy economy by educating, demonstrating and providing support for clean energy technologies, practices, and policies. The Center serves as a resource for innovative, clean energy technologies through demonstration, technical assistance, outreach and training.

CST FLEET SERVICES has expert municipal fleet consultants that specialize exclusively in identifying, implementing, and training operators how to fully achieve the cost savings associated with the implemented initiatives. Over the years, CST turned the knowledge gained from developing metrics for their customers into industry best practices, and their efforts have produced proven and measurable results.

This Fuel & Fleet Transformation Plan evaluates Raleigh's current petroleum-reduction initiatives and identifies additional cost-effective strategies for transitioning Raleigh's fleet to an even greater use of alternative fuels and advanced transportation technologies.