



**Session #7: Total Cost of Ownership—Alternative Fuels  
and Conventional Vehicles**

**October 05, 2021**



Sessions through December 09, 2021



Sessions September 09, 2021 – October 19, 2021

<https://www.sustainablefleetexpo.com/>

# SFT Conference Series Upcoming Sessions

- **10/07: Propane Applications and Success Stories**
- **10/09: Funding Sources & Creative Financing for Sustainable Fleet Deployment**
- **10/12: Funding Sources and Creative Financing for Sustainable Fleet Deployment**
- **10/14: Hydrogen as a Transportation Solution**
- **10/19: Future Proofing Electric Vehicle Charging Infrastructure**
- **10/21: Best Practices of the Top Green Fleet Winners 2021**

# 2021 SFT Conference Series Sponsors



# Format

- Q&A at the end
- Submit questions and comments to “Panelists”
- Scheduled for 2:00p-3:30p
- Handout
- Recording

# Total Cost of Ownership—Alternative Fuels and Conventional Vehicles October 05, 2021

2:00-2:05 **Rick Sapienza, NCCETC**--Introduction and Welcome

2:05-2:25 **Andrew Burnham, Argonne National Lab**—AFLEET Alternative TCO Tool and EV TCO Data

2:25-2:35 **Terrance Wilson, DeKalb County**—CNG Refuse Hauler Deployment Data

2:35-2:45 **Mike Phillips, Alliance AutoGas**—Propane as an Auto Fuel

2:45-2:55 **Brad Johnson, Iredell County**—Propane Paratransit Deployment Data

2:55-3:05 **Mark Stevens, City of Sacramento CA**—EV Sedan Deployment Data

3:11-3:30 Q&A





North Carolina State University  
NC Clean Energy Technology Center  
Clean Transportation Program  
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Andy Burnham  
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630-252-6606

- Principal Environmental Scientist at Argonne National Laboratory
- Research focuses on transportation energy and environmental issues specifically with the energy use and emissions analysis for advanced vehicle technologies and transportation fuels
- Developer the Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool
- Estimates petroleum use, greenhouse gas emissions, air pollutant emissions, and cost of ownership of light-duty and heavy-duty alternative fuel and advanced vehicles



# “AFLEET TOOL” TO ANALYZE THE TCO OF ALTERNATIVE FUEL VEHICLES



**ANDY BURNHAM**  
Principal Environmental Scientist  
[aburnham@anl.gov](mailto:aburnham@anl.gov)

October 05, 2021

## AFLEET Suite of Tools



### AFLEET Spreadsheet

Detailed energy, emission, and cost data for light- and heavy-duty AFVs



### AFLEET Online

User-friendly interface analyzes petroleum use, emissions, simple payback



### Heavy Duty Vehicle Emissions Calculator

Compares NOx, PM, GHGs and cost-effectiveness

[afleet-web.es.anl.gov](http://afleet-web.es.anl.gov)

# AFLEET INTRODUCTION



# AFLEET TOOL 2020

- **Examines light-duty & heavy-duty vehicle:**

- Petroleum use
- GHGs
- Air pollutants
- Cost of ownership

- **Contains 18 fuel/vehicle technologies**

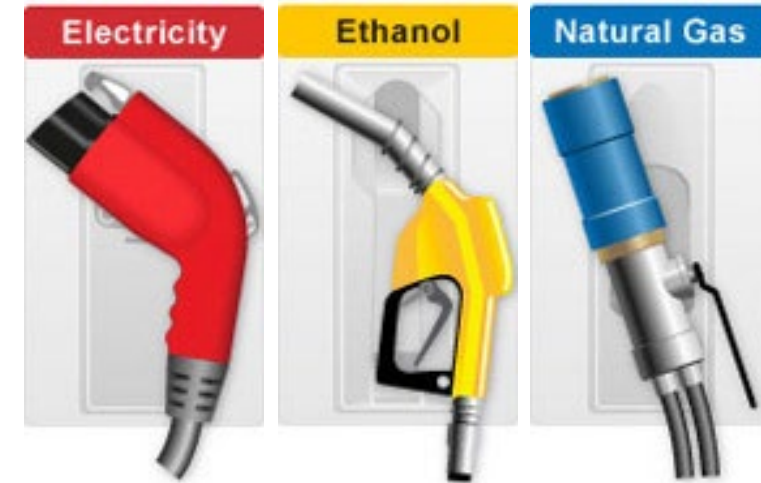
- Conventional
- Hybrids
- Plug-in electrics
- Alternative fuels: CNG, LNG, LPG, H<sub>2</sub>, ethanol, biodiesel, renewable diesel

- **New in AFLEET 2020**

- Updated vehicle and charging infrastructure costs
- New off-road payback calculator

- **AFLEET Spreadsheet and Online; HDVEC: [afleet-web.es.anl.gov](http://afleet-web.es.anl.gov)**

- AFLEET Online and HDVEC updated as well



# AFLEET TOOL'S CALCULATION METHODS

## 1. Simple Payback Calculator

- Annual emissions & simple payback: new AFV vs. conventional
  - On-road vehicles
  - Off-road equipment

## 2. Total Cost of Ownership Calculator

- Lifetime emissions & NPV of costs: new AFV vs. conventional

## 3. Idle Reduction Calculator

- Annual emissions & simple payback: IR equipment vs. idling

## 4. On-Road Fleet Footprint Calculator

- Annual & remaining lifetime emissions of existing & new vehicles

## 5. Off-Road Fleet Footprint Calculator

- Annual & remaining lifetime emissions of existing & new off-road equipment

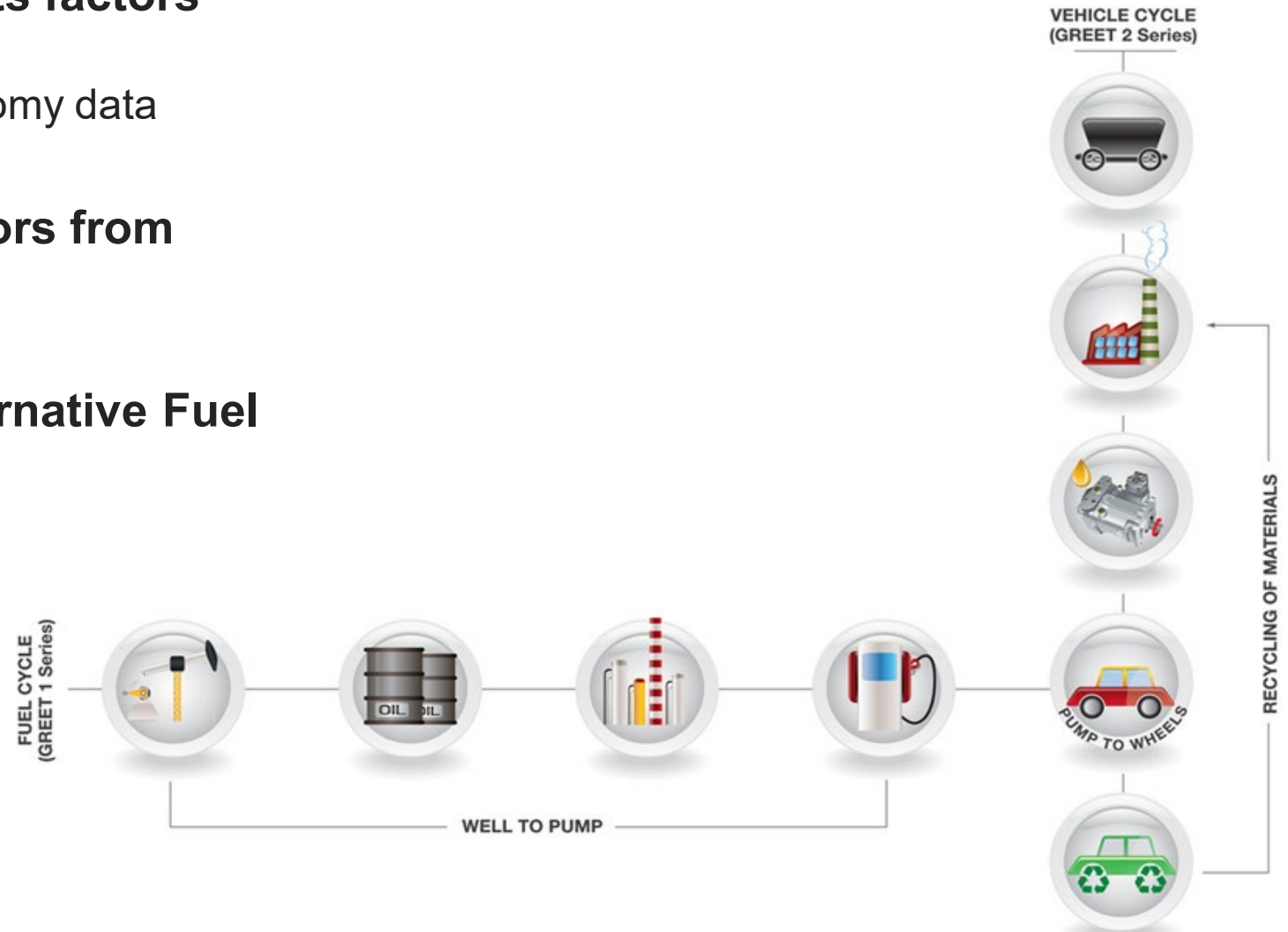
## 6. EV Charging Calculator

- Annual emissions benefit of utilizing public charging infrastructure



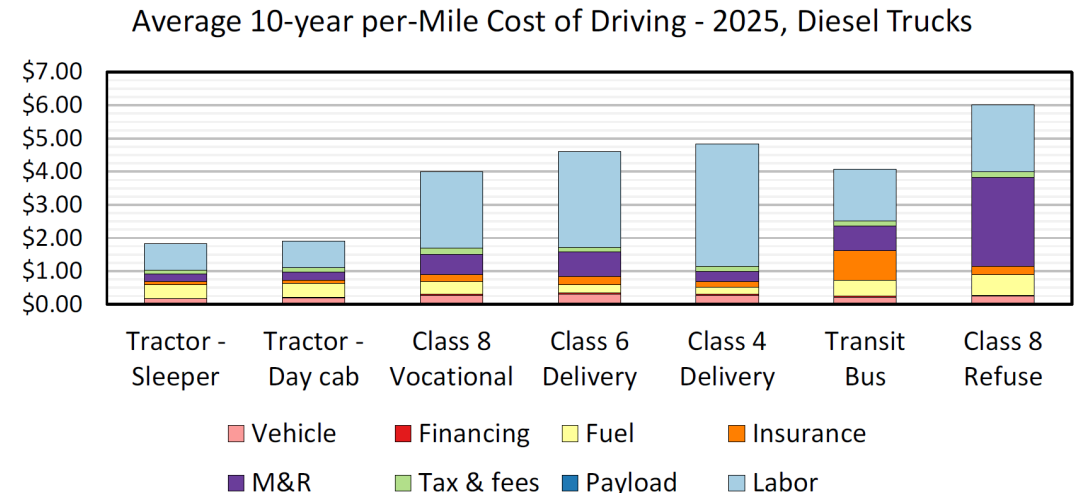
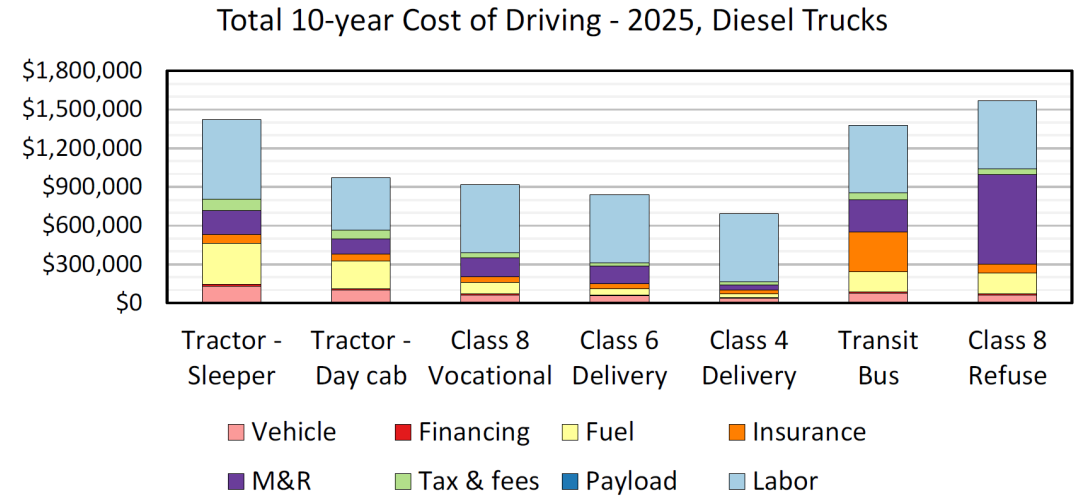
# KEY DATA SOURCES

- **Petroleum use, GHGs, air pollutants factors from Argonne's GREET 1 2020**
  - Light-duty and heavy-duty fuel economy data
- **Vehicle air pollutant emission factors from EPA's MOVES3**
- **Fuel prices using Clean Cities Alternative Fuel Price Reports**
- **Recent DOE TCO study**



# TCO STUDY: VOCATIONS

- Wide variation in costs across different vehicle vocations
- Labor costs: typically highest term
- Fuel costs: most important for tractors (driving 50,000+ mi/yr)
- Insurance: high for transit bus,
- M&R highest cost for refuse trucks



# TCO STUDY: POWERTRAINS

- For tractors, HEV slightly cheaper than conventional diesel
  - Much higher **vehicle** cost for BEV & PHEV
  - Very high **fuel** cost for FCEV
- For MDV truck, BEV is lowest cost option
  - Much lower **fuel** & **maintenance** costs

Avg. 10-year per-Mile Cost of Driving - 2025, Tractor - Sleeper

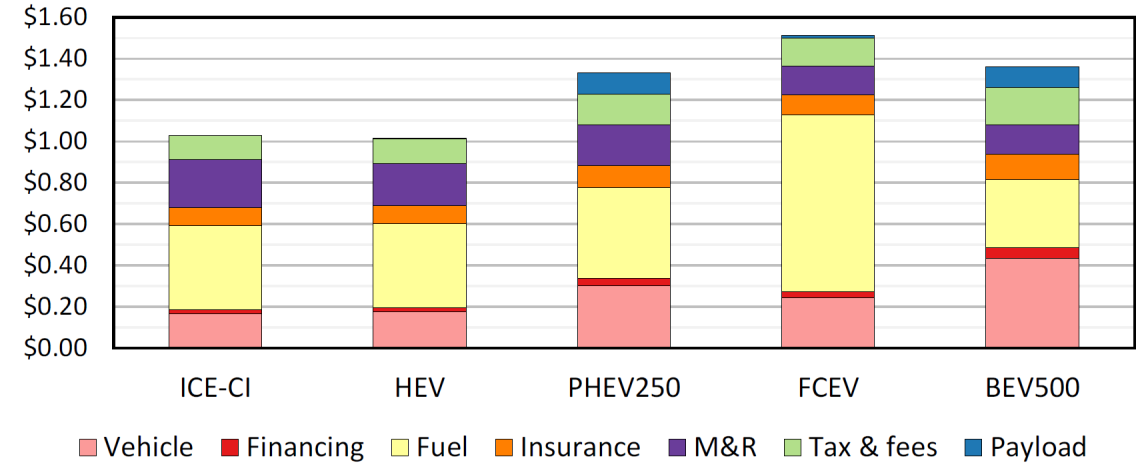


FIGURE 4.4 LCOD comparison across powertrains for MY2025 long-haul tractor trailers

Avg. 10-year per-Mile Cost of Driving - 2025, Class 4 Delivery

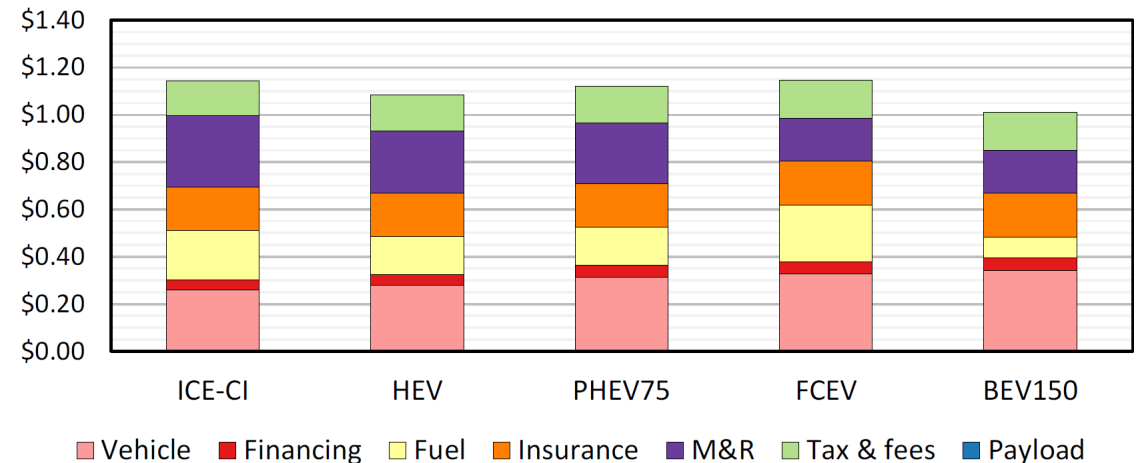


FIGURE 4.6 LCOD comparison across powertrains for MY2025 class 4 delivery trucks



## AFLEET TUTORIAL – DEMO #2

# Using Simple Payback and TCO Calculators to Compare Potential Acquisitions



# TRANSIT BUS CASE STUDY

## ■ Incremental cost of vs. diesel (\$500K)

- B20 ~ \$0
- CNG ~\$40,000
- HEV ~ \$175,000
- EV ~ \$400,000

## ■ Fuel price

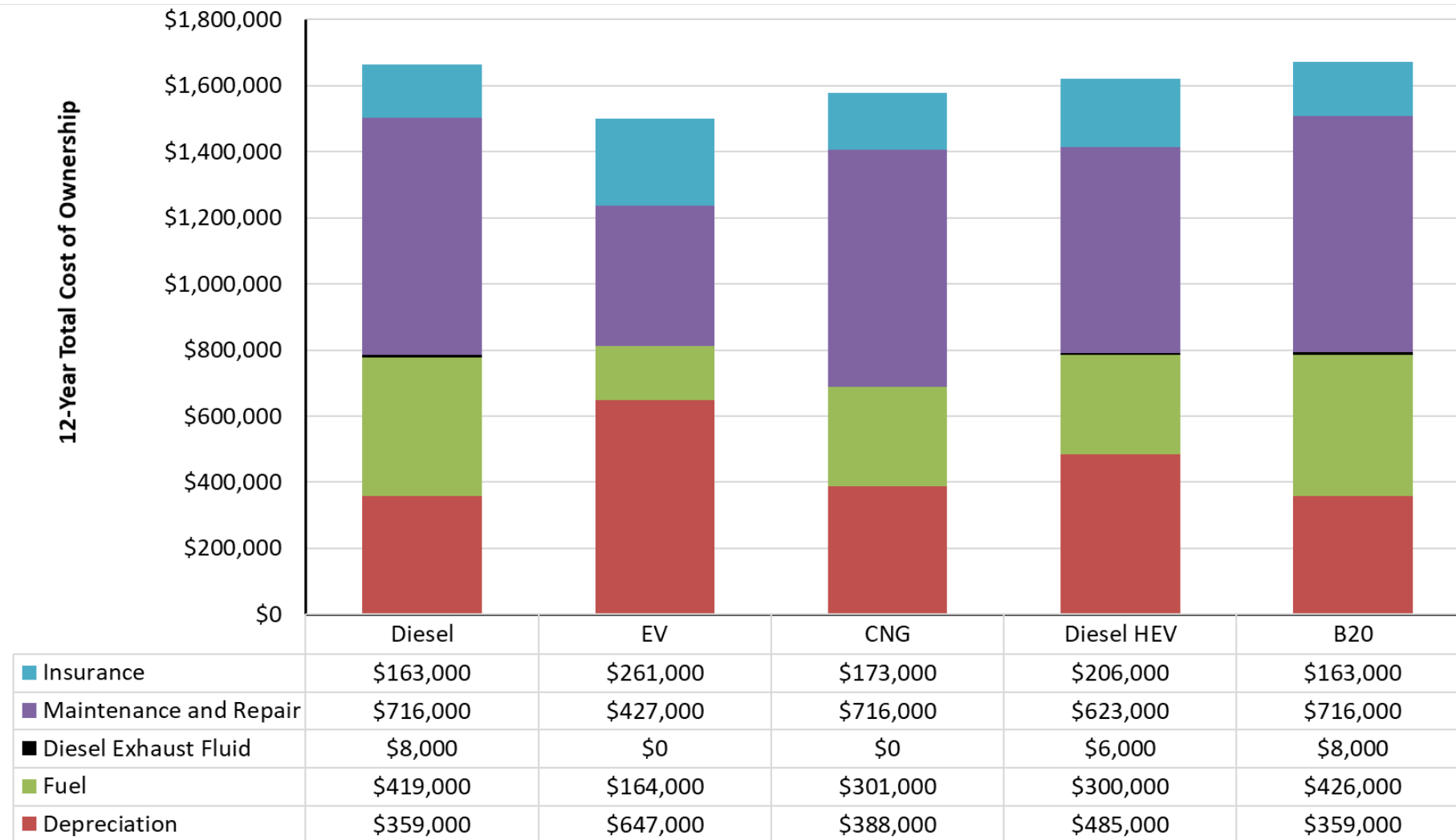
- Diesel ~ \$3/gal (2<sup>nd</sup> case ~ \$2)
- B20 ~ \$3/gal (2<sup>nd</sup> case ~ \$2)
- CNG ~ \$1.75/gge
- Electricity ~ \$0.10/kWh

## ■ M&R

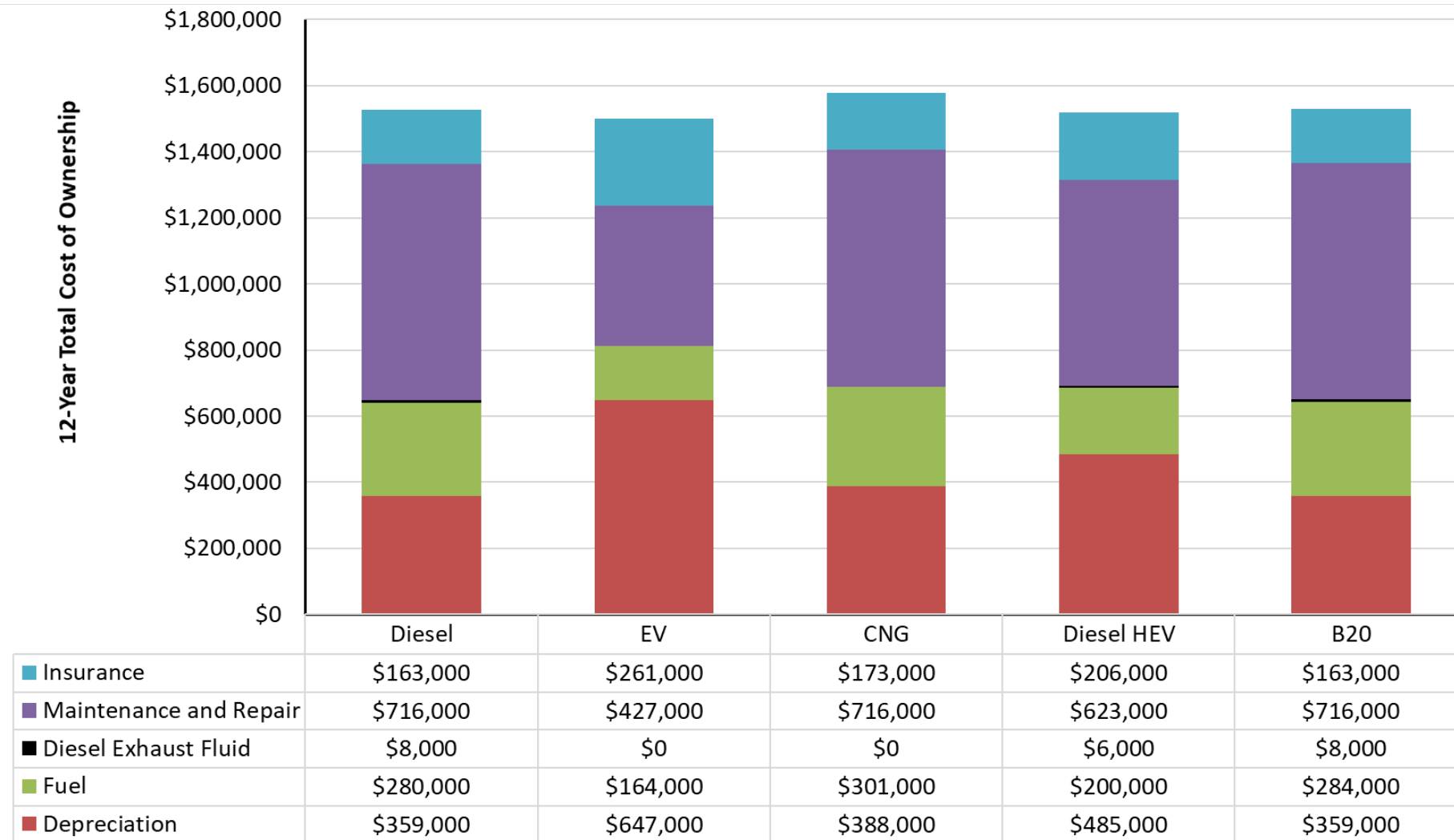
- Diesel, B20, CNG ~ \$1/mi
- HEV ~ \$0.87/mi
- EV ~ \$0.60/miOther
- Annual miles ~ 45,000
- Physical damage insurance ~ \$31 per \$1000 value



# TRANSIT BUS CASE 1 (DIESEL \$3/GAL) RESULTS



# TRANSIT BUS CASE 2 (DIESEL \$2/GAL) RESULTS



# THANK YOU!!!

Argonne National Laboratory's work is supported by the U.S.  
Department of Energy, Office of Energy Efficiency and Renewable  
Energy

**This work has been supported and assisted by:**

Margaret Smith: U.S. DOE

Marcy Rood: Argonne

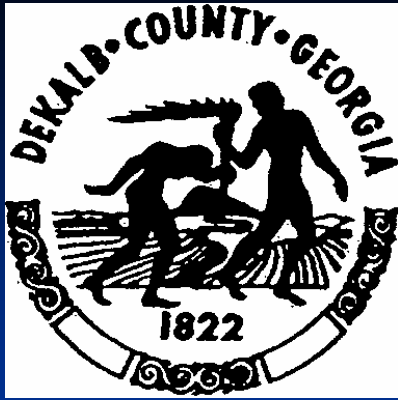
Joann Zhou: Argonne



Terrance Wilson  
tdwilson@dekalbcountyga.gov

- Fleet Maintenance Superintendant DeKalb County GA
- Manages fleet maintenance for the public government 1900 units gas, propane and cng powered engines
- 30 years automotive experience with 20 years in diesel maintenance
- Automotive Technology Diploma from Columbus Technical University, Bachelor of Science in Business Management 2015





# DeKalb County Fleet Management

## Alternative Fueled Fleet

### Natural Gas TCO







# Fleet Management

- 152 Positions authorized, 142 Filled
- \$30 million Annual Operating Budget
- \$28.5 million Annual Vehicle Replacement
- Fleet Management maintains 3640 vehicles
- Fleet averages 30,000,000 miles annually
- 424 Alternative Fuel Vehicles, 11.6% of the Fleet

# *The 100 Best Fleets in North America*

1<sup>st</sup> place 2018

2<sup>nd</sup> place 2016

2<sup>nd</sup> place 2015

5<sup>th</sup> place 2017

9<sup>th</sup> place 2021







# CNG / Propane Assets in our Fleet

- 74 Propane Light Duty Vehicles
- 73 CNG Light Duty Vehicles
- 249 CNG Heavy Duty Vehicles
- 2 CNG Fuel Stations (County Owned)
- 4 CNG Fuel Stations (Private Owned)
- 7 Propane Fuel Stations (County Owned)

# CNG Powered Vehicle types in our Fleet

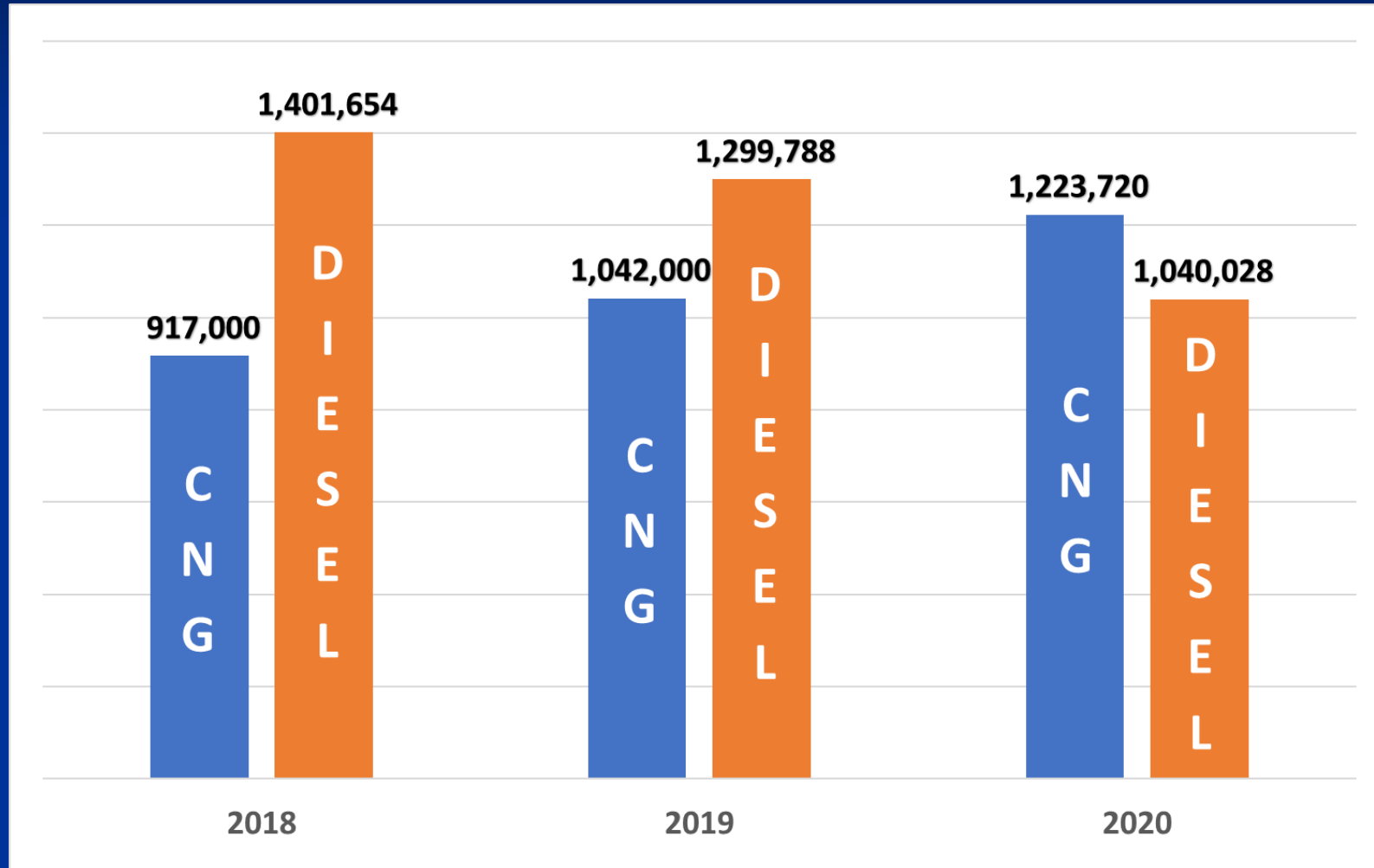
## Heavy Duty / Medium Duty

- Rear Loaders
- Front Loaders
- Side Loaders
- Automated Side
- Roll Off Trucks
- Grappler Trucks
- Crew Trucks
- Crane Trucks
- Level Lift Trucks
- Bucket Truck
- Road Tractors
- Road Fork Trucks

## Light Duty

- Pickup Trucks
- Sedans
- Vans
- Missed Collections Trucks

# Fuel Usage (in gallons)



# CNG Vehicles

## Advantages

- Less Maintenance than Diesel-Fueled Trucks
- Lower Fuel Cost
- Lower Emissions
- Less Noise

## Disadvantages

- 10% Higher Purchase Price; ROI around 5 years



# Average Total Cost Of Ownership (TCO) for Rear Loaders Based on 150,000 miles of usage with 1500 stops per day

	Diesel	CNG
Cost	\$240,000	\$270,000
Maintenance (Life)	\$390,000	\$316,500
Maintenance (CPM)	\$2.60	\$2.11
Fuel (Life)	\$213,000	\$187,500
Fuel (CPM)	\$1.42	\$1.25
Sale	(\$30,000)	(\$30,000)
<b>TCO</b>	\$813,000	\$744,000



Mike Phillips

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(704)574-4927

- Municipal and Law Enforcement Specialist, Alliance AutoGas (Blossman Gas)
- Works with public and private organizations to develop and expand their alternative fuel programs
- Previously Captain of Criminal Enforcement for the Iredell County Sheriff's Office
- Developed and executed 3 successful AutoGas conversion programs for the department's patrol division



# Autogas and Your Fleet

MICHAEL PHILLIPS,  
MUNICIPAL/ LAW  
ENFORCEMENT SPECIALIST

*Let's Clear the Air...*

Propane autogas reduces NOx  
emissions by over 30%



# Who We Are

- ① Vehicle Technology
- ② Conversions
- ③ Refueling Infrastructure
- ④ Fuel Supply
- ⑤ Maintenance



Founded in 2009, Alliance AutoGas offers the only complete program to convert, maintain, and support autogas fleets.



# Our Systems



- Alliance AutoGas offers a bifuel system, giving fleet vehicles the flexibility to run on either autogas or gasoline, eliminating range anxiety





# Supported Vehicles





# Less Is More

**79% LESS** CARBON MONOXIDE



**54% FEWER** SMOG-PRODUCING HYDROCARBONS




**42% LESS** NITROGEN OXIDE



**22% LESS** CARBON DIOXIDE



 Gasoline-fueled vehicle emissions

 Propane-autogas-fueled vehicle emissions

# Top Benefits of Autogas

1. Domestically Sourced
2. High Performance
3. Lowest Total Cost of Ownership
4. Reliable Emergency Fuel
5. Safe





# Refueling



Customers can choose private, on-site refueling infrastructure scaled for their needs, or take advantage of existing public or private refueling networks.





# Simple Dispensing

- Exclusive “Quick Connect” Nozzle
  - Safe
  - Faster fill than gasoline



## THE STÄUBLI QUICK CONNECT ULTRA-LOW EMISSIONS NOZZLE\*



\*Exclusively distributed through BSI

## DESCRIPTION

### THE STÄUBLI NOZZLE:

- † Is compatible with the standardized EN 13760 connector that is present on the vehicle
- Has UL Certification according to the UL 125 standard
- Is easy to use: Just as simple to handle as a gasoline pump nozzle
- The valve design allows effortless connection
- The 360° swivel connection between the nozzle and the hose reduces the stresses due to hose rigidity
- Nozzle weighs only 3.31 lbs
- The inline connection principle rules out any handling errors, meaning totally safe operation.
  - No gas can escape and no gas flow is possible unless the refueling nozzle is engaged in the connection piece
  - Incomplete locking is impossible
  - The nozzle is unlocked automatically when the trigger is released
- Ultra-low emissions: 0.4 cc of product released compared to 1.9 cc for the typical Acme Low Emissions Nozzle

# Safety



## AUTOGAS IS A SAFE, PROVEN AND RELIABLE FUEL.

*Fleets across the U.S. are fueled by autogas, partly because autogas is intrinsically safer than many other fuels.*

- Autogas tanks are **20 times** as puncture-resistant as gasoline tanks and can withstand **4 times** the pressure.
- The lower pressure required for storage makes autogas safer to maintain than CNG.
- Autogas vehicle tanks are constructed from carbon steel under code developed by the **American Society of Mechanical Engineers**.
- Properly installed autogas vehicle fuel tanks can actually add to the structural integrity of a vehicle.



Autogas tanks can

withstand  
**4X**  
the pressure



when compared to conventional gasoline vehicle fuel tanks

In accordance with NFPA 58 safety guidelines, all autogas tanks are equipped with an OPD (Overfill Protection Device) **which prohibits the tank from being filled past 80%** capacity. This 80% threshold allows room for liquid volume changes within the tank due to temperature fluctuations.

# Real Customers



“The argument for more propane autogas vehicles had to start with quantifiable savings... Fortunately, it was an easy story to tell.” – **Steve Hightower, City of Kingsport TN**

“It’s turned out really, really good for us.”— **Marty Byers, Iredell County Sherriff**

“Alliance has really taken our autogas program to the next level.”— **Asst. Chief Robert Abraham, La Crosse Police Department**

“This program is running effectively, saving our County money, supporting our efforts to be a “clean fleet’ and helping us to be excellent stewards of our environment.” – **Jeff Jeter, Chesterfield County, VA**

“Should power go out, we can still fuel vehicles and do what we need to do. Our onsite fueling stations are filled by our local Blossman Gas branch with fleet vehicles that also operate on autogas, so we can count on them to keep getting fuel to us when we need it.” – **Jimmy Riley, Spartanburg Regional Health Systems**

# Q&A



**Michael Phillips**

Alliance AutoGas

Municipal-Law Enforcement Spec.

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Brad Johnson

[bradley.johnson@co.iredell.nc.us](mailto:bradley.johnson@co.iredell.nc.us)

- Transportation Director for Iredell County Area Public Transportation (ICATS Transit)
- Experience comes from various transportation modes, including competitive cycling, motorcycle racing, and marine and public transportation
- Supervises the complete transit system operating fixed-route and paratransit services through a multi-county urban/rural region
- Seen considerable growth in ridership and miles in recent years
- ICATS fleet of 29 vehicles covering 700,000 plus miles a year
- Data-driven public transportation system on the leading edge of innovation and thinking outside of the box
- BS in Industrial Distribution and Logistics from East Carolina University

# ICATS

IREDELL COUNTY AREA  
PUBLIC TRANSIT

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Mark Stevens

[mstevens@cityofsacramento.org](mailto:mstevens@cityofsacramento.org)

916-808-5869

- Fleet Manager City of Sacramento CA
- Started career with Detroit Edison
- Previous fleet manager positions with Pompano Beach FL, Asheville NC
- Innovator and technology champion enhancing fleet operations for efficiency and sustainability
- #1 Green Fleet Award Winner 2019 & #2 Green Fleet Award Winner 2018 100 Best Fleets
- BSME Purdue University

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Fleet Management

*City of*  
SACRAMENTO

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# Fleet Management

# Fleet Facts

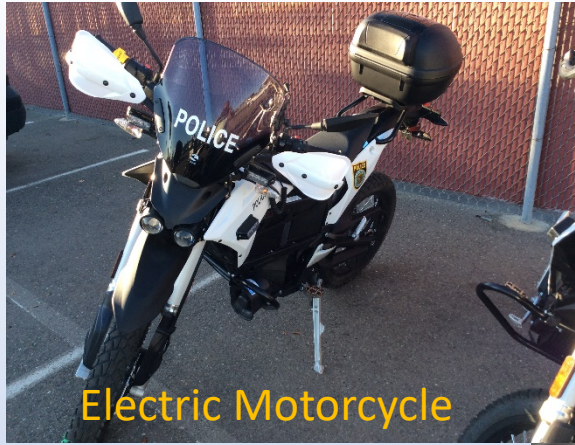
- 2400 units
- 75 FTE's
- 5 Maintenance Shops
- 1 Build – “Upfit” shop
- Fuel Management
  - 51 fuel tanks
- Fiscal Year 2020/21 Actuals:
  - \$27 million Operating Budget
  - \$27 million Replacement Budget



# Types of ALTERNATIVE Fuels

- **502** - Renewable Diesel
- **72** - Renewable LNG
- **61** - Renewable CNG
- **30** - Propane
- **126** - Electric (BEV)
- **49** - Hybrid's (Ford, Honda, & Dodge)
- **350** - E85 (85% ethanol & 15% gasoline)

**53% - Alternative fuel**



Electric Motorcycle



Hydrogen Fuel Cell



Renewable Diesel



Battery Electric Vehicle



CNG Powered



# TCO Analysis

Gasoline vs EV

# How Do I Justify Purchasing an EV

- Highly recommend a comprehensive Sustainability Policy
  - This helps ensure “Top-Down Mandate ensures Bottom-Up Sell”
  - Use TCO for costing on legacy vehicles to determine cost/mile
  - Compare with published cost/mile data for EV’s
  - Generate cost saving calculations based on previous data
- 
- If you don’t have a Sustainability Policy-this is a great way to promote the need for a policy – actual O&M savings

**13560 - 2019 CHEVROLET BOLT EV**

**TCO: \$48,871**

**Status:** Active  
**Description:** 2019 CHEVROLET BOLT EV  
**In Service Date:** 09/04/2019  
**In Service Age:** 2.1 Years  
**Model Age:** 2.0 Years  
**Current DeptID:** 14001631 - UTILITY BILLING  
**Maint. Location:** 24th ST Maintenance Shop  
**Category:** A22 - SDN,COMPACT 4DR  
**Asset Class:** PASSENGER  
**Expected Years/Meter:** 8 / 100,000  
**Meter Type:** Mile  
**Current Odometer:** 17,749  
**Original DeptID:** 14001631 - UTILITY BILLING  
**Parking Location:** WATER DEPT. 35TH AVE PARKING

**Fuel / Usage 5-Year Trend** Last Meter Reading: 10/4/21 9:58:32AM

	2022	2021	2020	2019	2018
Yearly Fuel Consumption					
Monthly Avg Consumption					
Yearly Driven	3,116	7,660	0	0	0
Monthly Avg Driven	1,039	638	0	0	0
Yearly Fuel Cost					
Monthly Avg Cost					

Life To Date Fuel Qty Consumed: 0      Life To Date Fuel Costs: \$0

**Service Job Cost History**

	In-House Work		Outsourced Work		Capitalization		Total
	Yearly Sum	Monthly Avg	Yearly Sum	Monthly Avg	Yearly Sum		
2021	\$965	\$ 80	\$157	\$ 13	\$130		\$1,252
2020	\$10	\$ 1	\$0	\$ 0	\$6,063		\$6,073
<b>Total</b>	<b>\$975</b>		<b>\$157</b>		<b>\$6,193</b>		<b>\$7,325</b>

**Accounting Information**

**Vendor:** 0000006611 - WINNER CHEVROLET      **Offroad Use:** 0%  
**Purchase Price:** \$35,352.79      **Acquisition Prep:** \$6,192.99      **Accessory Cost:** \$0.00      **Total:** \$41,545.78

**Technical Specification - (A2219BOLT)**

**Gross Vehicle Weight:** 4,443      **EPA Fuel Economy City (MPG):**      **Fuel Type:** ELECTRIC (B)      **Tank Size:** 0  
**EPA Fuel Economy Hwy (MPG):**  
**EPA Fuel Economy Combined (MPG):**

**Preventive Maintenance Schedule: PMB 1 YEAR 10K (EV'S)**

SMOG Required?: No      SMOKE Required?: No

Job Code	Job Description	Time Interval	Usage Interval	Last Done On	Job Count
PM-PMM-PMB	PM SERVICES PM-(B) LUBE/OIL/INSPECTIONS	360 Days	10,000 Miles	08/25/2020	2

**Unit Item**

**Budget Status:**      **VIB Installed?:** Yes      **Replaced Unit:** 10652 - 2007 HONDA CIVIC HYBRID  
**Budget Amount:** \$45,000.00      **Employee Required (Fuel)?:** N      **Incoming Unit:** -  
**Engine S/N:**      **Meter Retry:** 0      **Swapped Unit:**  
**Body S/N:**      **GPS ID:**      **Date Turn In By Dept:**

TCO  
Report



# Gasoline vs EV (O&M)

- Sedans (gasoline)
  - \$2,173,828 (O&M)
  - 9,023,694 miles
  - **\$.24/mile**
- EV (Chevrolet Bolt)
  - \$130,000
  - 1,103,800
  - **\$.12/mile**



# How Do I Afford an EV

## Direct Costs

- Sedan \$25,000      EV \$33,500
- Average 12,000 miles/year
- Sedan \$2,880/year      EV \$1,800/year

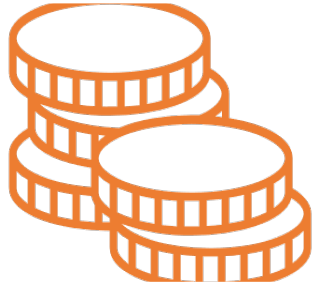
## Savings & Payback

- 4-1/2 year payback (\$1,080/year after that)
  - No PM's
  - No Emission tests
  - Reduced repair costs (fewer mechanical components)
  - Reduced fuel costs (electricity vs gas)
  - ZERO Emissions – GHG Reduction

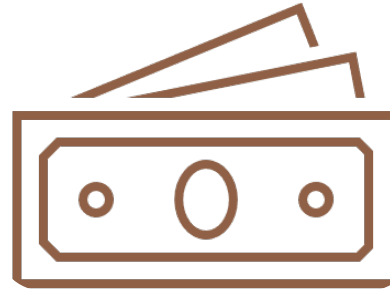
# Opportunities for Reducing Operating Costs

- Take advantage of off-peak demand charging rates
  - Program vehicle to start charging when off-peak rates begin
  - Install hardware to program electrical meter during off-peak hours
- Create schedule to alternate vehicle charging to reduce infrastructure
- Look at right-sizing EV vehicle purchases during replacement

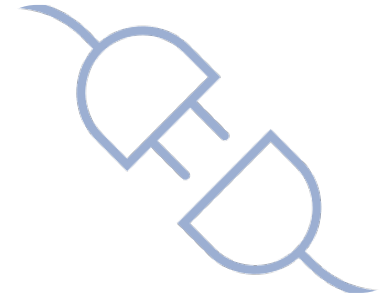
# Electrification Barriers



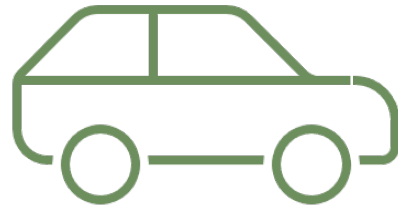
**Upfront capital  
costs**



**Understanding  
costs and savings**



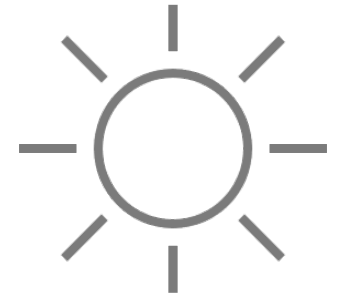
**Infrastructure**



**Right vehicles  
and equipment**

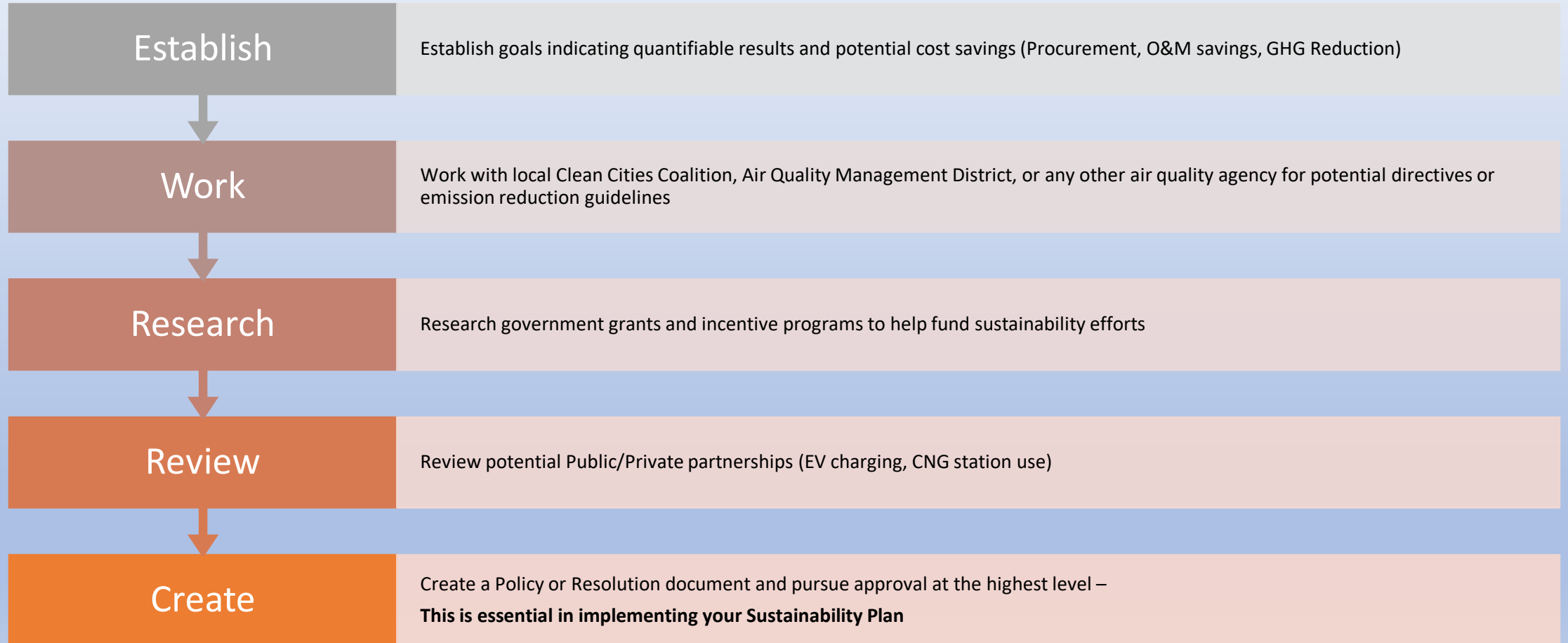


**Internal  
Champions**



**Climate and  
Energy Goals**

# Start with a Sustainability Policy



# GET STARTED



- Fleet
- Customer
- Taxpayer
- Environment



Sessions through December 09, 2021



Sessions September 09, 2021 – October 19, 2021

<https://www.sustainablefleetexpo.com/>