

Evaluating Investments in Natural Gas Vehicles and Infrastructure for Your Fleet



Vehicle Infrastructure Cash-flow Estimation – VICE 2.0

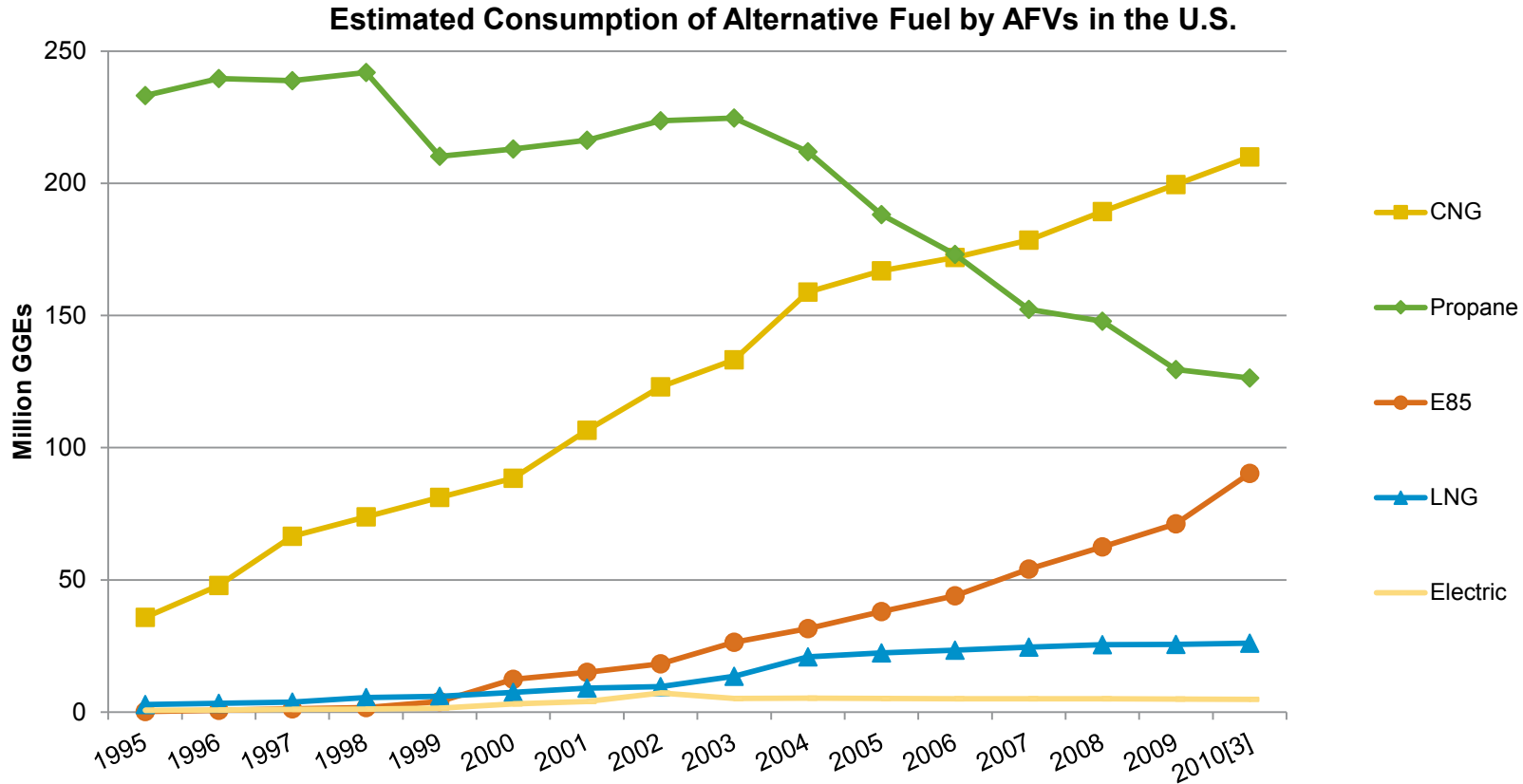
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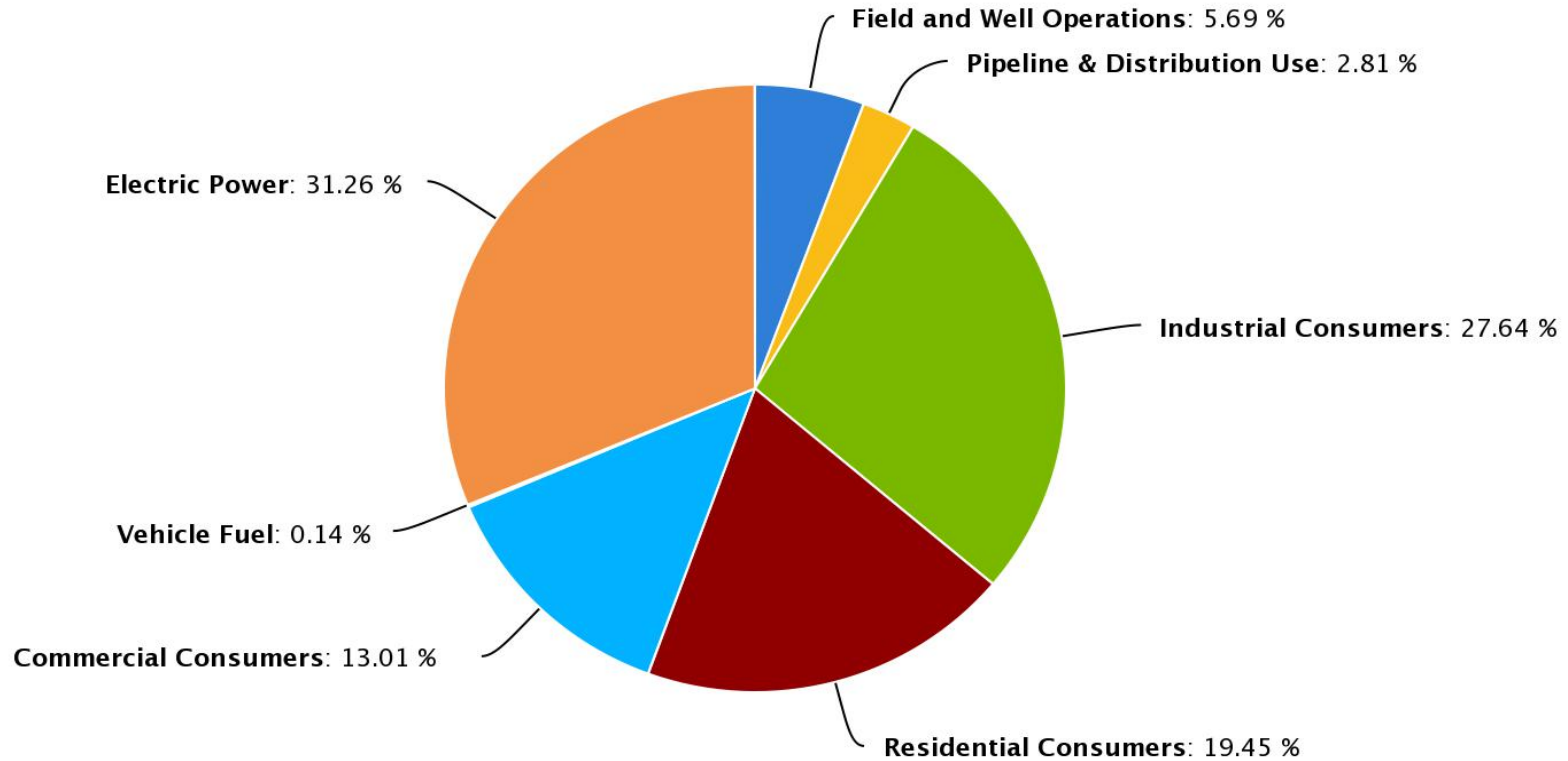
NREL/PR-5400-61898

- Trends in alternative fuel use
- Natural gas in transportation
- Natural gas as a fleet fuel
- Vehicle and Infrastructure Cash-flow Evaluation model (VICE 2.0)
 - Inputs
 - Calculation
 - Output
- Additional Clean Cities tools



- Alt fuels show steady growth With the exception of propane

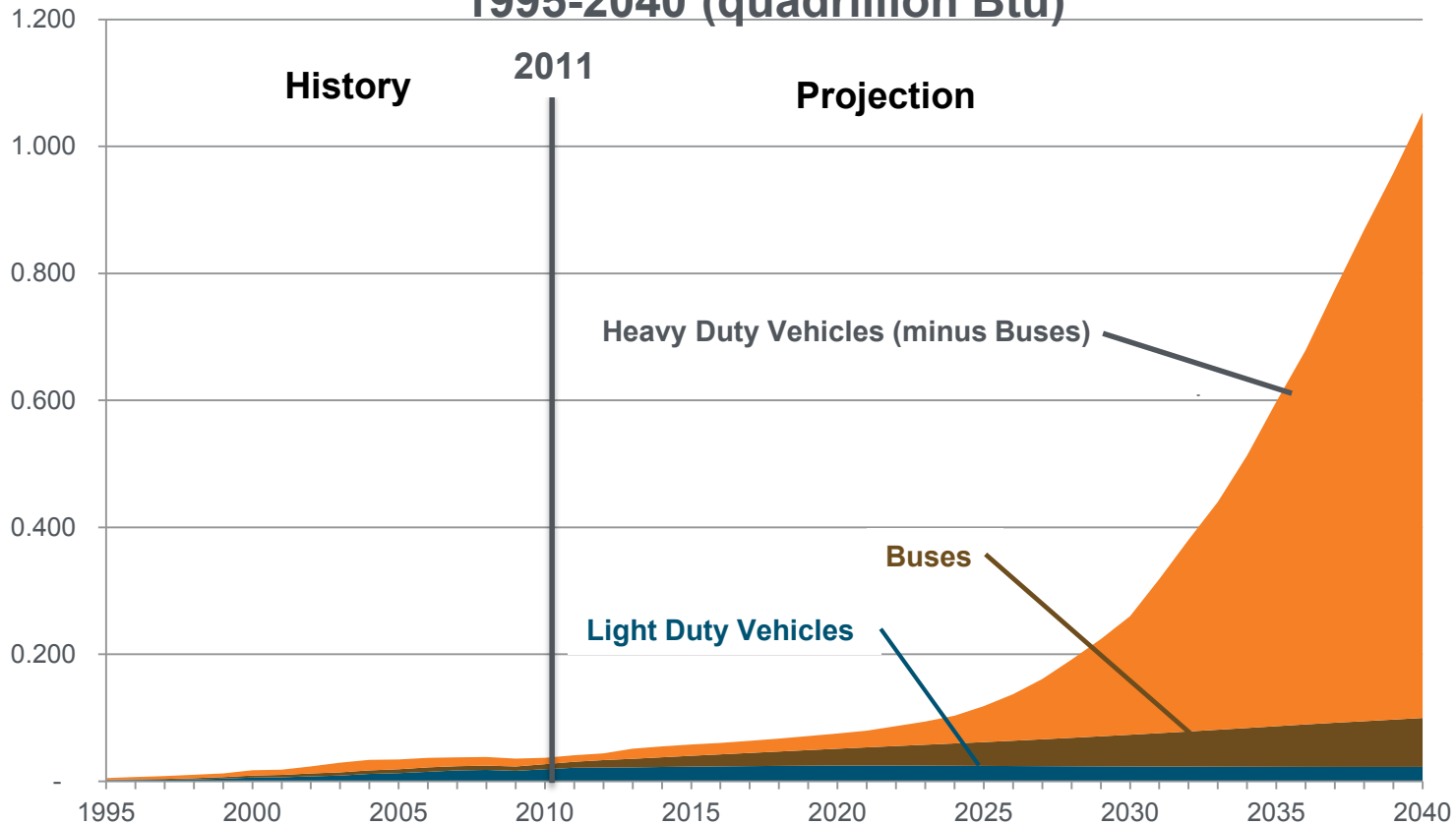
Consumption of Natural Gas in the U.S.



- **Vehicle fuel is a small fraction of overall usage**

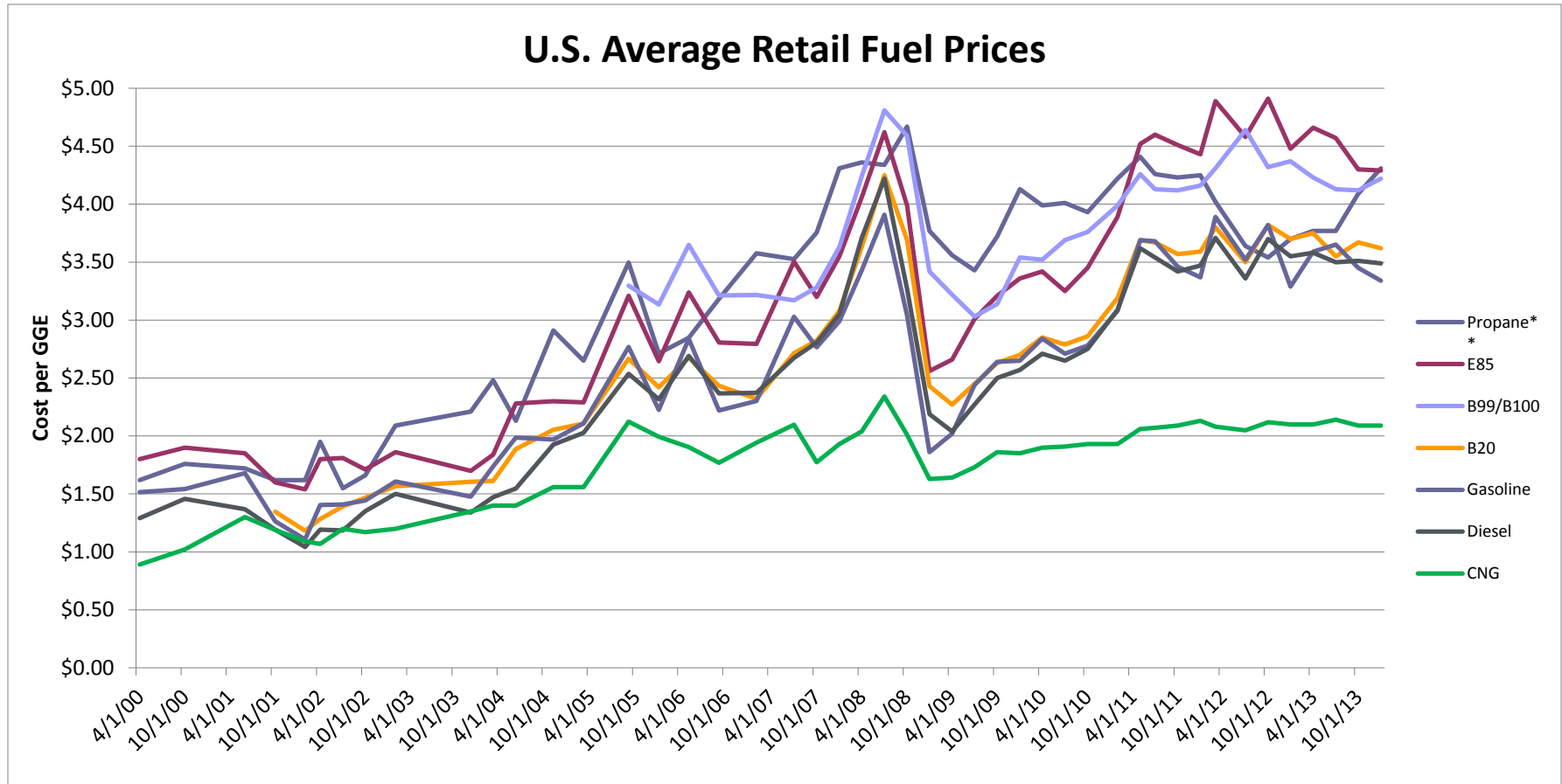
Source: U.S. Energy Information Administration

Natural Gas Consumption in the Transportation Sector 1995-2040 (quadrillion Btu)



- Significant heavy-duty usage forecast

Source: U.S. Energy Information Administration



- **CNG provides cost stability and predictability**
 - **Commercial natural gas is even more stable**

Renewed interest in natural gas as a transportation fuel

- Lower cost and less market volatility than gasoline and diesel
- Increased, steady supply of domestic natural gas
- Potential environmental benefits associated with lower GHG emissions from vehicles

Hurdles to using natural gas as a transportation fuel

- 1,235 CNG stations nationwide, compared with 157,000 gasoline/diesel stations
- Incremental costs for vehicles can be significant and are more pronounced for light-duty
- Continued favorable economics depend on natural gas prices remaining lower than petroleum-based fuel prices

National Average Price Between March 29 and April 12, 2013	
Fuel	Price
Biodiesel (B20)	\$4.11/gallon
Biodiesel (B99-B100)	\$4.29/gallon
Electricity	\$0.117/kWh
Ethanol (E85)	\$3.30/gallon
Natural Gas (CNG)	\$2.10/GGE
Propane	\$2.73/gallon
Gasoline	\$3.59/gallon
Diesel	\$3.99/gallon

Source: [Alternative Fuel Price Report, April 2013](#) and [U.S. Energy Information Administration](#)

Where is Natural Gas being Used?

Vehicles with predictable and central refueling patterns (i.e., fleets)

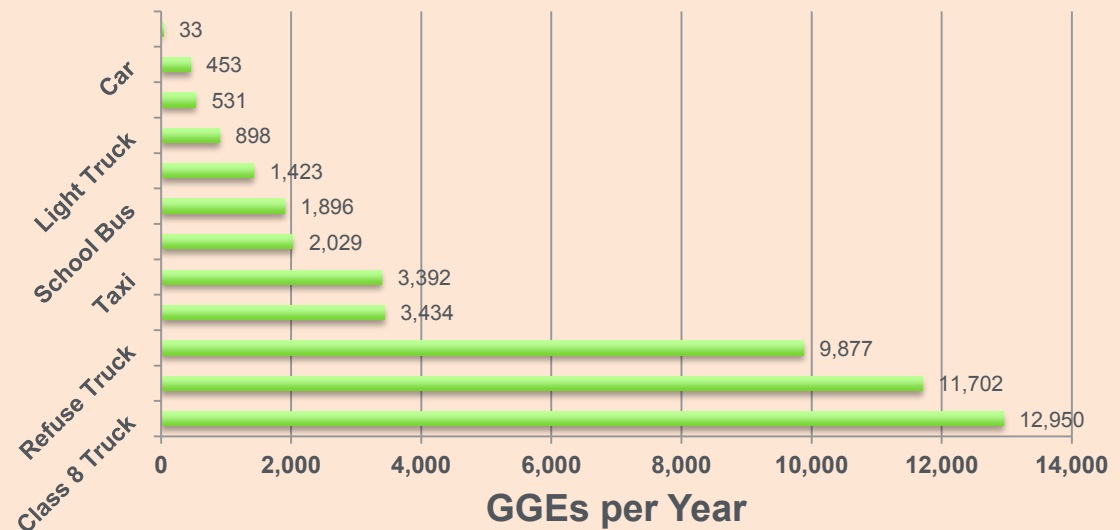
✓ Fleets benefit from shared infrastructure costs and logistics



High mileage and heavy fuel users

✓ Economic benefits come through fuel savings

Average Annual Fuel Use by Vehicle Type



www.afdc.energy.gov/afdc/data/

- **Contrasts the cash flow for CNG infrastructure, vehicles, and fuel with that of a diesel fleet**
- **Determines discounted payback period, NPV, and ROI**
- **Assesses finances for transit, refuse, school fleets, and mixes thereof**
- **Excel-based**

- **Significant enhancements beyond the original**
- **Customizable to better represent your fleet**
- **Vehicle only OR vehicle & Infrastructure**
- **Separate or combined investments**
- **Expanded vehicle choices**
 - **Light-duty & gasoline**
- **20 year investment matrix for vehicles and infrastructure**
- **Conventional fuel displacement and GHG savings**
- **Multiple visual and reporting enhancements**
- **Still Excel based**

VICE 2.0 can be used to investigate the operation of your fleet

- **How many vehicles does it take to make a project profitable**

VICE 2.0 may be used to look at effect of operational variables

- **Changes in vehicle lifespan**
- **Variations in fuel costs**
- **Changes in incremental cost**
- **Changes in operating cost**

Section 1 - Project and Investment Type Selection

	Cell Name	Select from List	Value
Project Type More info	Project_Type	1 = Vehicle & station (default)	1

1 = Vehicle and infrastructure investment
2 = Vehicle acquisition investment only

	Cell Name	Select from List	Value
Investment Type More info	Invest_Type	1 = Vehicle & station coupled (default)	1

1 = Coupled: Ties infrastructure investment to vehicle investment so they happen in the same year throughout the life of the project.
2 = Decoupled: Allows vehicle investment and infrastructure investment to be made in different years throughout the life of the project.

If you chose project type 2, then the investment type selection is ignored.

Section 2 - Tax Exemption Status

	Cell Name	Select from List	Value
Is your fleet tax exempt? More info	Tax_Status	Yes	Y

Note: Excise tax exemptions for diesel and gasoline = 0.38 \$/gal if you are a tax-exempt fleet.

Section 3 - Vehicle Data

Change the data in the yellow cells to reflect your individual fleet data and improve estimations.

Vehicle No.	Vehicle Type	Base fuel Used	Incremental Cost	Average VMT	Average Vehicle Life	Base Fuel Economy (MPG base fuel)	CNG Fuel Economy Loss	CNG Fuel Economy (mpGGE)	Realized Fed Vehicle Incentive	Hostlers or Attendants Needed
1	Transit Bus ^{A,C,G}	Diesel	\$50,502	35,286	15	3.4	7.6%	3.1	\$0	0
2	School Bus ^A	Diesel	\$31,376	12,000	15	7	12.5%	6.1	\$0	0
3	Trash Truck ^{A,C}	Diesel	\$30,295	25,000	12	2.8	10.5%	2.5	\$0	0
4	Para. Shuttle ^{A,B}	Gasoline	\$17,500	24,680	3.6	6.6	5.3%	6.3	\$0	0
5	Delivery Truck ^{A,D}	Gasoline	\$15,000	13,469	6.5	6.6	5.3%	6.3	\$0	0
6	Gasoline PU Truck ^A	Gasoline	\$10,000	13,401	7.4	13.9	5.3%	13.2	\$0	0
7	Gasoline Taxi ^{E,F}	Gasoline	\$8,000	56,000	7.4	16.5	5.3%	15.6	\$0	0

General Sources:

A: Alternative Fuel Data Center - <http://www.afdc.energy.gov/>

B: Transportation Energy Data Book, Edition 31, Table 4.33, Summary Statistics on Demand Response Vehicles

C: Transportation Energy Data Book, Edition 31, Table 5.1, Summary Statistics on Class 3-8 Single Unit Trucks

D: Transportation Energy Data Book, Edition 31, Table 4.3, Summary Statistics on Class 1, 2, 2b Trucks

E: Transportation Energy Data Book, Edition 31, Table 4.1, Summary Statistics for Cars

F: Public Transportation Fact Book 2011: http://www.apta.com/resources/statistics/Documents/FactBook/APTA_2011_Fact_Book.pdf

G: Report & - State of the Industry: U.S. Classes 3-8 Used Trucks, <http://www.actresearch.net/reports/usedtrucksample.pdf>

AAA: <http://newsroom.aaa.com/2012/04/cost-of-owning-and-operating-vehicle-in-u-s-increased-1-9-percent-according-to-aaa%E2%80%99s-2012-%E2%80%98your-driving-costs%E2%80%99-study/>

VICE 2.0 Model Inputs

Input your fleet information in the colored cells to evaluate the financial soundness of converting your fleet to compressed natural gas (CNG).

Input Cell Key

	Select project type, investment type, and tax status from dropdown list. (Required)
	Enter vehicle acquisition and infrastructure investment data. (Required)
	Enter vehicle data - infrastructure/fuels/operations/incentives. (Optional)*
	Calculated value. (Cannot be changed.)

* Changing defaults to match your operating parameters will enhance the accuracy of the results.

Seven vehicle types



Section 4 - Infrastructure, Fuels, Operations, and Incentives

Infrastructure	Cell Name	Value	Unit	Default
CNG Station Salvage Value	<i>CNG_Station_Salv</i>	20%	% of original price	20%
Monthly Cost of Hostler	<i>Hostler_Cost</i>	\$0.00	\$/month	\$4,167
Infrastructure tax credit rate	<i>infra_tax_credit_rate</i>	0%	percent	0%
Infrastructure tax credit cap	<i>infra_tax_credit_cap</i>	\$30,000	\$	\$30,000
realized infrastructure tax credit	<i>infra_tax_credit_realized</i>	\$0	\$	Calculated
Fuels				
Alt Fuel Excise Tax Credit	<i>Excise_Tax_Credit</i>	\$0.00	\$/GGE	\$0.00
Realized Alt Fuel Excise Tax Credit	<i>Realized_Excise_Tax_Credit</i>	\$0.000	\$/GGE	Calculated
Price of CNG (per GGE)	<i>CNG_Price</i>	\$1.18	\$/GGE	\$1.18
CNG Price Increase	<i>CNG_Inflation</i>	1.8%	% per year	1.8%
CNG Lifecycle Greenhouse Gas Factor (per GGE)	<i>CNG_GHG</i>	22.5	lbs/GGE	22.5 lbs
Diesel Fuel Price	<i>Diesel_Price</i>	\$3.91	\$/gallon	\$3.91
Diesel Price Increase	<i>Diesel_Inflation</i>	2.9%	%/year	2.9%
Federal Diesel Excise Tax	<i>Fed_Diesel_tax</i>	\$0.244	\$ per gallon	\$0.244
State Diesel Excise Tax	<i>State_Diesel_Tax</i>	\$0.244	\$ per gallon	\$0.243
Realized Diesel Excise Tax Exemption	<i>Diesel_tax_exempt</i>	\$0.488	\$ per gallon	Calculated
DGE/GGE Conversion factor	<i>GGE_DGE_Conv</i>	0.904	DGEs per GGE	0.904
Diesel Lifecycle Greenhouse Gas Factor (per GGE)	<i>Diesel_GHG</i>	25.4	lbs/GGE	25.4 lbs
Gasoline Fuel Price	<i>Gasoline_Price</i>	\$3.45	\$/gallon	\$3.450
Gasoline Price Increase	<i>Gasoline_Inflation</i>	2.5%	%/year	2.5%
Federal Gasoline Excise Tax	<i>Fed_Gas_tax</i>	\$0.184	\$ per gallon	\$0.184
State Gasoline Excise Tax	<i>State_Gas_Tax</i>	\$0.235	\$ per gallon	\$0.235
Realized Gasoline Excise Tax Exemption	<i>Gasoline_Tax_Exemption</i>	\$0.419	\$ per gallon	Calculated
Gasoline Lifecycle Greenhouse Gas Factor (per GGE)	<i>Gasoline_GHG</i>	24.8	lbs/GGE	24.8 lbs
Operations				
CNG Vehicle Maintenance Costs	<i>CNG_Diesel_Maint_Costs</i>	\$0.52	\$/mile	\$0.52
Diesel Vehicle Maintenance	<i>Diesel_Maint</i>	\$0.52	\$/mile	\$0.52
Total Number of Vehicles	<i>No_Vehicles</i>	50	Vehicles	Calculated
LDV Gasoline Vehicle Maintenance ^{AAA}	<i>Gasoline_Maint</i>	\$0.047	\$/mile	\$0.047
LDV CNG Vehicle Maintenance Costs	<i>CNG_LDV_Maint_Costs</i>	\$0.047	\$/mile	\$0.047
Incentives				
Required Rate of Return / Nominal Discount Rate	<i>Required_ROR</i>	6.000%	%	6.00%
Federal Vehicle Tax Incentive	<i>Tax_Incentive</i>	0.00%	% of Inc_Cost	0%
Realized Fed Veh Incentive	<i>Total_Realized_Incentive</i>	\$0	\$	Calculated
Post-Incentive Incremental Cost	<i>Total_Inc_Cost</i>	\$2,525,100	\$	Calculated

Base Case Parameters

- Numerous data sources
 - Most published, a few from interviews
 - multiple sources averaged
- Common starting point
- Links provided for updating



No individual or total vehicle limits

Vehicle quantities and investments can be made at any time in 20 year project timeline

Section 5 - Vehicle Acquisition Matrix Vehicle type, number of vehicles, and desired project year must be entered.

Enter the number of vehicles of each specific type to be purchased in years 0 through 20.

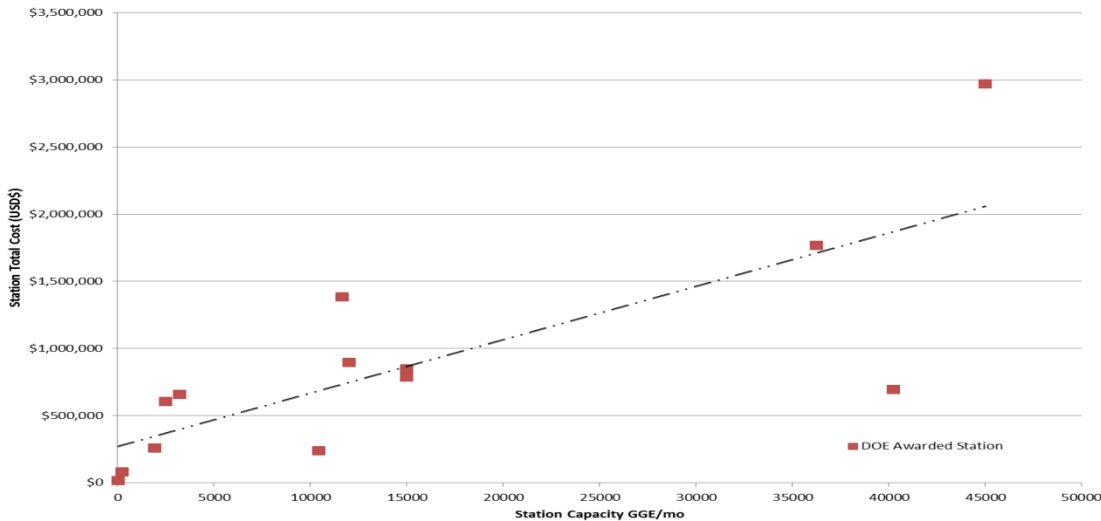
Project Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Total Vehicles	
Vehicle Type																							
No_Transit_Buses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
No_School_Buses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
No_Trash_Trucks	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
No_Para_Shuttle	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
No_Delivery_Truck	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
No_Pickup_Trucks	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
No_Taxis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Vehicle Investments	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Section 6 - Station Investment Matrix Only fill in if you chose project type 1 (vehicle and station) and investment type 1 (coupled) in Section 1.

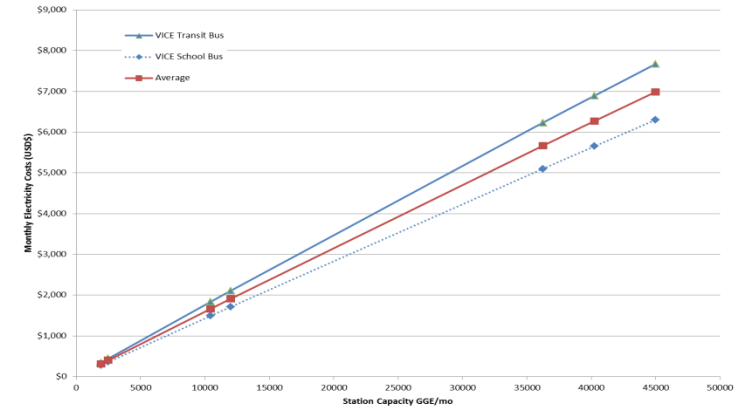
Project Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20		
Station Investment Input ¹ (\$)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Station Investment Calculated ² (\$)	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0

- 20 year project life
- Input matrices for both vehicle acquisitions and infrastructure investment

**CNG Station Cost Comparison
Station Cost Vs. Station Capacity (GGE/mo)**



**CNG Fast Fill Station Cost Comparison
VICE Predictions Monthly Electricity Costs**



- Cost versus throughput from DOE awarded stations
- Utility costs based on throughput
- Fleet composition and operation determines throughput

VICE 2.0 Results

Project/investment type: Combined vehicle and infrastructure investment (coupled)

Business Case Results Summary	
Net Present Value	\$14,261,317
Payback Period (yrs)	5.79
Simple Payback Period (yrs)	5.13

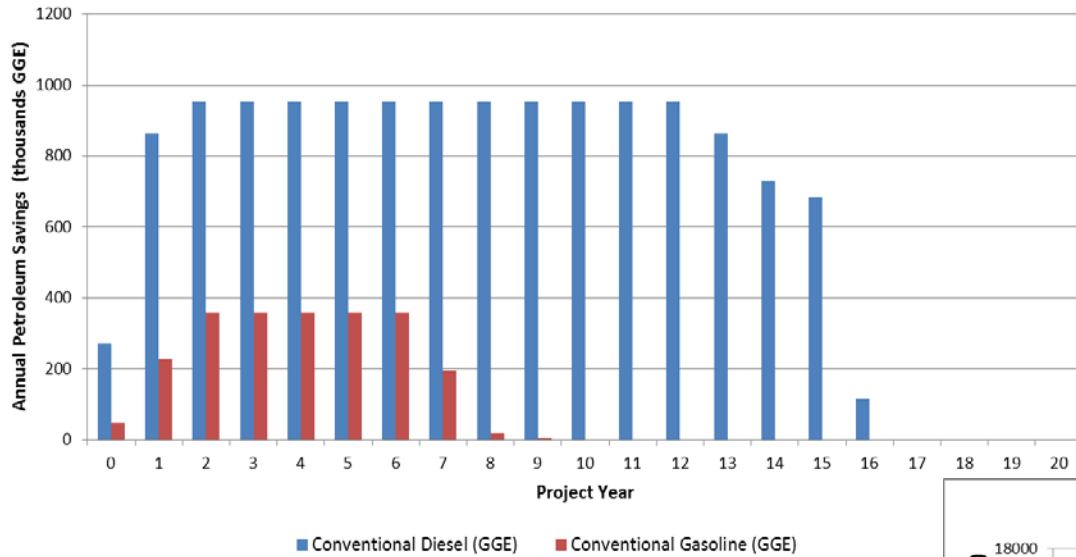
Petroleum and Greenhouse Gas Reduction Summary	
Displaced Diesel (GGEs)	15,497,557
Displaced Gasoline (GGEs)	2,291,604
Total Petroleum Displacement (GGEs)	17,789,161
Project Lifetime GHG Displaced (tons)	188,968

Vehicle Types	Vehicles Acquired	Total Incremental Cost (\$)
Transit Bus	66	\$3,333,132
School Bus	0	\$0
Trash Truck	30	\$908,850
Para. Shuttle	0	\$0
Delivery Truck	120	\$1,800,000
Gasoline PU Truck	30	\$300,000
Gasoline Taxi	25	\$200,000
		\$6,541,982
Total Infrastructure Investment (\$)	\$5,529,315	

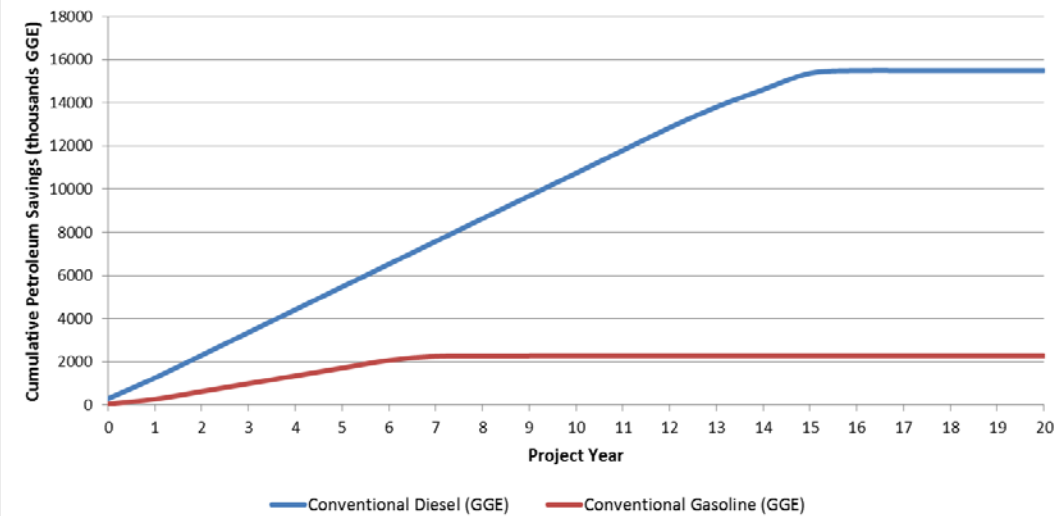
VICE 2.0 Results & Visualizations



CNG Project Annual Petroleum Savings (GGEs)



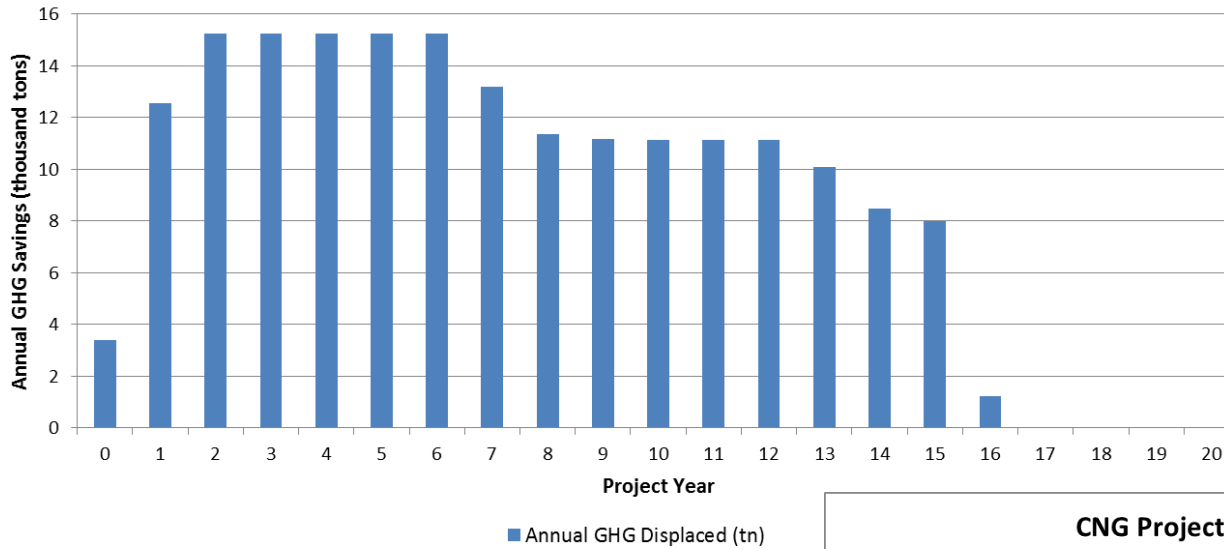
CNG Project Cumulative Petroleum Savings (GGEs)



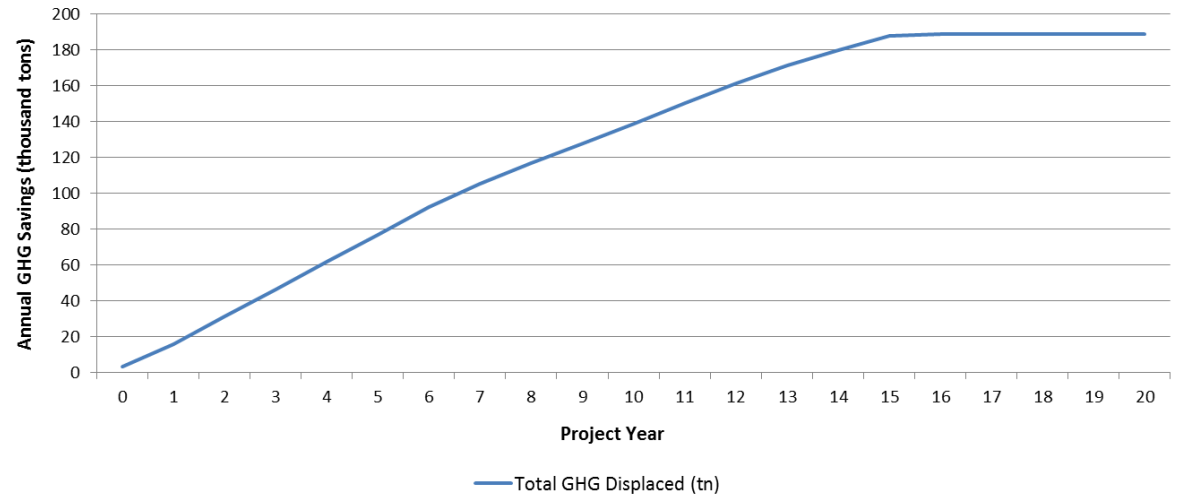
VICE 2.0 Results & Visualizations



CNG Project Annual Lifecycle GHG Savings (thousand tons)



CNG Project Total Lifecycle GHG Savings (thousand tons)



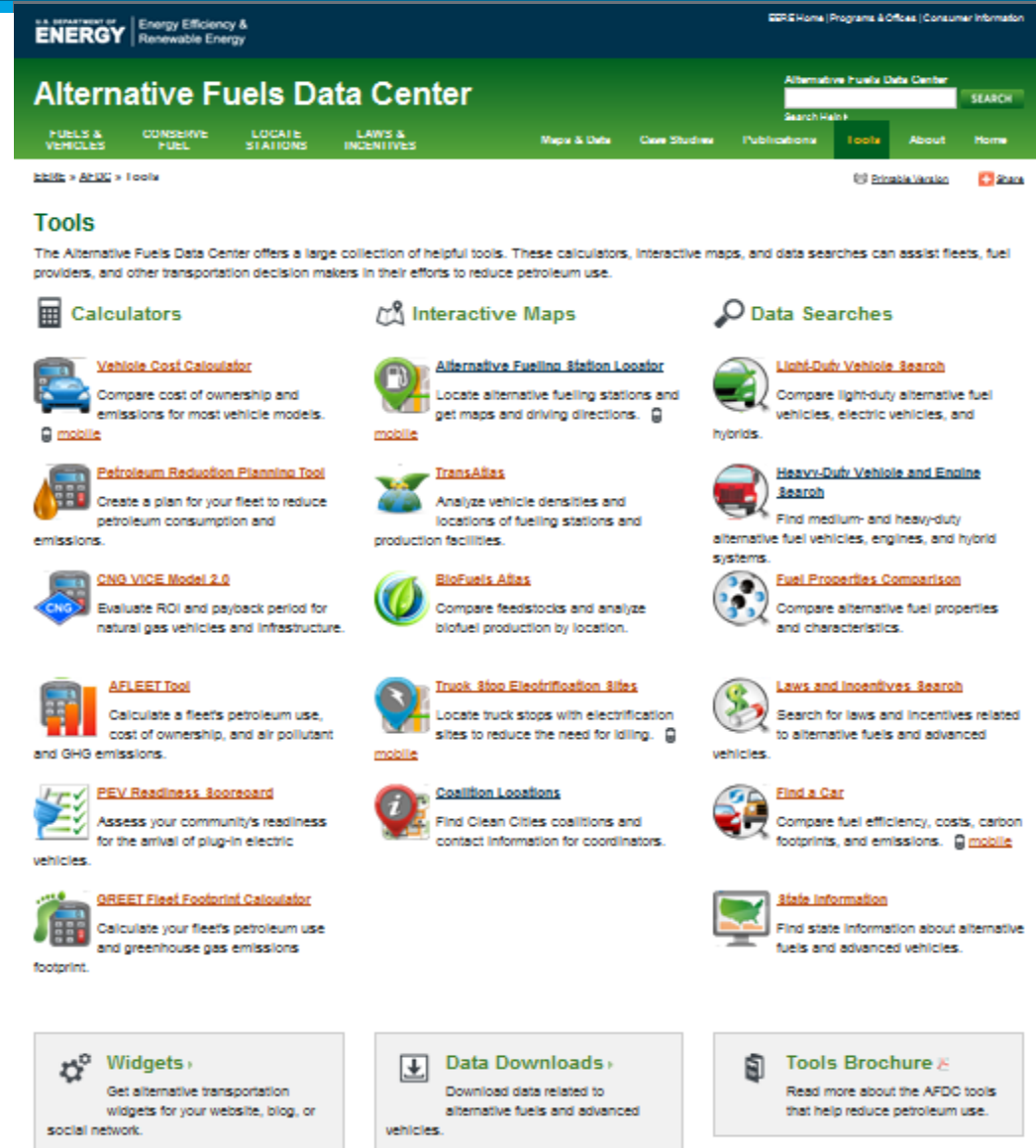
- Second generation of NREL's successful Vehicle and Infrastructure Cash-flow Evaluation model
- Allows fleet managers to assess the financial soundness of potentially converting their fleet to operate on CNG
- Allows comparison between different acquisition and investment strategies
- Tailor vehicle fleet to represent what you have
- Customizable to reflect your local operating environment
- Visualizations of cash-flow, fuel availability and use and GHG savings

Available at: http://www.afdc.energy.gov/fuels/natural_gas_stations.html

- Alternative fuels and vehicles
- Fuel conservation
- Station locator
- Laws & Incentives
- Maps & Data
- Case studies
- Tools

The screenshot shows the homepage of the Alternative Fuels Data Center (AFDC). At the top, it features the U.S. Department of Energy logo and the text "Energy Efficiency & Renewable Energy". The main header is "Alternative Fuels Data Center" with a search bar and navigation links for "FUELS & VEHICLES", "CONSERVATIVE FUEL", "LOCATE STATIONS", "LAWS & INCENTIVES", "Maps & Data", "Case Studies", "Publications", "Tools", and "About". Below the header, there are several sections: "Fuels & Vehicles" with icons for Biodiesel, Electricity, Ethanol, Hydrogen, Natural Gas, and Propane; "Maps & Data" with a "Fuel Prices" chart and a list of links; "Tools" with a "Station Locator" map and a list of tools; and a "Poll" section with a list of interests. At the bottom, there is a "Find State Information" section with a dropdown menu and a "GO" button, and a "YouTube" logo.

- Light- and Heavy-duty vehicle search tools
- Vehicle cost of ownership
- VICE 2.0
- Station locator



The screenshot shows the homepage of the Alternative Fuels Data Center, a website managed by the U.S. Department of Energy. The page features a green header with the title "Alternative Fuels Data Center" and a search bar. Below the header, there are navigation tabs for "FUELS & VEHICLES", "CONSERVATIVE FUEL", "LOCATE STATIONS", and "LAWS & INCENTIVES". The main content area is titled "Tools" and is organized into three columns: "Calculators", "Interactive Maps", and "Data Searches". Each column contains several tool cards with icons and brief descriptions. At the bottom of the page, there are three additional sections: "Widgets", "Data Downloads", and "Tools Brochure".

Calculators

- Vehicle Cost Calculator**: Compare cost of ownership and emissions for most vehicle models. [mobile](#)
- Petroleum Reduction Planning Tool**: Create a plan for your fleet to reduce petroleum consumption and emissions.
- CNG VICE Model 2.0**: Evaluate ROI and payback period for natural gas vehicles and infrastructure.
- AFLEET Tool**: Calculate a fleet's petroleum use, cost of ownership, and air pollutant and GHG emissions.
- PEV Readiness Scorecard**: Assess your community's readiness for the arrival of plug-in electric vehicles.
- GREET Fleet Footprint Calculator**: Calculate your fleet's petroleum use and greenhouse gas emissions footprint.

Interactive Maps

- Alternative Fueling Station Locator**: Locate alternative fueling stations and get maps and driving directions. [mobile](#)
- TransAtlas**: Analyze vehicle densities and locations of fueling stations and production facilities.
- BioFuels Atlas**: Compare feedstocks and analyze biofuel production by location.
- Truck Stop Electrification Sites**: Locate truck stops with electrification sites to reduce the need for idling. [mobile](#)
- Coalition Locations**: Find Clean Cities coalitions and contact information for coordinators.

Data Searches

- Light-Duty Vehicle Search**: Compare light-duty alternative fuel vehicles, electric vehicles, and hybrids.
- Heavy-Duty Vehicle and Engine Search**: Find medium- and heavy-duty alternative fuel vehicles, engines, and hybrid systems.
- Fuel Properties Comparison**: Compare alternative fuel properties and characteristics.
- Laws and Incentives Search**: Search for laws and incentives related to alternative fuels and advanced vehicles.
- Find a Car**: Compare fuel efficiency, costs, carbon footprints, and emissions. [mobile](#)
- State Information**: Find state information about alternative fuels and advanced vehicles.

Widgets: Get alternative transportation widgets for your website, blog, or social network.

Data Downloads: Download data related to alternative fuels and advanced vehicles.

Tools Brochure: Read more about the AFDC tools that help reduce petroleum use.

Thank You

Questions;

George Mitchell

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