



# Alternative fuels for school transportation

## A fuel-agnostic review of the options

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and guests



# What do we need to talk about?

- Why alternative fuels
- What is available
- Potential benefits
- Barriers
- Answers you need to know



# Even with the obstacles . . .

- Cleveland – propane buses
  - Canton City – CNG buses
  - Columbus City – diesel electric hybrids
  - Austintown – propane buses
- And others . . .



# Fuel options

- Diesel
- Diesel electric hybrid
- All electric
- Propane
- CNG
- LNG
- Bio-diesel (different %'s)
- Gasoline
- Hydraulic hybrid



# Comparing fuels

- Different fuels provide differing amounts of energy, expressed in BTUs/unit
- As a result, it is important to determine an equivalent volume to compare pricing

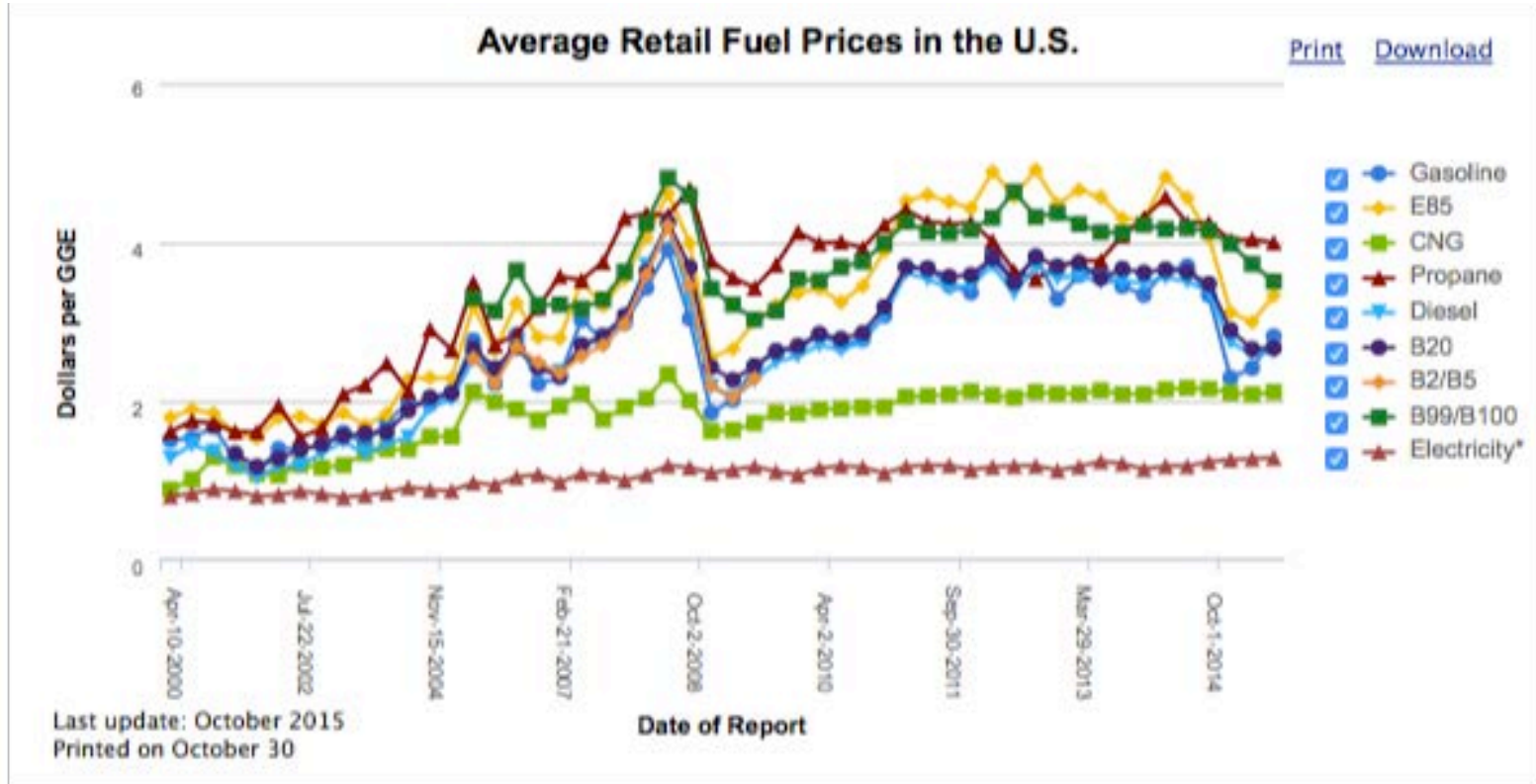


# Gasoline gallon equivalent

Fuel Type	Unit of measure	BTU's/unit	Gallon Equivalent
Gasoline	Gallon	114,100	1.00 gal
Diesel #2	Gallon	129,500	0.88 gal
CNG	Cubic foot	900	126.66 cu. Ft.
LNG	Gallon	75,000	1.52 gal
Propane	Gallon	84,300	1.35 gal



# Fuel prices – last 14 years





[www.afdc.energy.gov/fuels/prices.html](http://www.afdc.energy.gov/fuels/prices.html)

National Average Price Between July 1 and July 15, 2015	
Fuel	Price
Biodiesel (B20)	\$2.93/gallon
Biodiesel (B99-B100)	\$3.55/gallon
Electricity	\$0.12/kWh
Ethanol (E85)	\$2.36/gallon
Natural Gas (CNG)	\$2.12/GGE
Propane	\$2.90/gallon
Gasoline	\$2.82/gallon
Diesel	\$2.93/gallon

Source: [Alternative Fuel Price Report, July 2015](#) and [U.S. Energy Information Administration](#)





# October '15 pricing for GGE

Fuel	Price/gal	GGE factor	GGE
Gasoline	2.82	1	2.82
Diesel	2.93	.88	2.578
CNG			2.12
LNG	Not available		
Propane	2.90	1.35	3.915

Source: Alternative Fuel Price Report, July 2015  
U.S. Energy Information Administration



# Fuel availability

## Fueling Stations

**484** [stations in Ohio](#) with alternative fuels

Fuel	Public	Private
<a href="#">Biodiesel (B20 and above)</a>	6	6
<a href="#">Compressed Natural Gas (CNG)</a>	36	16
<a href="#">Electric</a>	137	43
<a href="#">Ethanol (E85)</a>	126	9
<a href="#">Hydrogen</a>	0	1
<a href="#">Liquefied Natural Gas (LNG)</a>	3	0
<a href="#">Propane (LPG)</a>	93	8

[Data Download](#) ▶



# Fuel Station Map

## Alternative Fueling Station Locator

Find alternative fueling stations near an address or ZIP code or along a route in the United States. Enter a state to see a station count.

**Find Stations** | **Plan a Route**

Q Ohio

All Fuels

[more search options](#)

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**401**  
alternative fuel stations  
in Ohio

Excluding private stations

[Download spreadsheet of matching stations](#)

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Location details are subject to change. We recommend calling the stations to verify location, hours of operation, and access.

**Legend**

- Biodiesel
- CNG
- Electric
- Ethanol
- Hydrogen
- LNG
- Propane

Map data ©2015 Google [Terms of Use](#)



# National Renewable Energy Lab

- NREL.gov
- Research on fleet DNA
  - Understand the duty cycle of your vehicles
  - Consider the right fuel for your duty cycle



# NREL school bus DNA

- Average speed 20-30 mph
- Average stops / mile 1.4
- Average operating hrs. 3-5 per day
- Average daily miles 50-80
  
- Summary: average route is High kinetic energy – (low speed, lots of starts and stops)



# If you like the data approach:

- NREL has a software package for you
  - DRIVE analysis tool
  - Fleet managers can use the tool to make educated investment decisions by determining in advance the payback period for given technology
- Available for 30-day trial at no cost, or receive software free via a collaborative data-sharing agreement
  - Contact Adam Duran at [adam.duran@nrel.gov](mailto:adam.duran@nrel.gov)



# Answers you need to know

- Engine maintenance
- Mechanics training
- Driver training
- Maintenance facility upgrades
- Pollution
- Driveability
  - power and driver feel
- Fuel range
- Fueling needs
- Supply dependability
- Pricing per diesel gallon equivalent
- Fuel taxes
- Grants
- Service options



# Literature review-page 1

- School Transportation News March '12
  - Kansas City Schools – 165 CNG buses
    - Adds 3000-5000 miles between oil changes
    - Reduces maintenance expense
    - Tank inspections every 3 yrs., replace at 15
  - Napa Valley public- 37 cng, 8 biofuel, 5 hybrids
    - CNG's have 200,000 miles on them, still strong
  - Jefferson County, Kentucky – 50 hybrid
    - Battery pack life 7-8 years, \$10-12K replacement





# Literature review-page 2

- Zeeland, Michigan propane & biodiesel
  - Propane uses  $\frac{1}{2}$  as much oil, runs very clean
- Mesa Arizona –propane buses
  - Less frequent oil changes
  - Very clean running
  - Gasoline block, simpler to work on
  - No exhaust after treatment parts or filters



# Literature review-page 3

- School Transportation News July '13
  - 1% of buses nationwide are alternative fuel
  - 4 primary options:
    - Propane
    - CNG
    - Hybrid
    - Plug-in electric
  - 250,000 vehicles in U.S. are propane, school buses are just a small portion of that total.
    - Propane is the most popular of the alternative fuels
    - This is a marked change from 15 years ago – when propane was not popular
    - Now--liquid propane injection, cleaner, better mileage, fueling infrastructure is easier



# Literature review-page 4

- Mesa Public schools (Phoenix) moving to 100% propane, currently at 89 buses
  - Projects 4.43 million savings over 5 years
- Other fleets using propane:
  - Dallas County
  - Los Angeles Unified
  - Omaha
  - Portland
  - Seattle



# Literature review-page 5

- Jordan Public (near Salt Lake) CNG buses
  - Reports early CNG buses were slow and underpowered
  - New CNG buses are as good or better than diesel
- Thomas Bus Body rolling out Cummins Westport ISB 6.7 on the C2 model bus
  - Already running CNG in HDX (rear engine bus)
- CNG has lower fuel cost, but more difficult infrastructure development



# Literature review-page 6

- Electric and Electric hybrid vehicles
  - Mostly in the automotive market
- Maximum of 1000 hybrid buses nationwide
  - International
  - Thomas Built
- Transtech working on 100% electric plug in bus
  - 60 mph
  - 120-130 mile range
  - 6-8 hour charge
  - Only smaller size buses



# Literature review-page 7

- School Transportation News July '13
  - Cleveland, Ohio orders 49 propane buses
  - 12% of new school buses sold are propane powered
    - Type A and C buses
  - Blue Bird and Roush study of Student Transp. Inc.
    - Switch to 435 propane buses for Omaha schools
    - Results in 50% fuel savings compared to diesel
    - Significant decrease in Carbon Dioxide in exhaust
    - Better cold weather start-ability
    - Reduced maintenance costs
  - Napa Valley runs 42 CNG buses – very clean oil
  - Houston Texas, 90 propane buses – very clean oil



# Literature review-page 8

- School Bus Fleet June 2015
  - “Making the business case for alternative fuels” (CNG & propane)
    - Even with diesel and gas costs down, there is still an advantage
    - fuel and maintenance savings
  - Hurdles to alternative fuels
    - Higher purchase price
    - Infrastructure
  - CNG fuel cost savings generates payback in 8-9 years
    - With bus life of 12-15 years, yields savings beyond payback.
  - For either fuel type, more important to look at total cost of ownership
    - Fuel costs, maintenance costs, repair cycle and downtime, air quality



# Literature review-page 9

- Crittenden County, Kentucky
  - Reports 23 cents / mile for alternative fuel
  - Reports 56 cents / mile for diesel fuel
- Propane maintenance
  - Districts report 1/3 less oil used, cheaper filters
- For both CNG and propane:
  - No exhaust after treatment (compared to diesel engines)
  - Cold weather startup is better – no block heaters required
- Propane incremental purchase cost around \$5,000
- CNG incremental purchase cost around \$40,000





# Some final facts:

- Fueling infrastructure
  - Propane is easier
    - Can be installed on a skid pad including pumps and tank
  - CNG requires another consideration
    - Slow fill
      - Buses fill overnight at low pressure, less labor involved, better fill %
    - Fast fill
      - Expensive, requires major installation, 10 minute fill, requires labor
  - For both fuels, there are industry partners
- Repair facility (bus garage)
  - Both fuels need building code attention
  - Propane settles, CNG rises
  - Lack of clarity or uniformity with building codes
  - Consultants are available to evaluate buildings
  - Generally speaking, propane is easier to accommodate without changes



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