

Alternative Lift Truck Technologies

Sponsored by:



Presented by:

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Industrial Truck Association (ITA)

Class 1: Electric Counterbalance (Cushion or Pneumatic Tire)

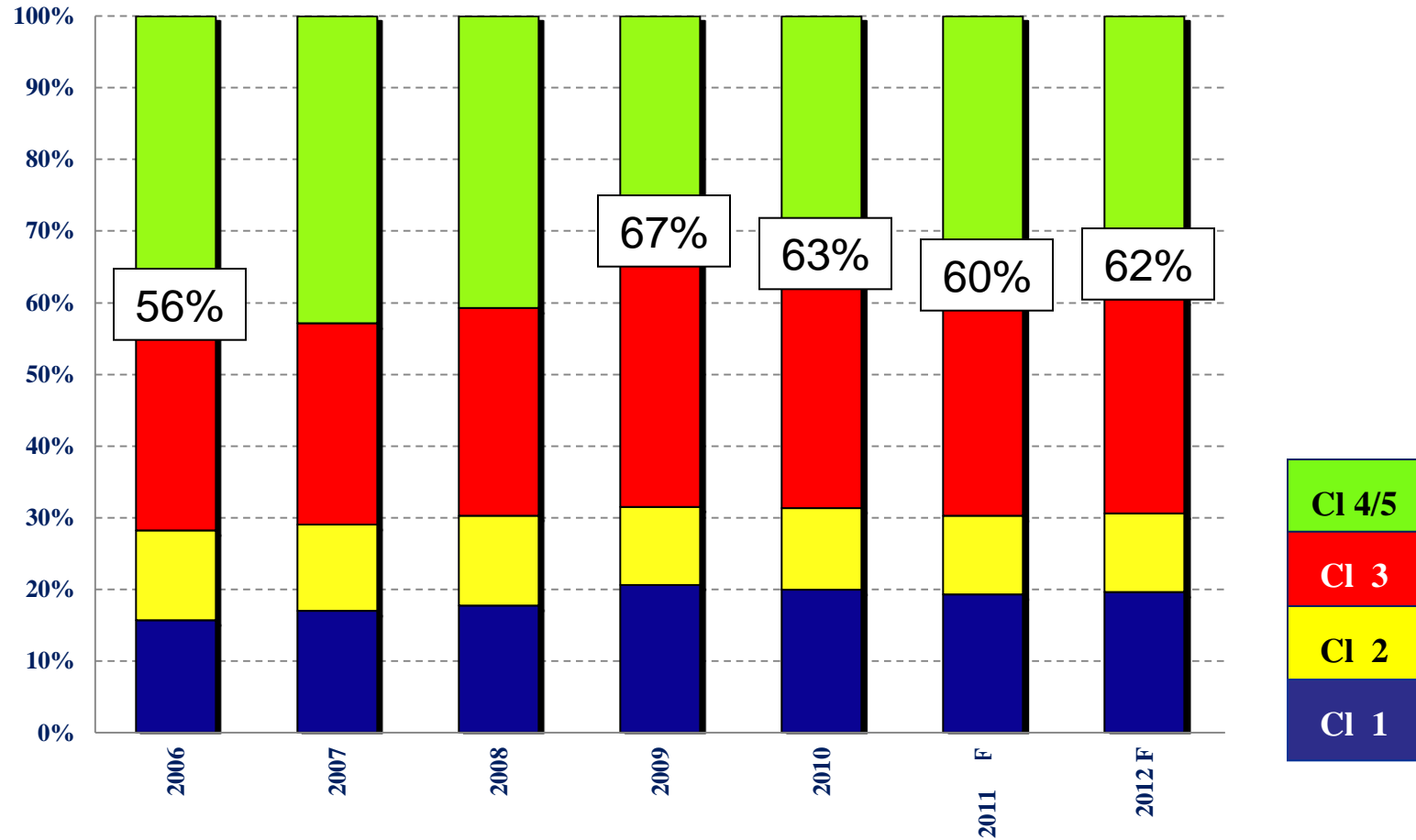
Class 2: Electric Narrow Aisle

Class 3: Electric Pallet Jacks

Class 4: Internal Combustion, Cushion Tire Counterbalance

Class 5: Internal Combustion, Pneumatic Tire Counterbalance

ITA Retail Orders (US,CAN,MX)



Fuel Choices by Class

Class 1: Lead Acid Battery & Charger → Fuel Cell

Class 2: Lead Acid Battery & Charger → Fuel Cell

Class 3: Lead Acid Battery & Charger → Fuel Cell

98+% Lead Acid Battery & Charger

**1%
FC**

Class 4: LP, Diesel, Gas → Electric, CNG, Fuel Cell

Class 5: LP, Diesel, Gas → Electric, CNG, Fuel Cell

85+% Liquid Propane

12% Diesel

1% CNG

Total Cost of Ownership Evaluation Sources

Energy Consumption Profiles & Energy Prices

US Dept of Energy

EIA
Energy Information
Administration

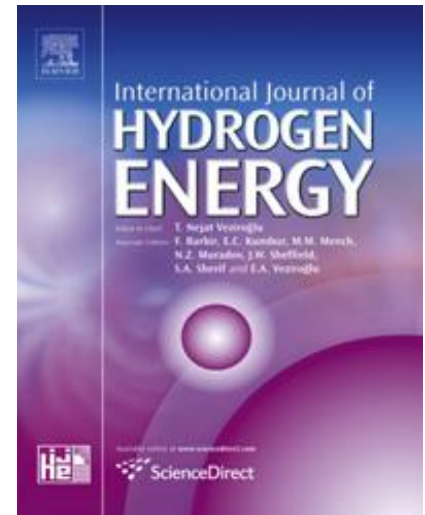
**Int'l Journal of H2 Energy
& Center for H2 Research**

The screenshot shows the EIA website's 'ANNUAL ENERGY OUTLOOK 2012' page. The header includes the EIA logo and navigation links for 'Sources & Uses', 'Topics', and 'Geography'. A search bar is present on the right. The main content area features a dropdown menu for 'DATA' with options for 'Reference Case', 'Side Cases', and 'Interactive Table Viewer'. Below this is a section for the 'Annual Energy Outlook 2012' report, which includes a cover image and a link to 'Download the complete June 2012 published report.' To the right, there are two sidebars: 'Analysis - By Topic' with categories like Energy Sources, Sectors, and Other Topics; and 'By Publication Chapter' with links to various report sections like Executive Summary and Market Trends. A 'Reference Case Tables' section is visible at the bottom right.

Additional Sources

Energy Consumption & Prices

& Leading Lift Truck OEM's



Environmental Evaluation Model



ARGONNE'S
GREET.net beta
TAKING LIFE CYCLE ANALYSIS TO THE NEXT LEVEL
A fresh design for GREET life cycle analysis tool

Evaluation of Liquid Propane

LP Attractions:

- Low initial investment
 - Little to no fueling infrastructure
- Highly Flexible
 - Add / remove additional units
 - Pay for fuel as you go

Evaluation of Liquid Propane

Also included with LP:

- Additional energy consumption for fresh air ventilation
- Injuries associated with carbon monoxide emissions / tank changes = lost productivity
- Dangers with tank storage

LP - Total Cost of Ownership Comparison

LP Total Cost of Ownership over 60 months

Price per gallon	\$4.00	\$4,125	\$29,400	\$52,641	\$81,027
	\$3.00	\$675	\$19,125	\$35,440	\$53,504
	\$2.00	(\$2,750)	\$8,775	\$18,238	\$25,981
	\$1.00	(\$6,200)	(\$1,575)	\$1,036	(\$1,542)
		500	1,500	2,500	4,000
	Annual Hours				

LP Environmental Evaluation



REET Fleet Footprint Calculator

Home | On-road Vehicles | Off-road Vehicles | **Results** | Assumptions | Specs | About

Select how the results will be displayed.

All | **Graph**
On-Road | Text
Off-Road | Detail

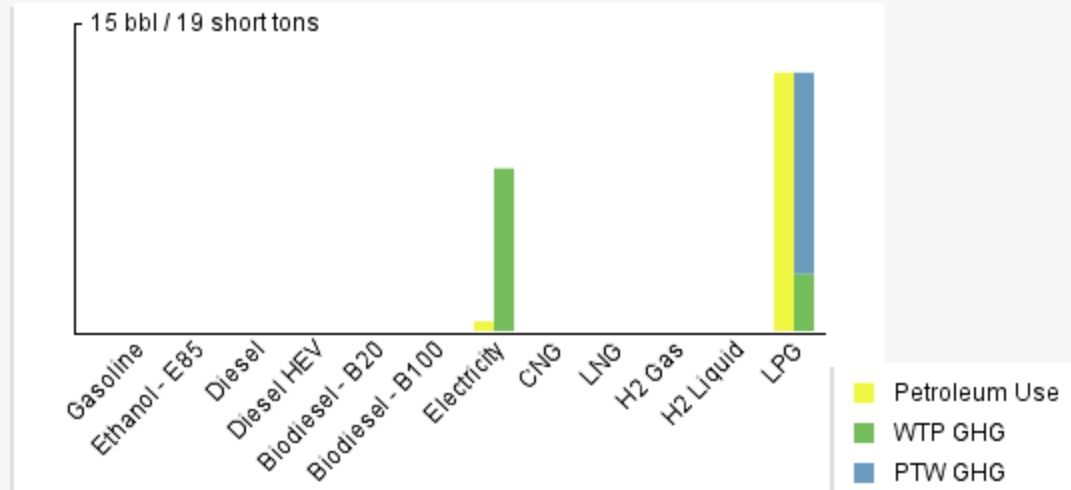
Off-road Petroleum Use

13 bbl

Off-road GHG Emissions

25 short tons

Results by: **Vehicle** | Fuel



WTP = Well to Pump
PTW = Pump to Wheels
WTW = Well to Wheels

Evaluation of CNG

CNG Attractions:

- Lowest emissions of IC fuel offerings
 - 60%-80% cleaner than LP
- 30-40% Lower energy cost per gallon versus LP
- Significant reserves = reduced price volatility
- Safer operation / no tank changes
- Grants ?
 - Not currently available for non-road vehicles

Evaluation of CNG

Also included with CNG:

- 5-15% reduction in performance resulting from lower energy density
 - Refueling usually required within a 8 hour shift
- Additional capital requirements for truck conversion
 - Reported to be \$6,500 per truck
- Special infrastructure requirements and system maintenance.
 - \$30,000 - \$40,000 Infrastructure to support up to 30 trucks per NGV.
- Only 1 Major Lift Truck OEM currently offering CNG approved system.
 - No longer available as aftermarket option as a result of 1997 EPA act 1A.

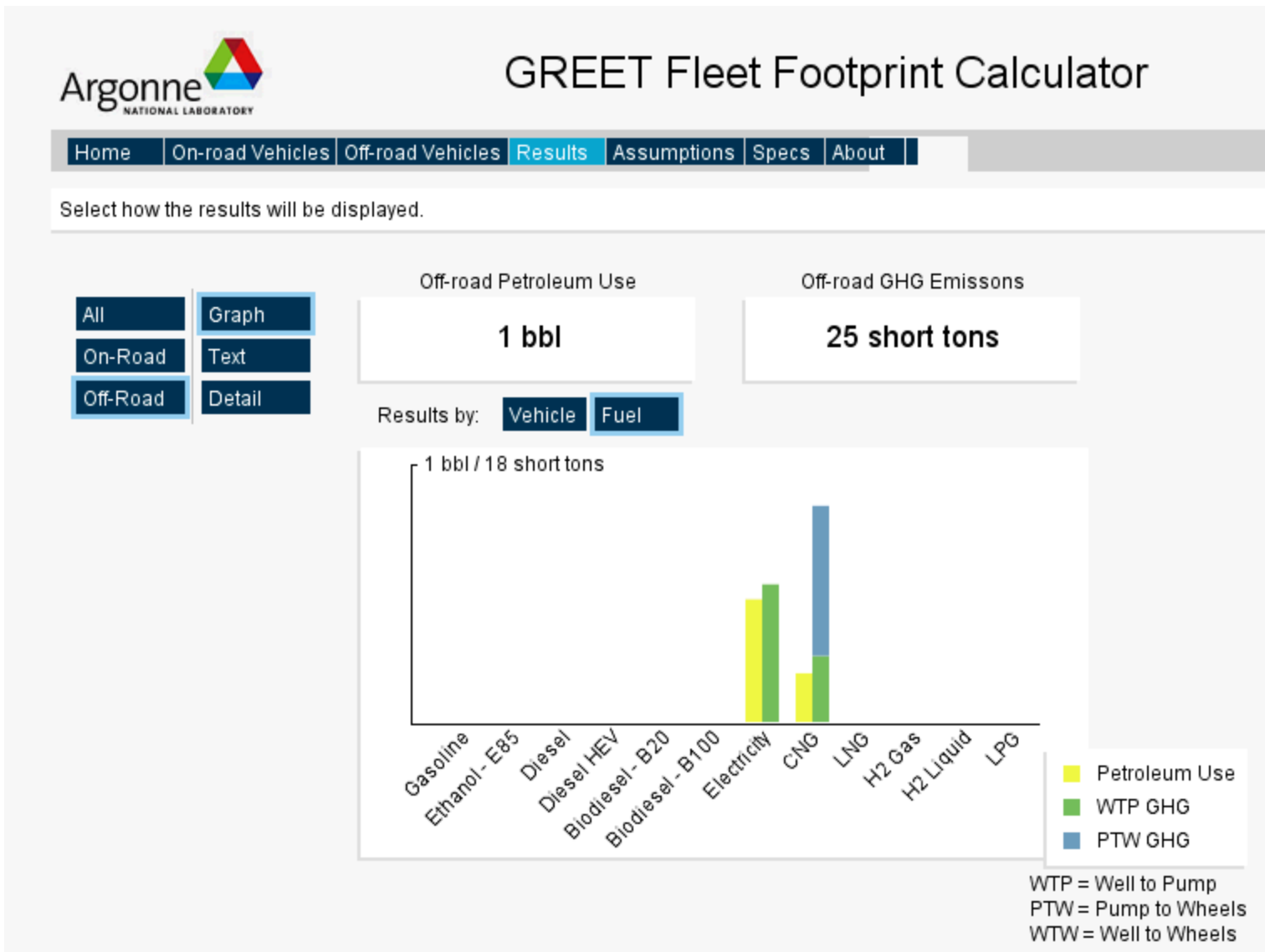
CNG- Total Cost of Ownership Comparison

CNG Total Cost of Ownership over 60 months

Price per GGE	\$2.00	\$3,479	\$14,436	\$23,394	\$31,830
	\$1.50	\$1,759	\$9,276	\$14,793	\$18,609
	\$1.00	\$38	\$4,115	\$6,192	\$4,307
		500	1,500	2,500	4,000
		Annual Hours			

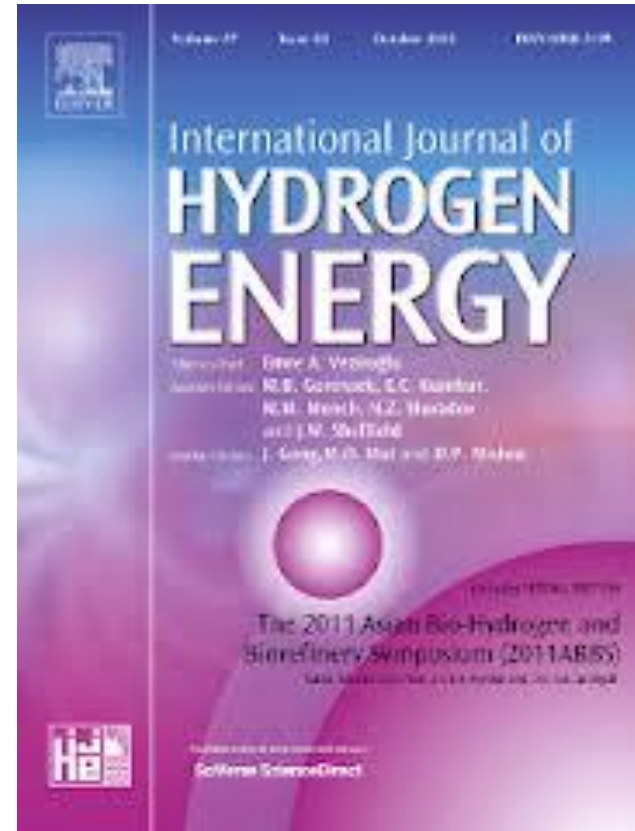


CNG - Environmental Evaluation Model



Evaluation of Hydrogen Fuel Cells

- H2 Attractions:**
Also included with H2:
- Zero plant level emissions
 - ~~Specialized Equipment/ changing Infrastructure~~
 - Low refuel times 2-3 minutes in most cases
 - Tend to work best in moderate applications due to limited kW offerings.
 - Govn't subsidies ?
 - Significant capital investment



H2 - Total Cost of Ownership

“Economic Modeling Parameters”

Cost Item Truck	HFC Lift Truck	15KW FC Lift
Power plant	\$35,000	\$27,500
Replacement Pwr	\$11,000	\$4,500
Power plant life	5 years	3 years
Refueling	5 min	N/A
H2 Storage Unit Maint	\$13,186	N/A
H2 Storage Equip	\$220,101	N/A
H2 Storage Install	\$85,839	N/A
Forklift Charge Area	N/A	\$75,000
Battery room wages	\$0	\$0
Power plant Maint	\$500 / yr	15 min / week

H2 - Total Cost of Ownership

Energy Usage / Efficiency

Cost Item	HFC Lift Truck	FC Lift Truck
Electricity Cost		\$.09 / kWh
Demand Charge		\$6.89 / KW
AC – DC Charge Efficiency		80%
Battery Energy Consumption		61 kWh / 8 hr
Energy cost per shift		\$5.49 / shift
H2 Cost	\$16.25 / Kg	
H2 Consumption	1.75 Kg / 8 hr	
H2 to DC Fuel Cell Efficiency	69%	
Energy cost per Shift	\$28.43 / shift	

H2 - Total Cost of Ownership Summary

- Fast charging at 15kW proved to be the most cost effective technology when operating between 1-2 shifts per day
- For applications greater than 2 shifts the 30 kW fast charge system proved to be the most cost effective technology.



H2 Environmental Evaluation Model



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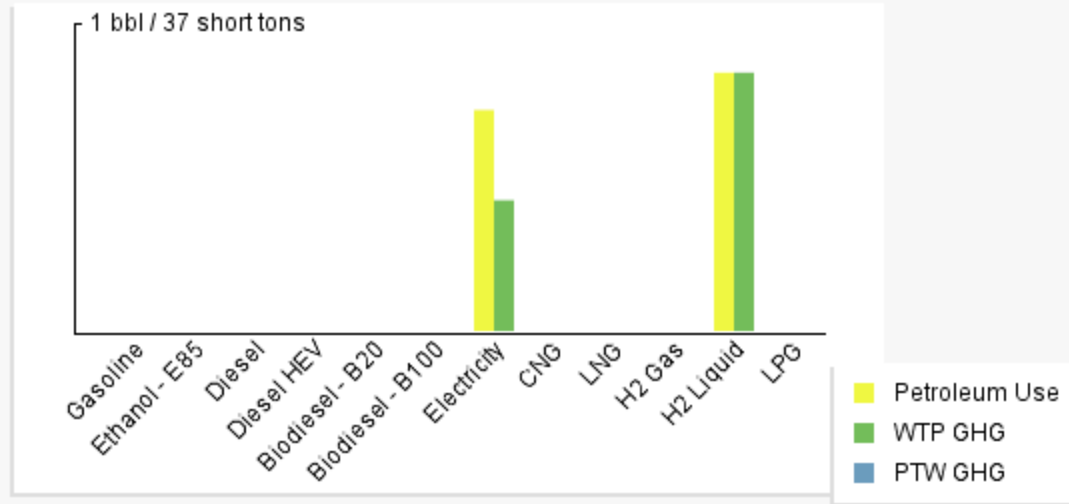
Off-road Petroleum Use

2 bbl

Off-road GHG Emissions

46 short tons

Results by: **Vehicle** | **Fuel**



WTP = Well to Pump
PTW = Pump to Wheels
WTW = Well to Wheels

The Choice is Yours

CONSIDER:

- Environmental Impact
 - Total “Well-to-Wheels” Emissions
- Total Cost of Ownership
 - Initial Purchase
 - Infrastructure
 - Energy Consumption

	Indoor	Outdoor	Low usage	High usage	Economical	Environmental	Proven
Liquid Propane		X	X	X			X
Fuel Cells	X			X		X	
CNG		X	X				
Diesel		X	X	X			X
Electric	X	X	X	X	X	X	X



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