U.S. Classes 3-8 Trucks

History at a Glance

Percent Mix 1946 – 2013 YTD

ACT Research Co., LLC, Copyright 2013
U.S. Class 8 Retail Sales
1996-2012

ACT Research Co., LLC: Copyright 2013
<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Cl 8 Truck Build</td>
<td>201,300</td>
<td>198,500</td>
<td>229,600</td>
</tr>
<tr>
<td>Does Not Include Transit Buses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NG %</td>
<td>~3%</td>
<td>~6%</td>
<td>~8%</td>
</tr>
<tr>
<td>Cl 8 + T. Bus Units</td>
<td>7,500</td>
<td>12,000</td>
<td>18-20,000</td>
</tr>
</tbody>
</table>
U.S. Freight Market Modal Share (2010 as a % of Revenues)

<table>
<thead>
<tr>
<th>Mode</th>
<th>2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trucking</td>
<td>81.4%</td>
</tr>
<tr>
<td>Rail Car</td>
<td>5.8%</td>
</tr>
<tr>
<td>I-Modal</td>
<td>2.7%</td>
</tr>
<tr>
<td>Other</td>
<td>10.1%</td>
</tr>
</tbody>
</table>

Source: American Trucking Association, ACT Research Co., LLC
EPA Emission Standards

- **PARTICULATE [g/HP-hr]**
  - 1994: 5.0
  - 1998: 4.0
  - 2002: 2.5
  - 2007: 1.2
  - 2010: 0.10

- **NOx / NOx+NMHC [g/HP-hr]**
  - 1994: 15 PPM
  - 1998: 500 PPM
  - 2002: 15 PPM
  - 2007: 15 PPM
  - 2010: 15 PPM

- **SULFUR**
  - 1994: 0.01
  - 1998: 0.2
  - 2002: 1.2
  - 2007: 2.5
  - 2010: 4.0
  - 2010: 5.0
Regulatory Considerations

- CSA (’11)
  - Productivity, liability, drivers

- EOBRs
  - 2015 seems likely
  - Productivity hit (eliminates log cheating)

- Hours of Service (July 1, ’12)
  - Keep 11 and 14 hours (for now)
  - NEW: 34 hour reset must include 2 overnights

- Advanced OBD (’13)
  - Last piece of the NOx, PM EPA puzzle

- CAFE/GHG Standards (’14, ’18)
  - Meaningful MPG improvement means short payback

- Electronic Stability Control
  - In proposed rulemaking phase
The Hypothesis

The North American commercial vehicle truck market will see a measured shift to the use of natural gas as a fuel for heavy duty class 8 vehicles, displacing currently used diesel fuel. In the next 1 to 2 decades, natural gas will become the fuel of choice for 50% of on-highway class 8 vehicles.
Source: Clean Energy Fuels
## Annual Fuel Cost Comparisons

<table>
<thead>
<tr>
<th></th>
<th>Diesel Fuel</th>
<th>Natural Gas @ 90% Efficiency (spark)</th>
<th>Natural Gas @ 85% Efficiency (spark)</th>
<th>Natural Gas @ 80% Efficiency (spark)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPG</td>
<td>6.0</td>
<td>5.4</td>
<td>5.1</td>
<td>4.8</td>
</tr>
<tr>
<td>Gallons of fuel required for 100,000 miles</td>
<td>16,667</td>
<td>18,519</td>
<td>19,608</td>
<td>20,833</td>
</tr>
<tr>
<td>Cost of fuel at $4.00 per gallon</td>
<td>$66,668</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Cost of natural gas fuel at $2.50 per gallon DGE</td>
<td></td>
<td>$46,298</td>
<td>$49,020</td>
<td>$52,083</td>
</tr>
<tr>
<td>DEF consumption in gallons</td>
<td>333.34</td>
<td>Not Required</td>
<td>Not Required</td>
<td>Not Required</td>
</tr>
<tr>
<td>DEF cost at $2.00 per gallon</td>
<td>$666.68</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Diesel particulate filter cleaning</td>
<td>$275.00</td>
<td>Not Required</td>
<td>Not Required</td>
<td>Not Required</td>
</tr>
<tr>
<td>Total fuel cost</td>
<td>$67,610</td>
<td>$46,298</td>
<td>$49,020</td>
<td>$52,083</td>
</tr>
<tr>
<td>Fuel cost savings</td>
<td>$21,312</td>
<td>$18,590</td>
<td>$15,527</td>
<td></td>
</tr>
<tr>
<td>Five year savings</td>
<td>$106,560</td>
<td>$92,950</td>
<td>$77,635</td>
<td></td>
</tr>
</tbody>
</table>
## Truck Fuel Payback Calculators

### Diesel, Natural Gas, Dual Fuel (HPDI/NG)

#### Inputs
- **Gallons of Diesel Consumed Per Year:** 16,067
- **Average Miles Driven Per Year:** 100,000
- **MPG Average Per Year:** 8.00
- **NG as % of Diesel:** 2.6%

### NG or Dual Fuel Vehicle Information
- **NG ENGINE Efficiency:** Over the Road, 90%
- **Percent of Fuel that is NG:** Spark-Ignited, 100%
- **Equipment Upcharge:** $50,000
- **DPF Annual Maintenance Cost:** $275

### Cost of Fuel and DEF
- **Diesel Per Gallon:** $4.00
- **DEF Per Gallon:** $2.40
- **NG DGE:** $2.00
- **Other Annual Savings (-) / Costs (+): maintenance, subsidies, etc.:** $0

### Diesel Subtotal
- **Cost Per Gallon or DGE:** $4.00
- **ANNUAL COST:** $67,943
- **DIESEL & DEF:** $67,943
- **DPF Annual Maintenance Cost:** $275

### Natural Gas Spark Ignited Engine
- **Percent of Fuel:** 100%
- **Fuel or Additive:** Natural Gas
- **Gallons of DGE:** 18,519
- **Cost Per Gallon or DGE:** $2.00
- **ANNUAL COST:** $37,038

### Natural Gas Subtotal
- **$37,038

### Results
- **Equipment Upcharge:** $50,000
- **Other Savings (-) / Costs (+):** $0
- **Net Equipment Upcharge:** $50,000
- **Annual Savings for Natural Gas Spark vs Diesel:** $30,905
- **Payback:** 1.6 Years or 19 Months

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# Truck Fuel Payback Calculators

**Diesel, Natural Gas, Dual Fuel (HPDI/DNG)**

## Inputs

<table>
<thead>
<tr>
<th>Item</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gallons of Diesel Consumed Per Year</td>
<td>16,687</td>
</tr>
<tr>
<td>Average Miles Driven Per Year</td>
<td>160,000</td>
</tr>
<tr>
<td>MPG Average Per Year</td>
<td>8.00</td>
</tr>
</tbody>
</table>

## Horsepower Engine

### Diesel Engine

- **NG Engine Efficiency:** 100%
- **Percent of Fuel that is NG:** 95%
- **Equipment Upcharge:** $70,000
- **DFP Annual Maintenance Cost:** $275

### Dual Fuel Engine

#### HPDI

- **Percent of Fuel:** 5%
- **Fuel or Additive:** Diesel
- **Gallons or DGE:** 833
- **Cost Per Gallon or DGE:** $4.00
- **Annual Cost:** $3,333

- **Percent of Fuel:** 95%
- **Fuel or Additive:** Natural Gas
- **Gallons or DGE:** 15,834
- **Cost Per Gallon or DGE:** $2.50
- **Annual Cost:** $39,584

**Cost of Fuel and DEF**

- **Diesel Per Gallon:** $4.00
- **DEF Per Gallon:** $2.40
- **NG DGE:** $2.50

**Other Annual Savings (−) / Costs (+):**

- Maintenance, subsidies, etc.

**Total Annual Cost:** $87,698

**Dual Fuel Subtotal:** $48,243

## Results

**Equipment Upcharge:** $70,000

**Other Savings (−) / Costs (+):** $0

**Net Equipment Upcharge:** $70,000

**Annual Savings for Dual Fuel vs Diesel:** $24,700

**Payback:** 2.8 Years or 34 Months
### Diesel Engine

<table>
<thead>
<tr>
<th>Percent of Fuel</th>
<th>Fuel or Additive</th>
<th>Gallons or DGE</th>
<th>Cost Per Gallon or DGE</th>
<th>ANNUAL COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>Diesel</td>
<td>16,667</td>
<td>$4.80</td>
<td>$66,668</td>
</tr>
<tr>
<td></td>
<td>DEF</td>
<td>417</td>
<td>$2.40</td>
<td>$1,000</td>
</tr>
<tr>
<td></td>
<td>Diesel &amp; DEF</td>
<td></td>
<td></td>
<td>$67,668</td>
</tr>
<tr>
<td></td>
<td>DPF Annual Maintenance Cost</td>
<td></td>
<td></td>
<td>$275</td>
</tr>
<tr>
<td></td>
<td>Diesel Subtotal</td>
<td></td>
<td></td>
<td><strong>$67,943</strong></td>
</tr>
<tr>
<td>50%</td>
<td>Diesel</td>
<td>8,334</td>
<td>$4.80</td>
<td>$33,334</td>
</tr>
<tr>
<td></td>
<td>DEF</td>
<td>208</td>
<td>$2.40</td>
<td>$500</td>
</tr>
<tr>
<td></td>
<td>Natural Gas</td>
<td>8,334</td>
<td>$2.50</td>
<td>$20,834</td>
</tr>
<tr>
<td></td>
<td>Natural Gas, Diesel &amp; DEF</td>
<td></td>
<td></td>
<td>$54,668</td>
</tr>
<tr>
<td></td>
<td>DPF Annual Maintenance Cost</td>
<td></td>
<td></td>
<td>$275</td>
</tr>
<tr>
<td></td>
<td>Dual Fuel Subtotal</td>
<td></td>
<td></td>
<td><strong>$84,943</strong></td>
</tr>
</tbody>
</table>

### Dual Fuel Engine

**DNG**

- Equipment Upcharge: $30,000
- Other Savings (-) / Costs (+): $0
- Net Equipment Upcharge: $30,000
- Annual Savings for Dual Fuel vs Diesel: $13,000
- Payback: 2.3 Years or 28 Months
# DIESEL GALLON EQUIVALENT (DGE) PRICE AT PUMP CALCULATOR

<table>
<thead>
<tr>
<th></th>
<th>Henry Hub*</th>
<th>Another Price for Comparison</th>
<th>Comparator % Increase (+) / Decrease (-) vs. Henry Hub</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price per Million BTU (MMBtu)</td>
<td>$ 3.220</td>
<td>$ 6.440</td>
<td>100%</td>
</tr>
<tr>
<td>Divide MMBTU by this factor for DGE</td>
<td>7.213</td>
<td>7.213</td>
<td></td>
</tr>
<tr>
<td>Subtotal, Spot (Cash) Price per DGE</td>
<td>$ 0.446</td>
<td>$ 0.893</td>
<td></td>
</tr>
<tr>
<td>Processing--Henry Hub to the Pump</td>
<td>$ 1.50</td>
<td>$ 2.393</td>
<td></td>
</tr>
<tr>
<td>Subtotal</td>
<td>$ 1.946</td>
<td>$ 2.393</td>
<td></td>
</tr>
<tr>
<td>Additional Markup</td>
<td>$ 1.946</td>
<td>$ 2.393</td>
<td></td>
</tr>
<tr>
<td>Pre Tax Price per DGE</td>
<td>$ 2.484</td>
<td>$ 2.931</td>
<td>18%</td>
</tr>
<tr>
<td>Federal, State, and Local Taxes</td>
<td>$ 0.538</td>
<td>$ 0.538</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>$ -</td>
<td>$ -</td>
<td></td>
</tr>
</tbody>
</table>
Lowest Total Cost

Factors For Consideration

**Natural Gas Adoption as a Class 8 Fuel of Choice**

**Forces For Change**
- Total Fuel Cost Per Mile
- Long Term Oil/Diesel Prices
- Price Stability (Pump Price Insensitive to NG Spot Prices)
- Energy Independence
- Recent Major Engine and OEM Vehicle Product Announcements
- 80% ENGINE Part Commonality with Diesel
- No Aftertreatment (No SCR System, No DEF Additive)
- Infrastructure Investments & Announcements (Clean Energy, Trillium, and Shell)
- Sustainability Commitment (& Green Marketing)
- Environmental: Combustion Advantage: Least CO₂ of Fossil Fuels

**Forces Against Change**
- Energy Content
- Engine Efficiency
- LNG/CNG Tank Cost
- Range
- Few Product Offerings
- LNG Handling (Cryogenic)
- Training (Drivers, Technicians, Sales, Marketing, Accounting, HR, etc.)
- Major Investment to Bring Repair Facilities Up to Codes
- Little Refueling Infrastructure
- Uncertain Truck Residual Value
- Environmental: Extraction (Frac’ing) Concerns: Contamination of Water Table, Earthquake Risk, Escaped Gas*

* The radiative forcing (heat trapping ability) of methane is many times that of CO₂. However, CO₂ lasts many times longer in the atmosphere.
From Force Field Analysis to

“Yeah, BUT”
Yeah, But NG....

1. Tractors are too heavy....

2. Engines don't have a long enough operating range...

3. NG Powered trucks are limited in availability...

4. NG Engines are less fuel efficient and don't save money...
Yeah, But NG…. 

5. Vehicles can’t provide enough ROI without subsidies 

6. Engine maintenance costs are too high 

7. Engines won’t be liked by drivers 

8. Shop modification is too costly
9. Cost-effective supply will not be available when pro-environmental (anti-frac’ing) groups successfully shutdown drilling operations

10. It’s not a safe fuel

11. Permitting and Construction are too slow

12. And sustainability aren’t a concern of my customers
Stages of U.S. Class 8 Natural Gas Adoption—Baseline Scenario
(Class 8 Truck Retail Sales Plus Transit Buses)

- Traditional Diesel Dominates
- Preconditions for Takeoff
- Takeoff of Natural Gas Adoption
- Drive to Maturity and Steady State Share

ACT Research Co., LLC, Copyright 2013
Natural Gas

• Current penetration: Approximately 3% of annual sales in 2012

• Estimated penetration:
  • 2025 – 2030: 50%
The Conclusion

History teaches us that profound changes in the powering of motor vehicles:

• Happen, but are hard to predict

• Do not occur overnight

• Are cost driven

• Only deviate within legal constraints
The Conclusion

By 2025-2030, natural gas will become

the fuel of choice

for 50% of Class 8

On-Highway Vehicles.
• GVW – Gross Vehicle Weight
• LTL – Less-than-truckload
• CSA – Compliance, Safety, Accountability
• EOBR – Electronic on-board recorder
• OBD – On-board diagnostics
• CAFE – Corporate Average Fuel Economy
• GHG – Greenhouse Gas
• MY – Model Year
• CO₂ - Carbon

• EPA – Environmental Protection Agency
• NHTSA – National Highway Traffic Safety Administration
• FMVSS – Federal Motor Vehicle Safety Standards
• BTL – Biomass to liquid
• DME – Dimethyl Ether
• CNG – Compressed Natural Gas
• LNG – Liquid Natural Gas
• DNG – Diesel Natural Gas
• DEF – Diesel Emissions Fluid
• DPF – Diesel Particulate Filter