Introduction to Dual Fuel Diesel Conversions

Growing High-Horsepower Dual Fuel Natural Gas Markets

Class 8

DF Gliders

Extreme Duty

Oil & Gas

Emergency Backup

Mine Haul

Marine

Rail

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Class 8 Natural Gas Engine Options

Category	NG Engine	EPA NG Engine Approvals	Models	
New Tractors	Dedicated (Spark-Ignited)	2	CWI 8.9L, 11.9L	
New Freightliner Dual Fuel Gliders	APG Dual Fuel (Factory Install)	6	CAT ReMan Cummins ReCon® DD Reliabilt®	C-15 ISX, ISM, N14 Series 60 12.7L, 14.0L
Existing Tractors	APG Dual Fuel (Conversions)	457 (Pre-SCR) 17 (SCR)	CAT, Cummins, Detroit Diesel, Volvo, Mack Volvo/Mack Detroit Diesel Cummins ISX MaxxForce	 D13, MP8 – EPA Approved DD13, DD15 – EPA Approved In EPA Testing – June 2015 In EPA Prep – July 2015

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APG Dual Fuel Highlights

- Turbocharged Natural Gas®
  - No fuel injectors
- No high-temp parts
  - Standard oil & maintenance
- Operate inside normal diesel engine specs
- Seamlessly can return to 100% diesel operation
- Net fuel savings
  - $0.05 - $0.20 per mile
- Diesel displacement
  - Peak 70%
  - Average 50% - 60%
- No loss of power & torque
  - Target 350HP – 600HP
- Non-invasive
  - Read-only J1939 interface
- Transferable system/tank
  - 20 year life
- Sustainability
  - Reduce diesel emissions
  - Reduce NOx & PM by 25% - 45%

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Turbocharged NG vs. Fuel Injected NG

APG's Turbocharged Natural Gas® Dual Fuel Technology	*Dedicated "Fuel Injected" Technologies*
• Non-invasive to OEM engine and CAN-bus system	• Invasive to OEM engine and CAN-Bus system
• Introduces NG thru low-cost mixer into turbocharger	• Requires expensive custom fuel injectors
• Operates within OEM engine temperatures and pressure	• Requires more expensive high-temp parts
• Uses normal OEM specified oil with extended oil life	• Requires special high-temp oil with shorter life
• Universally adaptable to all 4-stroke engines	• Requires custom design to each engine model
• No practical limit on horse power to be converted	• Current design limit around 400HP
• No loss of power or pulling torque	• Power and pulling torque are compromised
• Seamlessly returns to 100% diesel fuel when required	• Dedicated to natural gas therefore subject to "range anxiety"
• Low cost of entry	• Higher cost of entry
• Can be transferred to another approved engine	• Cannot be transferred to another engine

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APG Vehicular Dual Fuel Progress

EPA Approvals

CARB Executive Orders

MY 2009 & Older	457 Engine Approvals
MY 2010 & Newer	17 Engine Approvals
CARB EO	3 Engine Certifications

Dual Fuel Experience

500+ APG DF Conversions in operation

50+ million road miles of DF experience

Filling the 350HP – 600HP natural gas gap

Customer Feedback

Fuel Savings of $.05 to $.20 per mile

Reliable design with high uptime

Standard oil & engine maintenance

No loss of power or torque

Sustainability

NOx & PM reductions of 25% - 45%

Eligible for emissions reduction grants

Increase market share with customer

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APG Customers: 50 Million Miles Of On-Road Dual Fuel Experience

State	Application
Louisiana	Forest Services
West Virginia	Coal Mines
Ohio	Rolled Steel / Aluminum
Georgia	FedEx Ground Contractor
Virginia	For Hire: Double-Trailers

State	Application
Illinois	Food Grade Bulk Hauling
Oklahoma	Dairy & Ice Cream / C Store
Texas	Top 100 For-Hire Fleet
Idaho	Buses – National Research Lab
North Dakota	Oil & Gas Fields

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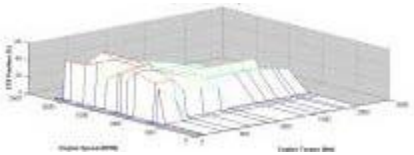
APG's Patented Third Generation Designed By Power-Train Leaders in Detroit

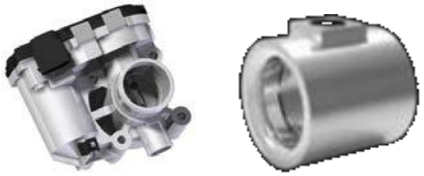
Digital Dual Fuel Electronic Control Unit

- Non-Invasive Read-only access of OEM CANBus system
- Maintains OEM temperatures & pressures
- Dynamic fuel control system – no custom fuel injectors



3D Natural Gas Software Mapping System

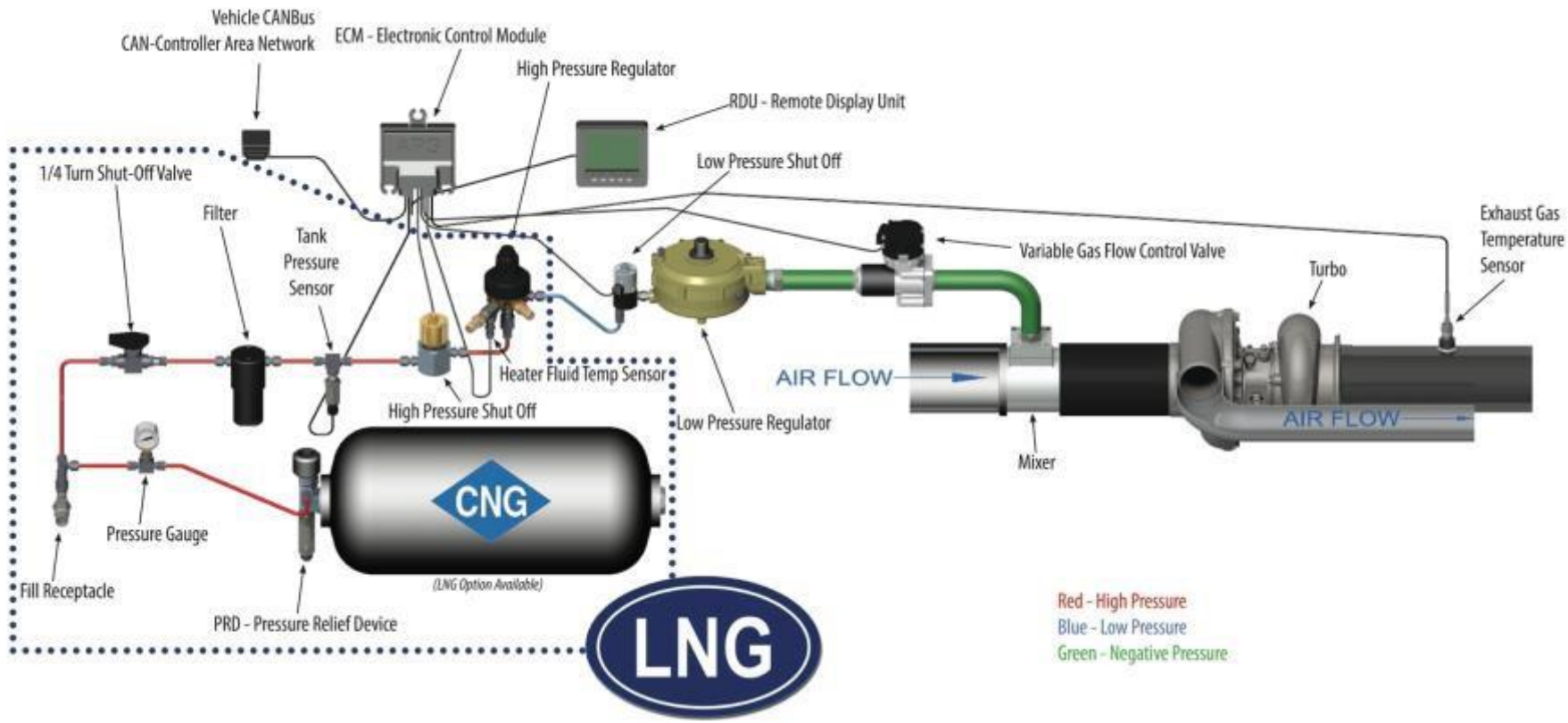
- Meet emissions – optimize displacement at all load ranges
- APG control strategies ensure seamless operation



Variable Fuel Metering

- Optimize displacement through full RPM & load ranges

V5000 Dual Fuel System Components

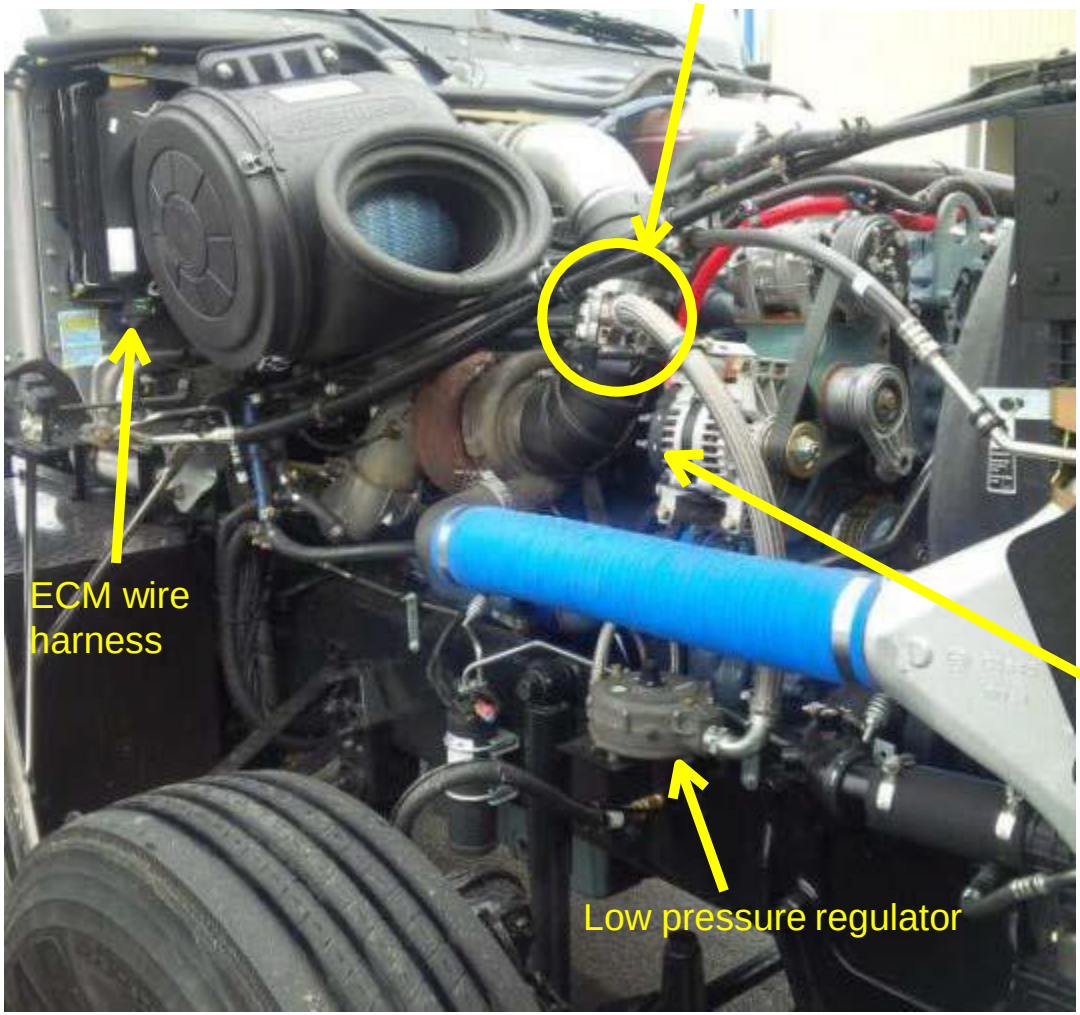


Dotted area represents components not present in V5000LNG Systems

*(*Tank Pressure Sensor is present in both V5000CNG & V5000LNG systems)*

V5000 Engine Kit Installed

Venturi/Throttle Body Configuration Controls NG substitution %



Remote Display Unit

1-3% by volume of Natural Gas in the air induction system

LEL (Lower Explosion Limit requires 5-15% by volume)

Many EPA Approved Class 8 Engine Families

474 EPA APPROVALS

Caterpillar	C11, C13, C15	2006 – 2004
	C-16	2002 – 1997
	C-10, C-12, C-15	2003 – 1993
Cummins	ISX, ISM, ISL, ISC	2009 – 1998
	N14, M11, L10, C8.3	2001 – 1991
Detroit Diesel	DD15, DD13	2012 – 2008
	DD13 12.8L	2009
	Series 60 14.0L	2009 – 1999
	Series 60 12.7L, 11.1	2006 – 1987
Daimler	MBE 4000 12.8L	2009 – 2001
	OM457LA, OM460LA	2003 – 2000
Volvo	D11, D12, D13, D16	2012 – 2004
	VE D12	2002 – 1996
Mack	MP7, MP8, MP10	2012 – 2002
	E7	2006 – 1996
	EM7	2002 – 1996

APPROVED SCR ENGINES

Volvo/Mack

D13/MP8 (2010 – 2012)

Detroit Diesel

DD15 (2010 – 2012)

DD13 (2010 – 2012)

Cummins

ISX (In Process – July)

Navistar

MaxxForce (Est. July)

2013 MY Approvals – (July)

CA CARB EO

Volvo

D13 (2010 – 2012)

More certifications in process

Note: Some engines may not have been produced in each year shown above and some horsepower ratings may not be included. Contact the Dual Fuel System manufacturer or an authorized distributor of the system for more details

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APG Dual Fuel Emissions Reductions Based on EPA OUL & IUL Testing

	SCR* 2013 – 2010	DOC/DPF 2009 – 2007	EGR 2006 – 2004	Pre-EGR 2004 – 1987
CO	99.9%	0.00%**	96.9%	83.3%
NMHC	99.3%	100.0%	100.0%	100.0%
NOx	42.5%	22.5%	42.4%	27.1%
PM	77.0%	0.00%**	37.5%	25.0%

** SCR results measured to EPA 2010 baseline. Balance are measured to EPA approved diesel engine baseline*
*** Diesel baseline and Dual Fuel results are either at zero or non-measurable*

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Much More Can Be Done to Reduce NOx

Existing Registered Class 8 Tractor Count By Engine Emission Age*

	Pre-EGR/EGR 2006 & Older	**DOC/DPF 2007 – 2009**	**SCR 2010 – 2015**	**Total**
United States	1,336,000 – 61%	203,000 – 9%	649,000 – 30%	2,188,000
California	113,500 – 58%	40,400 – 21%	41,300 – 21%	195,200
Texas	152,900 – 63%	20,600 – 9%	68,200 – 28%	241,700

*RL Polk Census Data – May 2015

EPA Tested NOx Reduction of Existing Engines with APG Dual Fuel:	12,000 – 14,000 lbs Million Miles	6,000 – 7,000 lbs Million Miles	500 lbs Million Miles

Tank Sizing and Range

	Typical Tank Size	Rated DGE	Estimated Useable DGE	Dedicated NG Engine Mileage @ 6 MPG*	Assume Average Dual Fuel NG Engine Mileage @ 6 MPG *(50% Diesel + 50% NG)*
CNG Boss Mount	25” x 60”	30.2	24	145	290
	25” x 80”	41.2	33	198	396
	25” x 90”	46.5	37	223	446
CNG BOC	25” x 80” (x3)	123	98.4	590	1,180
LNG	26” x 75”	55	55	330	660
	26” x 90”	69	69	414	828
	26” x 116”	89	89	534	1,068

**Actual mileage range will vary based on tank size, load, idle time and route profile*

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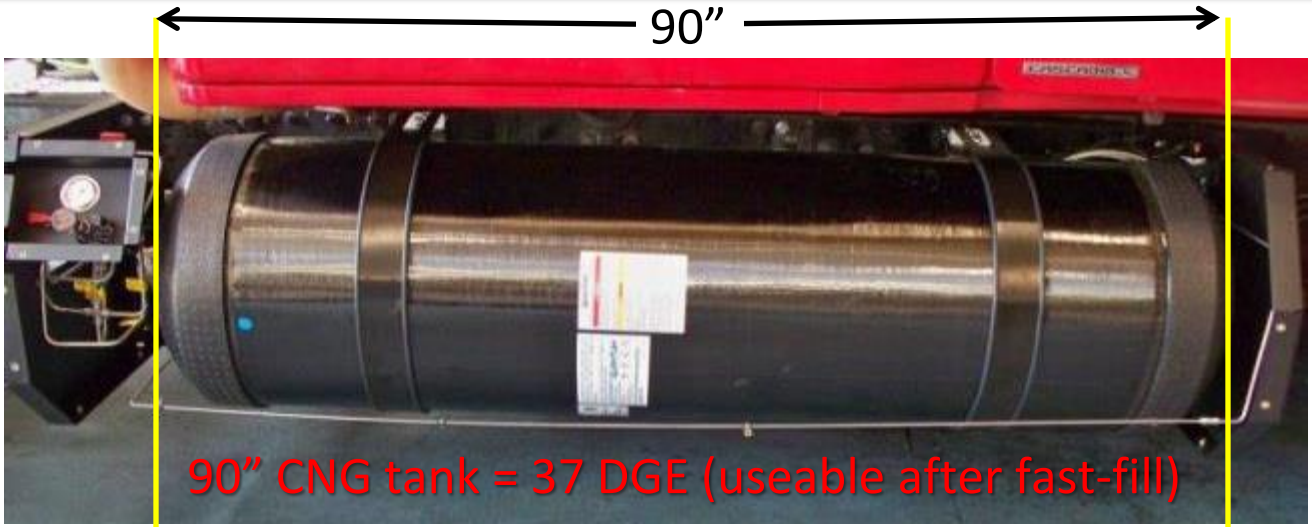
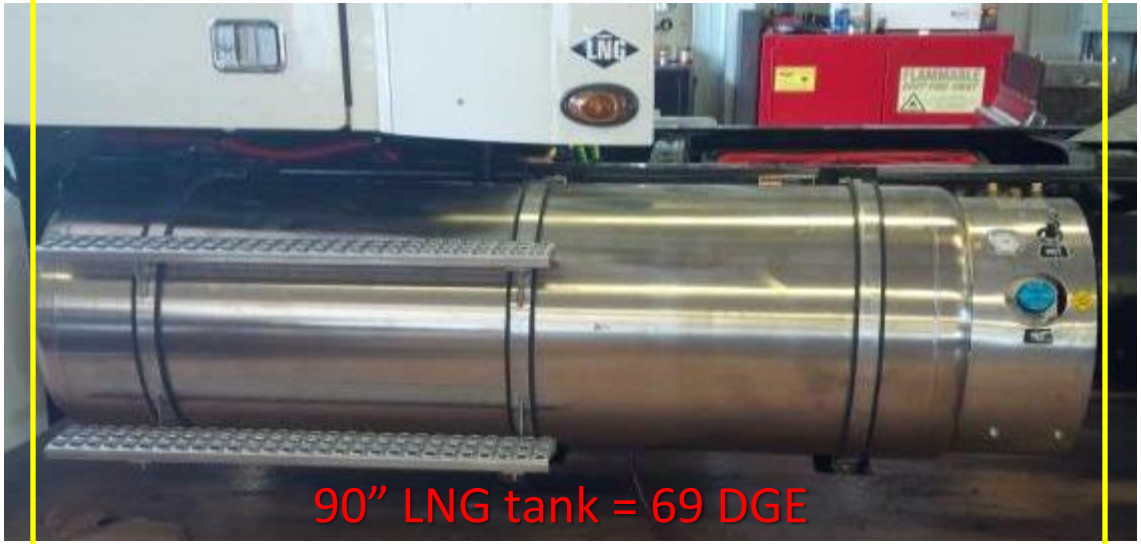
LNG / CNG Tank Capacity Comparison





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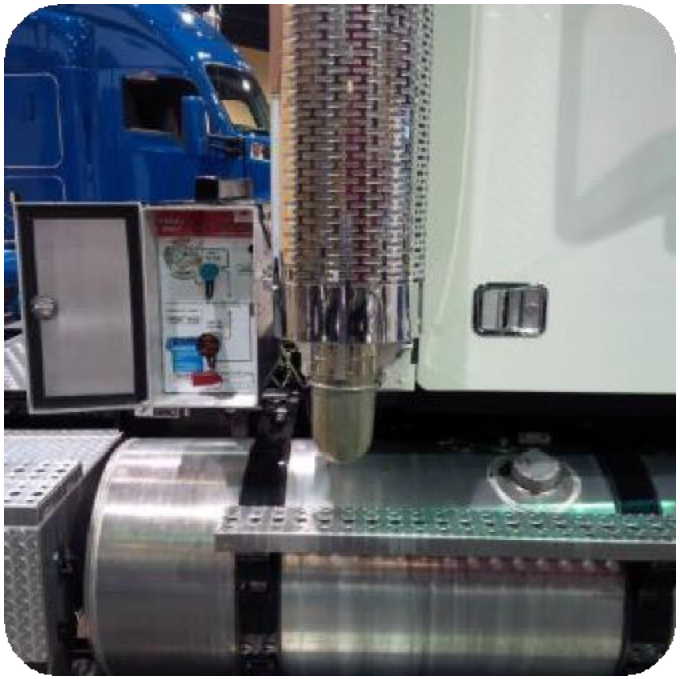
Tank Installation Options

Side Rail



Back of Cab (BOC) = 98.4 DGE (useable)

Estimated Change in Net Weight When Tanks are Full

Configuration:		100% Diesel	CNG Dual Fuel	LNG Dual Fuel	CNG Dual Fuel BOC
Tanks:	Diesel	Two 120 Gallon	One 120 Gallon	One 120 Gallon	One 120 Gallon
	Natural Gas	N/A	One 25” x 90”	One 26” x 90”	Three 25” x 80”
Rated DGE:		240 DGE	46.5 DGE	69 DGE	123.6 DGE
Effective DGE:		240 DGE	37 DGE	69 DGE	98.9 DGE
DF Range @ 6.0 MPG & 50%		1,560 miles	440 miles	828 miles	1,170 miles
APG System Weight:		N/A	38 lbs	38 lbs	38 lbs
Tank/Brackets/Fill Box Weight:					
	Diesel	424 lbs	212 lbs	212 lbs	212 lbs
	Natural Gas	N/A	720 lbs	935 lbs	1,600 lbs
Fuel Weight – Full:					
Diesel @ 7.02lbs/DGE		1,685 lbs	843 lbs	843 lbs	843 lbs
CNG @ 6.2lbs/DGE		N/A	229 lbs	N/A	613 lbs
LNG @ 6.06 lbs/DGE		N/A	N/A	418 lbs	N/A
Estimated Total Weight at Full:		2,109 lbs	2,042 lbs	2,446 lbs	3,306 lbs
Estimated Net Weight Change:		0	67 lbs lighter	337 lbs heavier	1,197 lbs heavier

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How Much Can I Save?

Assumptions: 120,000 miles/year @ 7.0mpg = 17,100 diesel gallons/year

100,000 miles/year @ 6.0mpg = 16,700 diesel gallons/year

Use 17,000 diesel gallons/year – assume displace 55%-60% with natural gas

	Diesel / NG	Price Spread	Annual Diesel Cost	Est Annual Dual Fuel Savings	Savings Per Mile
Last Year	$3.90 / $2.25	$1.65	$66,300	$15,400 - $16,800 23% - 25%	$0.13 - $0.17/mile
This Year	$2.60 / $2.00	$0.60	$44,200	$5,700 - $6,100 12% - 14%	$0.05 - $0.06/mile
Est. 2016	$3.40 / $2.10	$1.30	$57,800	$12,100 - $13,300 21% - 23%	$0.10 - $0.13/mile
Est. 2017/2018	$4.25 / $2.25	$2.00	$72,250	$18,700 - $20,400 26% - 28%	$0.16 - $0.20/mile

Leverage Sustainability Options: Diesel Reduction per Invested Dollar

Base Diesel Assumption:

100,000 miles per year @ 6MPG = 16,700 gallons/year

OR

Option	Capital Investment	Diesel Reduction
New Dedicated NGV	$180,000	16,700 gal/year
Total Over 5 Years		83,500 gal/year
Convert 6 Existing Trucks to DF @ 55% Displacement	Same $180,000	55,110 gal/year
Total Over 5 Years		275,555 gal/year

3.3x higher diesel displacement

APG Dual Fuel 20-Year Life Cycle Return

Base Assumptions:

- Assume 100,000 miles per year @ 6 mpg = 16,700 of diesel fuel consumed per year
- Assume dual fuel displacement of diesel with natural gas averages 55%
- Assume re-flash to a new tractor engine every five years - 20 year life on NG tanks & core APG system

Diesel to NG Price Spread	Investment	$1.00 Per DGE	$1.25 per DGE	$1.50 Per DGE
Annual Dual Fuel Savings		$9,185	$11,481	$13,777
Fleet Ownership:				
Years 1 – 5	$30,000	$45,925	$57,405	$68,885
Years 6 – 10	$5,000	$45,925	$57,405	$68,885
Years 11 – 15	$5,000	$45,925	$57,405	$68,885
Years 16 – 20	$5,000	$45,925	$57,405	$68,885
Life Cycle Investment & Savings	$45,000	$183,700	$229,620	$275,540
Payback on Investment		4.1X	5.1X	6.1X
At 120,000 Miles & 6MPG – Total Savings	$45,000	$220,000	$275,000	$330,000
Payback on Investment		4.9X	6.1X	7.3X

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Announces Factory Installed Class 8 Natural Gas Dual Fuel Glider Kits by American Power Group

- Freightliner/Western Star Dealer
- Freightliner's New Truck Warranty
- Total Lowest Cost of Ownership
- Factory Installed APG DF System
- Day Cab or Sleeper Units
- Lighter Weight than SCR Engines
- Engine Options:

  DD Reliabilt® Series 60 | Cummins ReCon® N14, ISM, ISX | Caterpillar ReMan C-15

New Freightliner Severe-Duty Glider Kit

Severe Duty 122SD Natural Gas Dual Fuel Glider

(Oil & Gas ~ Logging ~ Mining ~ Oversized Loads)

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APG's Dual Fuel Solution

Customer

Hassle-Free One-Stop-Shop Dual Fuel Purchase Experience

Engine Technology

- APG Conversions
- APG Dual Fuel Gliders

CNG/LNG Tank Packaging

- Determine Route Profile
- Select CNG or LNG
- Tank Sizing: Frame Rail or Back of Cab

Certified Installation

WheelTime Network

- APG System
- LNG & CNG Tanks

CNG/LNG Fill Station

- On-Route Availability
- Class 8 Accessible
- GPM Fill Rate
- One Stop Fill Hoses

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Benefits of Dual Fuel

Economics

- Save $0.05 to $0.20 per mile in fuel savings / normal maintenance costs
- Convert 6 existing trucks for same price as a new dedicated NG truck
- Non-invasive & lowest total cost of ownership

Performance

- No loss of power or torque compared to diesel
- Operates within normal diesel temps & pressures
- Handles extreme heavy-duty loads

Flexibility

- Can return to 100% diesel when needed
- Protection against future price spread changes
- Can transfer system & tanks to another truck – 20 year asset life

Environmental

- Reduce diesel-related emissions – increased emphasis on lowering NOx and PM
- Meet sustainability goals – increase market share

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