Converting A Diesel Engine To Use Biogas,

A Virtually Untapped And Renewable Fuel.

Presented By:
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Biogas

Methane-rich gas produced from plants, agricultural waste, animal waste, sewage and landfills.

Virtually untapped & renewable energy resource!

Landfills send Billions of BTU's of usable energy into the air and animal waste goes largely unused.

- **Using Biogas substantially reduces GHG inventories**
- **Combat global warming**

Biogas

Use of Biogas for transportation only possible after Purification.

Converting the Purified Biogas to LNG best solution for storage and transportation.

Prometheus Energy Co., USA - Has proprietary technology for processing and purification of Bio-Methane

PROMETHEUSenergy

Biogas-LNG Supply / USA

Potential Biogas LNG Supply / Day (DGE)

		% of US Diesel Demand
Landfills	8,800,000	8.7%
Manure Management	3,300,000	3.2%
Waste Water Treatment	3,000,000	2.9%
		14.8%

1 EIA - Adjusted Sales For Transportation Use: Distillate Fuel Oil and Residual Fuel Oil, 2004
LNG Diesel Gallon Equivalents (DGE)

- **Purifying & liquefying Bio-gas consumes large amount of energy, but a viable option at today's energy prices.**
- **Expense can be avoided if Biogas is used in natural state.**
- **High cost and low energy content makes the use of Biogas for transportation in most situations not a good solution.**
- **Onsite use of the raw Biogas for power generation, combined with heat recovery, is the best option.**

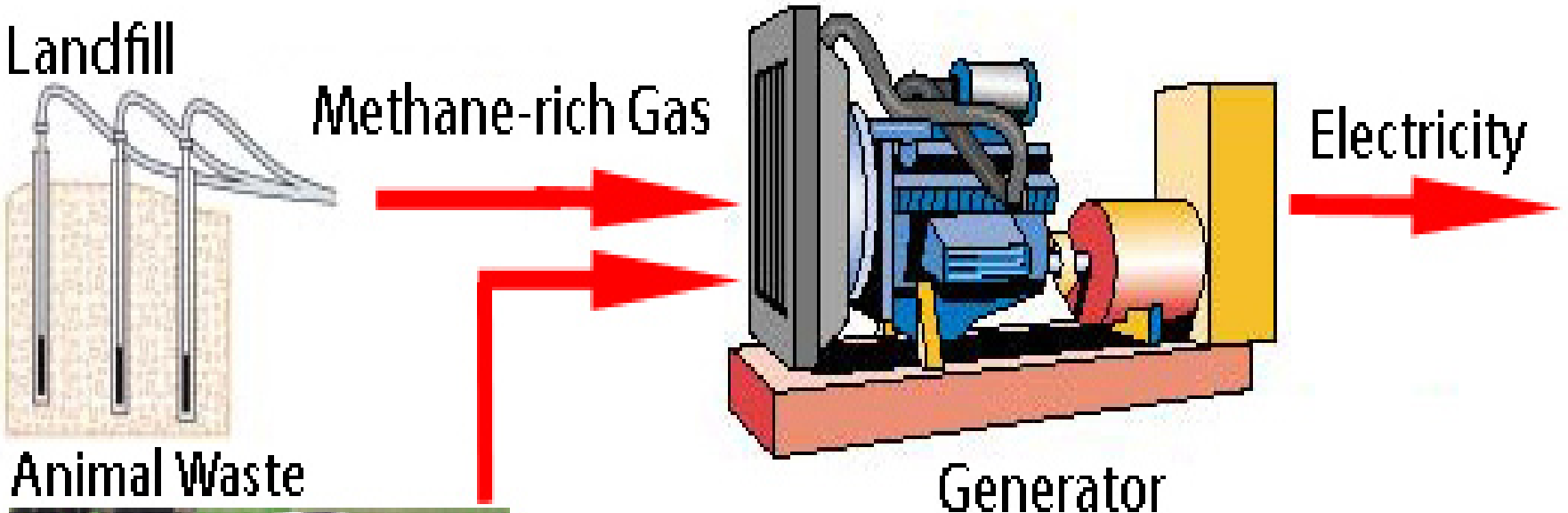
Uses for Biogas

- **Raw unprocessed Biogas not useable as transportation fuel. Typical composition does not meet vehicle fuel specifications.**
- **CO_2 and H_2S content too high for vehicle fuel.**
- **Processing is too expensive and often not practical.**

Component	CNG Fuel	Raw Biogas
Methane (CH_4)	**≥ 88**	**50 - 65**
Inert gases (CO_2 + N_2)	1.5 – 4.5 (range)	35
Hydrogen Sulfide(H_2S)	16 ppm	50 – 2000 ppm

- **Biogas can be used for electricity generation**
- **Some of the waste heat can be recovered for other uses.**
- **Combined Heat and Power (CHP) installations possible**

Biogas For Electric Power Generation



A 1,000-cattle farm can produce approx. 50,000 ft^3 of biogas per day (600 Btu/scf) The biogas captured would be over 215 DGE/day or about 78,000 DGE/year.

Biogas Engine

- Electricity generation, or CHP, using Biogas - a commercially available and proven technology.
- Typical installations use diesel engines that have been modified to operate on Biogas.
- Converting a diesel engine to run on Biogas is straightforward.
- Engines should be specifically modified to run on Biogas to allow for low methane content and impurities in the gas.

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Engine Modified To Run On Biogas

- Adjusting ignition timing -- slower flame velocity of biogas.
- Proper maintenance procedures – Shorter oil change intervals.
- Engine oil with high base number (pH) to inhibit acid formation.
- To minimize condensation of acid fumes in the crank case, engine coolant temperatures should be maintained above 190° F.
- Intake and exhaust valves should be stainless steel.
- Avoid copper alloys for crankshaft and rod bearings.

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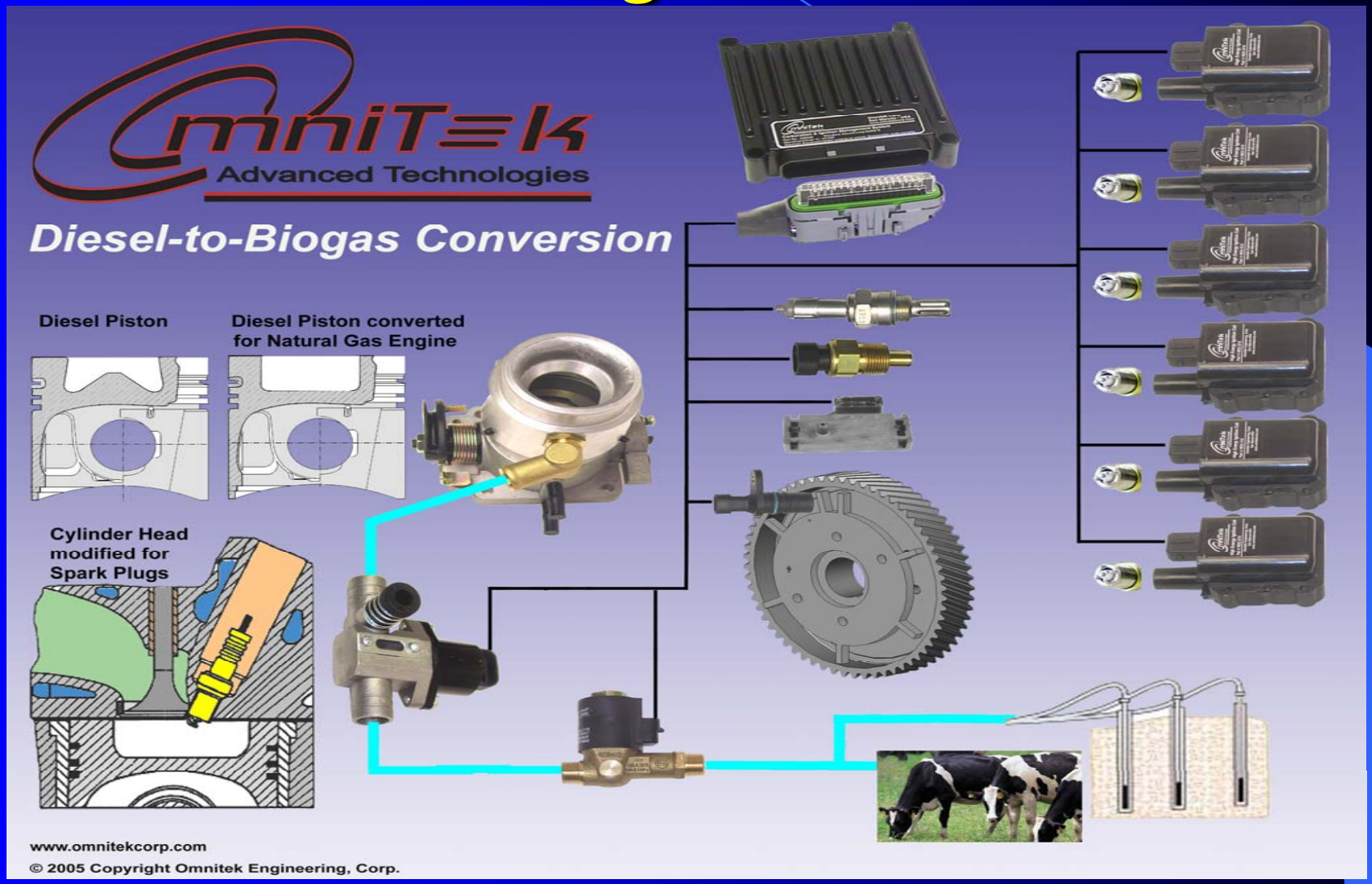
Engine Modified To Run On Biogas

Diesel-to-Biogas Conversion



Engine Conversion Steps

1- Disassemble engine.

2- Checking components and replace as necessary.

3- Modify pistons for Biogas use (lower compression ratio).

4- Modify cylinder head (spark plugs, new valves, guides, etc.).

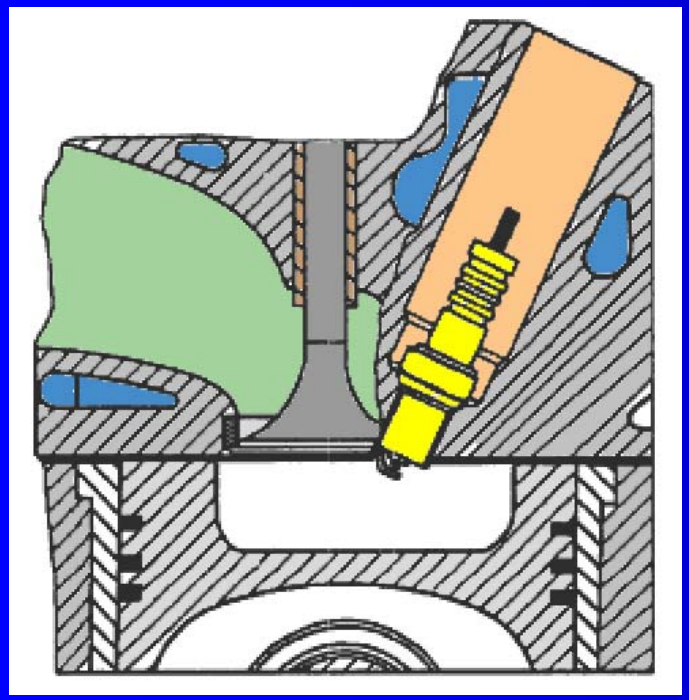
5 - Install camshaft sensor and timing wheel.

6 - Reassemble engine.

7 - Install throttle body, mixer, fuel control valve and sensor.

8 - Tuning of the engine (fuel and ignition).

Cylinder Head Modifications



1. Cylinder head modified to allow installation of spark plugs.
2. Intake valves and exhaust valves stainless steel to withstand corrosion and the higher combustion temperatures of gas.

Calculating Compression Ratio

Calculating Compression Ratio

The calculation of compression ratios (C.R.) is based on the following formula:

$$\text{Compression ratio} = \frac{\text{SWEPT VOL.} + \text{TDC VOL.}}{\text{TDC VOL.}}$$

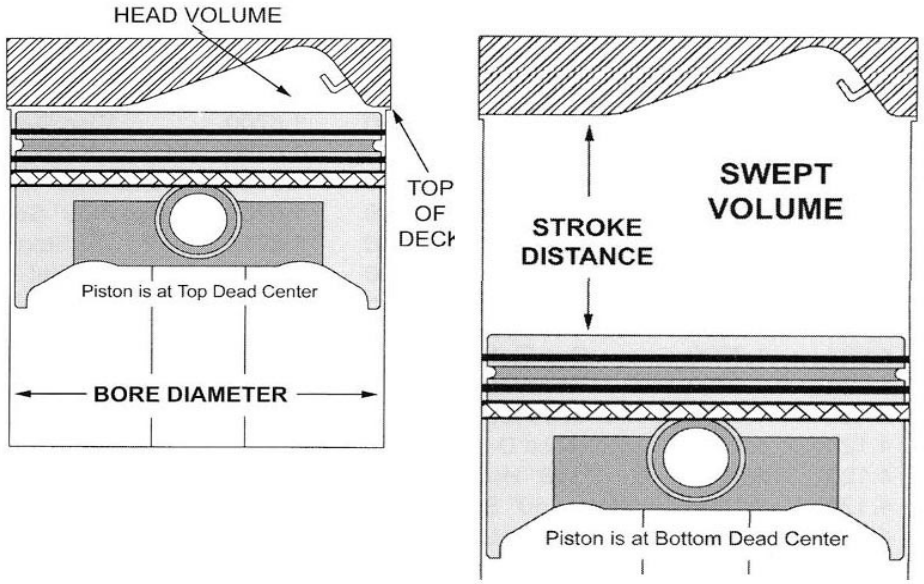
$$\text{Swept Vol.} = \frac{3.1416 \times \text{BORE DIA.} \times \text{BORE DIA.} \times \text{STROKE}}{4}$$

T.D.C. Vol.= Head vol. + gasket vol. + deck vol. + dish/dome vol.

Head Vol.= is published or measured in cubic centimeters (cc)

$$\text{Gasket Vol.} = \frac{3.1416 \times \text{GASKET BORE} \times \text{GASKET BORE} \times \text{GASKET THICKNESS}}{4}$$

$$\text{Deck Vol.} = \frac{3.1416 \times \text{BORE DIA.} \times \text{BORE DIA.} \times \text{DECK CLEARANCE}}{4}$$



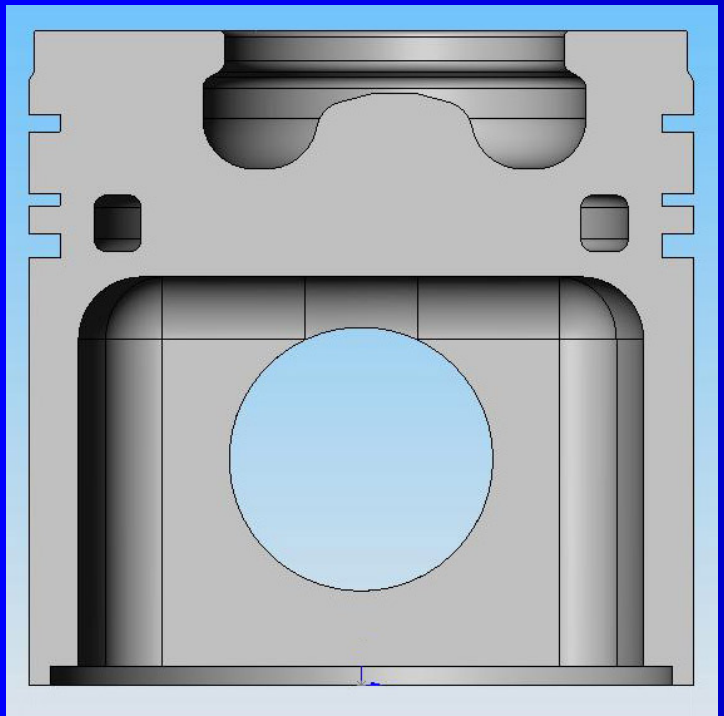
Optimum Compression Ratio depends largely on:

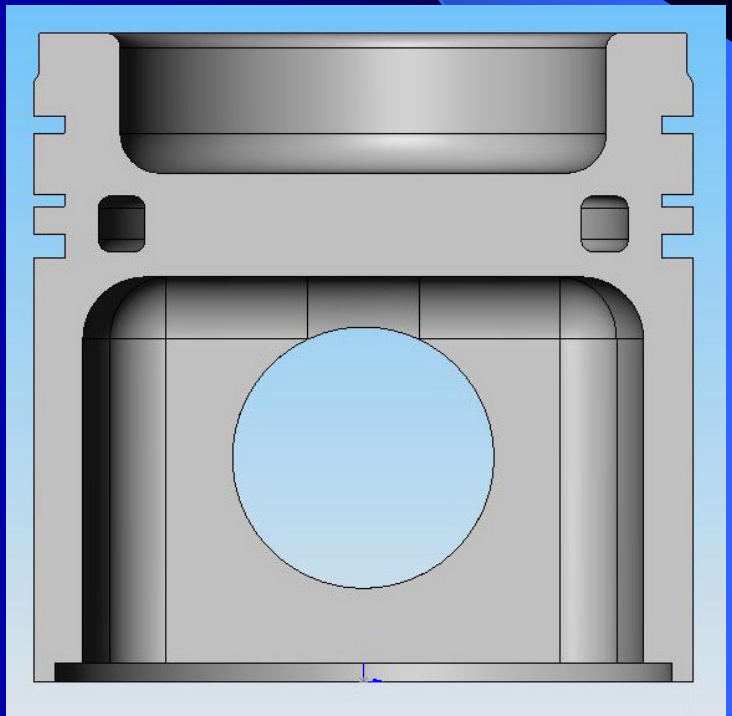
- **Biogas Composition**
- **Engine Power**
- **Combustion Chamber Design**
- **Ambient Temperature**

Pistons

Diesel pistons are modified to lower compression ratio.

Optimum Compression Ratio for NA Engines:
Biogas: 9:1 to 11:1
CNG: 12:1 to 14:1





Throttle Body, Mixer & Fuel Metering

- A high-efficiency mixer design assures optimum mixing of gas and air at any engine speed and load.
- The closed-loop controlable fuel metering valve regulates gas flow to the engine to optimize A/F ratio.
- The throttle body meters the intake air quantity and is used to control engine power.

Engine Speed and Position Sensor

- Diesel injection pump removed.
- Timing wheel and sensor intalled.
- Engine speed and position must be acurate.

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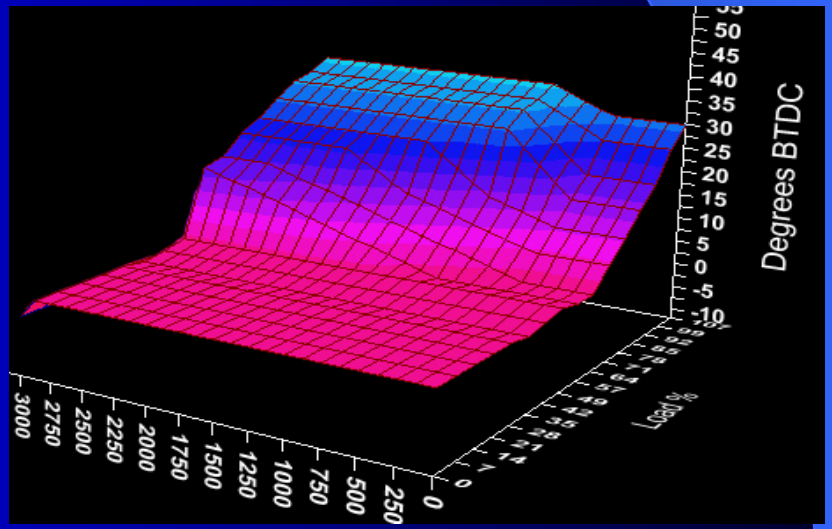
Programmable Ignition System and Fuel Metering

- Computer controlled fuel metering.
- High-energy ignition system.
- Individual ignition coils.
- PC configuerable Software.



Conclusion

In today's marketplace where energy costs are skyrocketing and global warming is a real threat, Biogas as fuel offers a real-world solution.

Thank you for your attention.

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