

---

**Compressed Natural Gas and  
Compressed Biogas**

**An Overview of the Technology,  
Economics and  
Project Development Process**

*December 2012*



Building a Better World  
for All of Us™

## Introduction

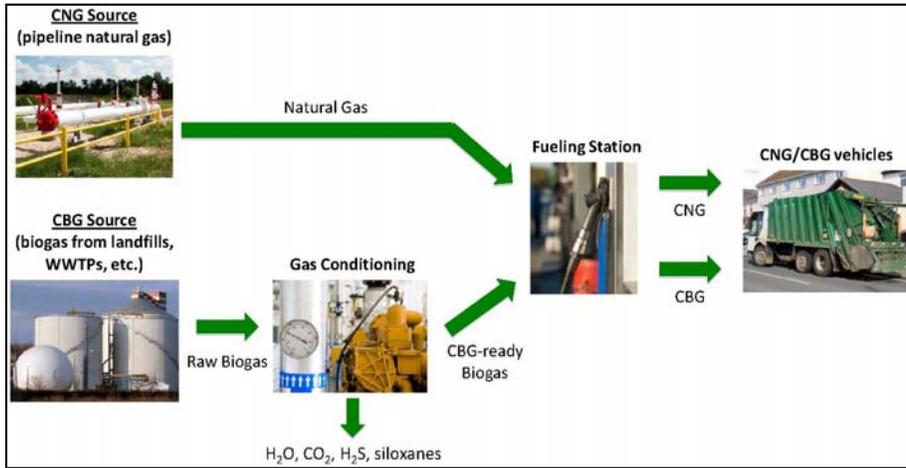
As a result of volatile petroleum prices, public and private entities are exploring ways to reduce fuel costs for vehicle fleets. Compressed natural gas (CNG) and compressed biogas (CBG) offer opportunities to reduce vehicle fleet fuel costs while also meeting environmental goals. This document presents the basics of CNG and CBG vehicle fuel projects and how to take advantage of the economic and environmental benefits that this technology offers.

## Technology

CNG and CBG are both compressed, methane-based gases. They can be used interchangeably as fuel in CNG vehicles. CNG is made from pipeline natural gas. CBG is made from the methane-rich biogas produced from the anaerobic decomposition of organic wastes at landfills, wastewater treatment plants, or other facilities with digesters (e.g. food processing plants, dairy farms). While pipeline natural gas is CNG-ready and requires no conditioning (cleaning) before compression, CBG requires conditioning for the raw biogas before compression. After conditioning, CBG is functionally equivalent to CNG. The technology involved in each step of the fuel production process is described below:

1. Conditioning (clean-up) System – A biogas conditioning system (only required for CBG) removes moisture ( $H_2O$ ), increases the methane ( $CH_4$ ) content by removing carbon dioxide ( $CO_2$ ), and cleans the gas by removing hydrogen sulfide ( $H_2S$ ), siloxanes, and other trace constituents.
2. Fueling Station – A fueling station typically includes a compressor and fuel pump. The compressor compresses the cleaned biogas and/or natural gas from ~10 psi to ~4,000 psi. The compressed fuel is usually expressed in terms of DGE (diesel gallons equivalent) or GGE (gasoline gallons equivalent). Many fueling stations will have more than one compressor for system back-up or so both CNG and CBG can be used at the same time. The fuel pump dispenses the compressed fuel to vehicles at a rate (DGE or GGE per minute) dependent on compressor size and number, the amount of compressed fuel storage, and other project specifics.
3. CNG Vehicles – Petroleum-fueled engines will not run on CNG or CBG fuel, so a petroleum vehicle fleet must be transitioned to CNG. CNG engine technology has improved significantly over the past several decades, and the performance and efficiency of current CNG engines is comparable to petroleum engines. CNG engine types include dedicated (CNG only), bi-fuel (runs on either CNG or gasoline), or dual-fuel (runs on both CNG and gasoline). Fleets can be transitioned either by retrofitting existing petroleum engines, or purchasing new vehicles designed to run on CNG.

### *CNG/CBG Production Process*



### **The Economic Benefits**

Because conventional natural gas prices are at long-term lows, an estimated total fuel price for producing CNG vehicle fuel from pipeline natural gas is currently around \$1.80/DGE. This cost is based on current industrial natural gas purchase prices in Wisconsin, estimated production costs, and CNG fuel taxes (\$0.43/GGE or \$0.49/DGE). On the other hand, an estimated total fuel price for producing CBG from raw biogas (a “free” fuel) is typically less than \$1.60/DGE (includes production costs and fuel taxes, does not include any incentives or credits).

As of December 2012, total estimated fuel prices for CNG and CBG are both roughly \$2.00 cheaper than diesel (\$4.00/DGE) and gasoline (\$3.30/gal or \$3.75/DGE) at current Wisconsin prices. Given current price differences, fueling a vehicle fleet with CNG instead of diesel would result in significant annual cost savings. The table below shows the annual fuel costs savings for CNG and CBG at two system sizes and three potential diesel prices (capital expenditures not included). CNG fuel tax credits (pending at the federal level) also have the potential to increase cost savings.

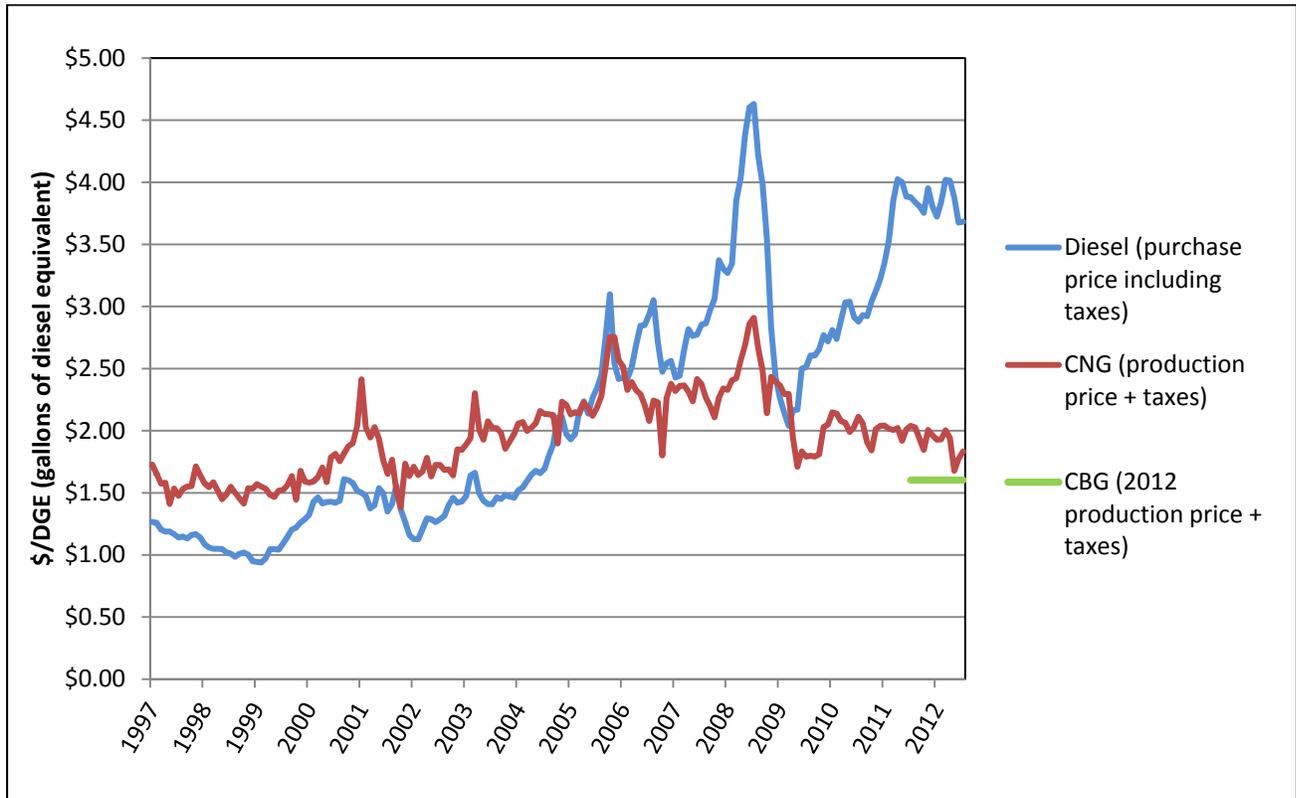
*Annual Fuel Cost Savings*

<b>Fuel</b>	<b>System Size*</b>	<b>Potential Diesel Prices</b>		
		<b>\$3.50/gal</b>	<b>\$4.00/gal</b>	<b>\$4.50/gal</b>
<b>CBG</b>	<b>50 cfm (200 DGE/day)</b>	\$139,000	\$175,000	\$212,000
	<b>100 cfm (400 DGE/day)</b>	\$277,000	\$350,000	\$423,000
<b>CNG</b>	<b>50 cfm (200 DGE/day)</b>	\$124,000	\$161,000	\$197,000
	<b>100 cfm (400 DGE/day)</b>	\$248,000	\$321,000	\$394,000

*\*Size description: cubic feet per minute (cfm) of raw biogas into system; DGE/day of CNG fuel produced by system*

The figure below shows the historical price comparison for diesel, CNG, and CBG. Conventional natural gas and petroleum prices are projected to remain steady or gradually rise over the next 10-20 years, so the future price difference between CNG, CBG, and petroleum fuels is expected to remain relatively constant. While CBG is currently cheaper to produce than CNG, the higher capital costs associated with CBG (due to gas conditioning) have the potential to offset this difference.

*Vehicle Fuel Price Comparison (Midwest U.S.)*



Sources: U.S. Energy Information Agency, Wisconsin State Energy Office

## Additional Benefits of CNG

In addition to the saving money, CNG projects can also result in:

- Energy Independence – By using CNG (North American market) or CBG fuel (stable cost), vehicle fleets are not subject to fluctuating petroleum prices on the global market.
- Lower GHG Emissions – Reduced greenhouse gas emissions as compared to petroleum.
- Improve Air Quality – Reduced smog-producing pollutant emissions from vehicles.
- Reduced Vehicle Noise – CNG vehicles operate much quieter than diesel vehicles.
- Renewable Fuel Credits (CBG only) – There is the potential to sell the renewable/green attributes of CBG fuel as renewable fuel credits or RINs (Renewable Identification Numbers). Current CBG projects are generating \$0.80/DGE to \$1.15/DGE of additional revenue by selling RINs.

## Key Factors when Considering a CNG Vehicle Fuel Project

- Vehicle Fleet – Identifying a vehicle fleet to use the CNG is one of the most important project considerations. Ideal fleets for CNG projects are
  - driven many miles
  - return to the same location daily
  - have low fuel economies

Commonly considered fleets include refuse trucks, municipal or county vehicles, law enforcement vehicles, and school or transit buses. While CNG vehicles operate similarly to comparable petroleum vehicles, maintenance facilities that service CNG vehicles must meet certain regulatory requirements that could require facility upgrades.

- Location and Sizing of CNG System – The location of a fuel source will largely determine which vehicle fleets could best utilize the fuel. The fueling system should be sized based on both on the amount of CNG and/or CBG that is economically available and the fuel needs of the vehicle fleet.
- Grant/Funding Sources – Depending on how a project is structured, there are many funding options to support CNG systems and vehicles in Wisconsin including:
  - Wisconsin State Energy Office
  - Congestion Mitigation and Air Quality Program (WI DOT)
  - CDBG Programs (Wisconsin Economic Development Corporation)
  - USDA Rural Development Programs (USDA) Renewable Energy for America Program (USDA)
  - Tax Increment Financing
  - Business Energy Investment Tax Credit (IRS)
  - Qualified Energy Conservation Bonds (US Treasury)
  - National Clean Diesel Campaign (EPA)
  - Diesel Emissions Reduction Program (EPA)
  - Clean Cities Program (DOE)
- Payback Period – Estimated payback periods for CNG projects can vary significantly depending on a number of factors including:
  - *Price of diesel/gasoline* – The larger the price difference between CNG and the alternative, the larger the return.
  - *Price of natural gas*
  - *Vehicle Fleet attributes* – Ideal fleets for CNG projects are driven many miles, return to the same location daily, and have low fuel economies.
  - *Biogas source* – What, if any, investment is required to produce or capture the biogas?

- *System operations and maintenance costs* – The cleaner the raw biogas, the lower the O&M costs to produce CBG.
- *Renewable Fuel Credits (RINs)* – Credits can provide additional revenue for each unit of CBG fuel produced.

## Conclusion

CNG and CBG represent a significant opportunity for vehicle fleet owners. The main driver for undertaking a CNG project is fuel cost savings, but energy independence and environmental benefits are also important drivers. CNG projects are customizable and have many potential applications.



### About Short Elliott Hendrickson (SEH®)

*SEH is an employee-owned company that specializes in engineering, architecture, science and planning. More than 550 employees serve public sector and industrial clients from offices in 10 states. Founded more than 85 years ago, SEH's mission is Building a Better World for All of Us. Our clients count on SEH to provide innovative, cost-effective and sustainable solutions to meet their infrastructure and environmental challenges.*

*As society's need for secure, reliable, efficient energy sources and systems continues to grow, SEH is actively involved in developing new technologies, and finding creative ways to leverage existing technologies to help you keep pace with this rapidly changing market. Contact SEH for additional information on CNG-CBG opportunities.*

*Mark Broses, Co-Director, Energy and Sustainability*  
[mbroses@sehinc.com](mailto:mbroses@sehinc.com)

*Scott Sannes, Co-Director, Energy and Sustainability*  
[Ssannes@sehinc.com](mailto:Ssannes@sehinc.com)