OEM DEALER RESOURCE GUIDE

GoWithNaturalGas.ca

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1. Doing the Math

Natural gas has its own units of measure. Several different units are used for natural gas including cubic meters (m³), cubic feet (ft³), and gigajoules (GJ). Measurement Canada also requires that public or cardlock stations sell natural gas on a cents per kilogram (kg) basis.

So how does the energy content of each of these units of measure compare with a litre of diesel?

<table>
<thead>
<tr>
<th>NATURAL GAS</th>
<th>DIESEL LITRES EQUIVALENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 GJ</td>
<td>27.7 litres of diesel</td>
</tr>
<tr>
<td>1 kg</td>
<td>1.462 litres of diesel</td>
</tr>
<tr>
<td>1 m³</td>
<td>1.032 litres of diesel</td>
</tr>
<tr>
<td>1 ft³</td>
<td>.0292 litres of diesel</td>
</tr>
</tbody>
</table>

Natural gas fuel pricing for heavy vehicles is always based on the equivalent amount of energy compared to a litre of diesel. This way of pricing natural gas is called a “diesel litre equivalent” or DLE. In the US, the term diesel gallon equivalent or DGE is used. There are 3.7 DLE in a DGE. To figure out how all of the various units of energy compare to a litre of diesel, you have to go back and find a common unit of energy. The term “BTU” is often used to describe energy, at least when it comes to heat. Furnaces, for example, are described by their energy output in BTUs.

Energy content assumptions for all values in the table are shown on the next page.
1. Doing the Math

A BTU is the amount of energy needed to increase the temperature of a pound of water by 1 degree Fahrenheit. The BTU values for the different natural gas units and for diesel are shown below:

<table>
<thead>
<tr>
<th>Natural Gas Unit</th>
<th>BTU</th>
</tr>
</thead>
<tbody>
<tr>
<td>1GJ of natural gas</td>
<td>947,950 BTU</td>
</tr>
<tr>
<td>1kg of natural gas</td>
<td>50,020 BTU</td>
</tr>
<tr>
<td>1m³ of natural gas</td>
<td>35,300 BTU</td>
</tr>
<tr>
<td>1ft³ of natural gas</td>
<td>1,000 BTU</td>
</tr>
<tr>
<td>1 litre of diesel</td>
<td>34,210 BTU</td>
</tr>
</tbody>
</table>

These energy content values are best estimates.

Calculators including those listed below are available to help you do the math and can be found at:

www.gowithnaturalgas.ca/others/cngva-calculators/

- Per litre fuel savings CALCULATOR
- Natural gas pricing on a DLE basis CALCULATOR
- Convert diesel litres to natural gas units CALCULATOR
2. CNG & LNG

Natural gas has to be compressed (CNG) or liquefied (LNG) for use as a transportation fuel. CNG is natural gas that is stored at high pressure in durable fuel cylinders. Compression reduces the volume by 300 times compared to natural gas at normal pressure.

LNG is natural gas that has been cooled to -162 degrees Celsius. Liquefaction reduces the volume by 620 times compared with natural gas at normal pressure. LNG is stored in insulated, thermos-like tanks. As LNG warms up, it returns to a gas.

Whether CNG or LNG is used, more fuel storage space is needed to hold the equivalent amount of energy compared to diesel. CNG and LNG are just ways of storing energy. Whether a vehicle operates on CNG or LNG, in both cases the natural gas is always delivered to the engine as a gas.

CNG has odourant added which gives the natural gas a distinctive rotten egg smell. LNG does not have odourant added because this interferes with liquefying the gas. As a result, all LNG vehicles are equipped with methane detectors.

CNG is lighter than air and, if released, will rise and will not pool on the ground. A small spill of LNG will evaporate and rise. A larger spill of LNG may run to low spots or float on water. The properties of CNG and LNG need to be taken into account for any indoor facilities where CNG and LNG vehicles are serviced, stored or loaded.

### Energy Content & Storage Volume

<table>
<thead>
<tr>
<th>FUEL</th>
<th>ENERGY PER LITRE</th>
<th>VOLUME NEEDED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel</td>
<td>36 megajoules per litre</td>
<td>1.0</td>
</tr>
<tr>
<td>LNG</td>
<td>21 megajoules per litre</td>
<td>1.7</td>
</tr>
<tr>
<td>CNG</td>
<td>7.5 megajoules per litre</td>
<td>4.8</td>
</tr>
</tbody>
</table>

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CNG is dispensed to a settled pressure of 3,000 pounds per square inch (psi) at public stations in Canada. Private stations can dispense CNG to a settled pressure of 3,600 psi.

In the U.S, all stations dispense CNG to a settled pressure of 3,600 psi. Canada is working to harmonize fill pressure with the U.S. The code that defines Canadian CNG station requirements, CSA B108 – Natural Gas Fuelling Stations Installation Code, is being updated. If approved, the harmonized 3,600 psi fill pressure will be in place in the revised code in early 2014.

No special equipment is needed to refuel with CNG, although training is recommended to ensure safe refueling procedures are followed.

CCNG stations can be fast fill, time fill or a combination of the two.

- **Fast fill** can match the speed of refueling with diesel, but the heat of compression during refueling may reduce the total volume that goes into the tank by up to 20%.

- **Time fill** is used for fleets that return to base where vehicles can be refueled overnight. Time fill stations refuel all vehicles simultaneously over an estimated 6-8 hours.

- **Combination fill** refers to time fill stations that can also provide some fast fill capability on a limited basis. If a truck returns to the yard mid-shift, it can be refueled quickly.

Canada’s network of approximately 40 public CNG stations have been designed for light-duty vehicles. While a medium or heavy truck could refuel at these stations, it is important to understand fill time for a larger vehicle and to ensure there is adequate access.
3. Filling Up - LNG

**LNG** is sold at two different temperatures. *Saturated* LNG is warmer and results in higher pressure in the fuel tank. *Unsaturated* LNG is colder and results in lower pressure in the fuel tank. Unsaturated LNG use increases driving range, but it can only be used in vehicles that have an internal pump or pressure booster.

If an LNG vehicle is being specced, you need to know what type of LNG your fleet customer will be using in order to ensure that the right type of tank system is planned for the vehicle.

LNG is a very low temperature, cryogenic fuel. Gloves, a face shield, and long sleeves are needed when refueling an LNG vehicle in order to avoid frozen skin and inhaling cold vapours.

Canada currently has four LNG cardlock LNG refueling stations that can be accessed by fleets. Vedder Transport operates a station in Abbotsford (BC). Shell Flying J has an LNG station in Calgary (AB). Gaz Metro Transport Solutions has LNG stations in Cornwall (ON), and Quebec City (QC). Local fleets should contact these station owners for information on fuel pricing and how to set up an account.
Factory-built CNG and LNG vehicles are under the jurisdiction of Transport Canada for safety compliance and importation, and under the jurisdiction of Environment Canada for emissions compliance.

**CNG Safety Regulations**

Transport Canada regulations allow the use of CSA B51 or ANSI NGV2 CNG cylinders. Except for school buses, these regulations also allow CNG vehicle manufacturers to demonstrate compliance either via: (a) crash testing; or (b) complying with Section 4 of CSA B109 – Natural Gas for Vehicles Installation Code.

Canadian regulations currently have a stricter requirement for impact loading compared to U.S. regulations. The brackets holding the CNG cylinders must be capable of withstanding a 20G force in one direction. Based on a Transport Canada study, it is now proposed that this impact loading requirement be changed to 8 G in all directions which would harmonize Canada’s requirements with the U.S. If approved, this change will apply to heavy vehicles above 4,536 kg and will be included in the CSA B109 code in early 2014.
4. Who Approves What - Vehicles

**LNG Safety Regulations**
Transport Canada does not have any regulations, at present, that apply to LNG vehicles or LNG fuel systems. Accordingly, industry best practices should be followed and the use of equipment certified to third party standards is recommended.

**Emissions Regulations**
For emissions, Canada is aligned with the U.S. EPA certificates are recognized by Environment Canada. Another option is for manufacturers to follow EPA test procedures and obtain a National Emissions Mark from Environment Canada.


**Aftermarket Conversions**
The aftermarket conversion of vehicles falls under provincial jurisdiction. Provinces across Canada require that aftermarket conversions have Canadian Registration Numbers (CRNs) on all CNG fuel cylinders and on all pressure components. This requirement does not apply to factory-built natural gas vehicles.

5. Who Approves What – Stations

CNG and LNG refueling stations are primarily under the jurisdiction of provincial Authorities who are responsible for fuels safety and pressure vessels. In some provinces such as Alberta, these responsibilities are split between two different bodies. Municipalities also have approval requirements and, depending on the specific station location, there may be additional approvals required. For CNG refueling stations, these authorities will refer to the CSA B108 – Natural Gas Fuelling Stations Installation Code. For LNG refueling stations, these authorities will refer to a new section of CSA Z276 – LNG Production, Handling & Storage code called Annex D which is being finalized in late 2013. The list of Authorities involved in station approval is shown below.

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<table>
<thead>
<tr>
<th>PROVINCE</th>
<th>AUTHORITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberta</td>
<td>AB Boiler Safety Association &amp; AB Municipal Affairs</td>
</tr>
<tr>
<td>British Columbia</td>
<td>BC Safety Authority</td>
</tr>
<tr>
<td>Manitoba</td>
<td>Office of the Fire Commissioner</td>
</tr>
<tr>
<td>New Brunswick</td>
<td>Department of Public Safety</td>
</tr>
<tr>
<td>Nova Scotia</td>
<td>Ministry of Labour</td>
</tr>
<tr>
<td>Ontario</td>
<td>Technical Standards &amp; Safety Authority</td>
</tr>
<tr>
<td>Prince Edward Island</td>
<td>Department of Environment</td>
</tr>
<tr>
<td>Québec</td>
<td>Régie du Batiment</td>
</tr>
<tr>
<td>Saskatchewan</td>
<td>Emergency Management &amp; Fire Safety Branch</td>
</tr>
</tbody>
</table>

Note - Newfoundland is not listed as there is currently no local supply of natural gas in the province.
Before a fleet approaches the relevant Authorities regarding a new station, it is recommended that a plan be developed and that a package of required documentation be put together. Your local natural gas utility and companies that provide fuel, refueling stations or refueling station equipment will be able to help secure an approval for a new CNG or LNG station. These companies and knowledgeable technical experts may also be able to provide assistance related to local municipal requirements.

Detailed technical CNG Station Approval Guidelines are available for Alberta, British Columbia, Ontario, and Québec. These Guidelines outline the specific information that Authorities will need in order to review any new CNG station application.

Alberta Station Approval Guideline
British Columbia Station Approval Guideline
Ontario Station Approval Guideline
Québec Station Approval Guideline

At present, there are no similar guidelines available for LNG stations. Fleets should contact their fuel provider for advice regarding the process to get a private onsite LNG station approved.

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6. National Safety Mark

Transport Canada regulations require that modifications made to new factory-built vehicles prior to first retail sale be done by companies that hold a National Safety Mark (NSM). A NSM essentially states that the vehicle complies with all applicable Canadian Motor Vehicle Safety Standards. To apply for a NSM, a company must be Canadian and must manufacture vehicles in Canada, act as a dealer or agent for a vehicle manufacturer or import new vehicles into Canada.

Companies apply to Transport Canada for authorization to use the NSM for a specific modification or installation. For example, companies that install refuse bodies on truck chassis need to hold a NSM for that specific installation. If a company installs both the body and the natural gas fuel system, then the company needs to hold a NSM for each type of installation in order to be in compliance.

Transport Canada granted the first NSM for a natural gas fuel system installation to a Canadian company in 2012. Since then, other companies have also applied and received their NSM for natural gas fuel system installations. Vehicles manufactured in this way do not require provincial CRNs on the CNG cylinders.

To check if a company holds a NSM for a specific type of installation, consult Transport Canada’s website at the following link:


To learn more about the NSM and how it applies to a natural gas fuel system installation, refer to the following technical guideline:


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7. Fuel Pricing

**Commodity**
Natural gas is a commodity like crude oil that is traded on the open market. Crude oil pricing is reported based on the cost per barrel. Natural gas pricing is reported based on the cost per million BTU (MMBTU). A barrel of oil contains the same amount of energy as approximately 6 MMBTU.

To directly compare the commodity price of natural gas with crude oil, multiply the cost of natural gas per MMBTU by six. If natural gas is priced at $3.50 per MMBTU and oil is priced at $95 per barrel, this means that natural gas is trading at a significant discount to oil. In this example, natural gas costs 20% of the cost of an equivalent amount of energy in crude oil form.

**Dispensed**
Both oil and natural gas must be processed and delivered to refueling stations in order to be used as vehicle fuel. Natural gas is extracted, processed, moved via large transmission pipelines and then delivered via local utility distribution systems. When used as a vehicle fuel, natural gas also needs to be compressed (CNG) or liquefied (LNG). CNG can be produced wherever there is a natural gas pipe in the ground. LNG is produced at a central facility and moved to local refueling stations via tanker truck.

Compared to diesel, the dispensed cost for either CNG or LNG has less exposure to the cost of the natural gas commodity and to fluctuations in commodity cost. The graph from the U.S. Department of Energy’s Alternative Fuels Data Centre shows how commodity cost makes up a smaller portion of dispensed CNG cost compared to dispensed diesel cost.

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7. Fuel Pricing

Taxes
All transportation fuels, including natural gas, are currently subject to GST or HST. There is no federal excise tax on natural gas. This tax is levied at $.04/litre on diesel fuel. Natural gas is currently exempt from provincial road and motor fuel tax in most provinces. In British Columbia, where a carbon tax also applies to fuel sales, natural gas is taxed at a lower rate because it is a lower-carbon fuel. For current tax savings compared to diesel, see:

The unique properties of natural gas need to be considered for any new or existing facilities where CNG or LNG vehicles are to be maintained, loaded or stored indoors. When in gas form as CNG, natural gas is lighter-than-air. When in liquid form as LNG, a small amount of LNG will quickly vaporize and rise. A larger amount of spilled LNG may pool in low spots before it starts to warm and become a gas.

The cost to upgrade a facility to ensure that it is safe for indoor CNG or LNG vehicle maintenance, loading or storage will depend on the facility’s age, ceiling structure design, ventilation requirements, heating system, and the location of the electrical systems. In addition, methane detectors will be needed. As with any facility, it is also recommended that an emergency plan be available and be regularly updated and reviewed with staff.

A technical guideline is available that details the Canadian codes and standards that apply to facilities where natural gas vehicles are serviced, stored or loaded. This guideline is to be used by an engineering or architectural expert to determine what changes are needed and what they will cost. The guideline is available here:


The guideline can be used by a technical expert in order to conduct a gap analysis which will then detail what changes are required to make a facility gas-safe. As with any building modification, it is important to check regarding local municipal requirements related to facility modification.
ADDITIONAL RESOURCES

Factsheets
• Natural Gas as a Vehicle Fuel – CNG & LNG
• Comparing Natural Gas to Diesel – Energy Content
• Natural Gas Vehicle – Weights & Dimensions
• Natural Gas Vehicle – Station Safety
• Natural Gas Vehicle Fuel Systems – Inspection & Types

Websites
• Go With Natural Gas
• Canadian Natural Gas Vehicle Alliance
DISCLAIMER

This Reference Guide for OEM vehicle dealers is intended to improve access to information about natural gas as a vehicle fuel, compressed (CNG) and liquefied (LNG) vehicles, natural gas refueling, and the approvals required for fleet projects.

An increasing number of Canadian fleets are purchasing factory-built natural gas vehicles given the potential for fuel savings as well as the emissions reduction benefits. For refueling, fleets may be able to access public or cardlock stations or they may work with a third party to get a private station built at their own site.

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