

CNG and LNG Move to the Head of the Class

With High Scores for Energy Efficiency as a Fuel

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One of the hallmarks of western civilization is the increasingly efficient use of energy. For energy to be useable it must be transportable; very rarely is a source of energy and a use of energy found at the same location. Energy is typically transportable in three ways — it can be carried in wires as electricity, carried as a solid, liquid, or gas on a transport, or it can be transported as a liquid or a gas in a pipeline. The more concentrated the energy is, the easier it is to carry and to transport. On a per gallon basis, diesel fuel contains the most energy, and pure liquid hydrogen the least.

An important measure of the suitability of a fuel is the energy required to produce the fuel. Commonly known as EROEI (Energy Returned Over Energy Invested), this is the measure of the overall economics of a fuel. The more energy required to produce a fuel, the less the overall efficiency is. For example, 100 years ago about one gallon of oil was required to extract and refine 100 gallons of oil. Now, oil is a bit harder to find and producers have to drill deeper, frac rock, use horizontal drilling techniques, etc. This takes more input energy and today it takes about 13 to 15 gallons of oil to find, produce, and refine the

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same 100 gallons of oil. Those 13-15 gallons represent resources lost in the process of “harvesting” the oil we get to keep.

A low EROEI means that a fuel is more costly in absolute terms than one with a high EROEI. Of the vehicle fuels listed in Figure 1, the least energy is required to make LNG and CNG, so they have the highest EROEI.

Natural gas, in addition to being an energetic fuel and easy to extract, has recently been found to be abundant in the United States. Reserves are increasing as extraction methods become more sophisticated. It is estimated that currently the US has natural gas in reserve for at least 80 to 100 years. This abundance should result in extended price stability.

And finally, after hydrogen, natural gas is the least polluting and generates fewer greenhouse gases. Relatively high energy density, very low costs, and low pollution make natural gas an effective fuel for vehicles of all kinds. Natural gas can either be transported to a destination as a liquid, or a pipeline can be built to transport the gas. Natural gas can also be transported as compressed gas in Gas Transport Modules.

flexibility. LNG is particularly appropriate as a replacement for diesel in heavy duty engines because of its low-cost and high energy density.

Chart is one of the first companies to manufacture equipment for the whole LNG value chain, from LNG terminal equipment and liquefiers to on-board fuel tanks for vehicles, as shown in Figure 2.

LNG is produced either to make natural gas easy to transport, or to purify it by removing contaminants such as nitrogen and carbon dioxide. LNG is an odorless, colorless liquid at a temperature of -259°F. It is, at 26.5 lb/ft³, about half the density of water, and after warming up, the gas is less than half the density of air. So as a liquid it does not mix or contaminate and — once vaporized — it rises quickly to disperse safely. It is harder to ignite than normal fuels: the concentration range at which it will ignite is small, and the required ignition energy is very high.

LNG is carried in double-walled, vacuum insulated tankers. These tankers have an impressive safety record, since the outer jacket protects and shields the inner tank, even in the event of a fire. Tankers are typically designed to maximize payload to a specific country's road laws. Typically, capacities range from 15 tons to 22 tons per tanker.

Generally in the US, LNG is transferred by pumps to minimize venting and losses. Pumps are either on the ground at each site to maximize tanker payload, or on the tanker to maximize flexibility and minimize overall costs.

One of the advantages that LNG shares with conventional fuels is that large amounts of fuel can be stored in reserve for use during peak periods. Typically, storage is sized to contain a minimum of 1½ times the capacity of a road tanker to allow com-

ENERGY CONTENT OF FUELS

Fuel	Unit Energy BTU/US Gal	Content MJ/Liter
No 2 Diesel	128,000	35.68
Biodiesel (B20)	117,000	32.61
Gasoline	109,000	30.38
LPG	84,000	23.41
Ethanol (E85)	80,000	22.30
LNG	73,500	20.49
Methanol (M85)	56,000	15.61
CNG (Compressed)	33,000	9.20
Hydrogen (Liquid)	30,500	8.50

Figure 1

Source: Chart Inc.

Fueling with LNG and CNG

Liquefied Natural Gas (LNG) and Compressed Natural Gas (CNG), both technically mature fuels, have distinct characteristics. LNG has high energy density but — as a cryogenic liquid — cannot be stored indefinitely like CNG. CNG, though it can be stored indefinitely, becomes expensive when large volumes are required. In some cases there may not even be enough space on the vehicle to store sufficient CNG.

LNG follows the same distribution economics as conventional liquid fuels, such as diesel and gasoline, and provides the same

plete deliveries of a tanker before the tank runs empty. The majority of the tanks in the US are sized to hold 15,000 gallons of LNG, since trailers carry around 10,000 to 11,000 gallons.

Once in an appropriate storage tank, the LNG fuel can be used in a variety of ways. It can be dispensed directly into a vehicle tank as low-pressure LNG, it can be dispensed as saturated LNG, and it can be pumped to high-pressure and vaporized to form CNG. The East Valley station in California, operated by the City of Los Angeles, has five LNG dispensers and three CNG dispensers, all fed by the liquid stored in the tanks. The exact form in which the natural gas is dispensed depends on the engine conversion that is being used.

Fueling with natural gas has become very simple as the technology matures. It consists of connecting the fueling coupling to the vehicle tank, pushing the start button, and disconnecting the coupling when the fueling is complete. And at fueling rates of up to 30 gallons per minute, LNG fueling is very quick!

In place of a conventional diesel or gasoline tank, LNG fuel is stored in double-



LNG is carried in double-walled, vacuum insulated tankers. Photo courtesy of Chart Inc.



The East Valley fueling station in California, operated by the City of Los Angeles, has five LNG dispensers and three CNG dispensers. Photo courtesy of Chart Inc.

walled containers. They are manufactured entirely out of stainless steel, so maintenance requirements are very low. LNG tanks are larger than conventional fuel tanks since more LNG is required per mile. On average about 1.67 gallons of LNG is required to achieve the same mileage as one gallon of diesel. Typically, LNG and CNG are priced as "Gasoline Gallon Equivalents," so the price already takes into consideration the larger amount of fuel required.

The technology and experience to allow use of natural gas is known and widespread. With lower tail-pipe emissions than current,

commercially available fuels such as diesel and gasoline, natural gas can reduce greenhouse gas emissions when increasingly used as a domestic fuel. The use of natural gas as a transportation fuel also can have an immediate impact on our ability to reduce the nation's dependence on foreign oil, since vast usable natural gas reserves exist in the continental United States.

For more information on Chart's NexGen Fueling, visit www.chartindustries.com or www.nexgenfueling.com or contact Claus Emmer at claus.emmer@chartindustries.com.

TRANSPORTATION FUEL SUPPLY CHAINS — DIESEL AND LNG



Figure 2

Source: Chart Inc.