

## **Natural Gas as Fuel for Large Engines**

Natural gas is a mixture of hydrocarbon gases that can be burnt to release considerable amounts of energy. Though mainly methane, it can contain small amounts of other gases such as ethane and butane as well as inerts. Natural gas, a fossil fuel, is more environmentally friendly than other fossil fuels because it does not release harmful products of combustion to the atmosphere, other than CO<sup>2</sup>. Natural gas can be compressed and delivered by pipeline to a user, or transported by surface transport as either liquefied natural gas (LNG) or compressed natural gas (CNG). Although LNG is transported and stored in liquid form, it is converted to CNG prior to use.

Natural gas has long been used in the engines of both fixed and small mobile equipment. Its use in large fixed engines such as turbine driven generators and large spark ignition machinery is well understood and commonly used where a gas supply exists. It is also becoming more common as fuel for small spark ignition engines in mobile applications such as cars, buses and delivery trucks.

Less common has been its use on large mobile equipment such as heavy duty trucks, ships, railway locomotives and mobile mining machinery, as such equipment has normally been powered by diesel cycle engines. The energy density of diesel fuel permits large quantities of energy to be carried in relatively small fuel tanks. Recent developments in engine and fuel system design, including on-board LNG re-gasification, are now creating the opportunity for natural gas to be used as fuel in these high energy usage applications.

A political imperative has emerged to convert engines which consume large quantities of liquid fuel to natural gas. The imperative varies from country to country, but recent discoveries of shale gas in a number of countries which presently depend on imported liquid fuels have provided a significant impetus to efforts to convert to indigenous gas and reduce reliance on imports. Nowhere is this more evident than the USA, where CNG prices are consistently below Diesel Gallon Equivalent (DGE) prices by as much as \$2.00 per DGE and \$1.00 below LNG equivalent.

Three types of engine can utilize gas for all or part of their fuel requirements: spark ignition, dual fuel and high pressure direct injection (HPDI). Spark ignition engines use 100% gas for fuel but have not been used for heavy duty applications due to insufficient power and torque. Engine manufacturers are trialling large spark ignition engines up to 11 litre capacity (up to 425HP). Many of the heavy duty trucks in North America are of a size that will be able to use 400 - 425HP engines, creating the opportunity for gas to displace 100% of the liquid fuel used in such applications. Few heavy duty trucks in Australia will be able to use these 400-425HP engines as our highway fleet typically has 500-600HP engines

Dual fuel technology uses a conventional diesel engine with after-market gas delivery system fitted to mix gas with combustion air somewhere along the air intake path. The resultant air/gas mixture is compressed in the cylinder and ignited with the diesel fuel injected at the top of stroke. A number of organizations around the world are developing such systems, aware that premature detonation of the fuel/air mix presents a real danger particularly under transient load conditions. Over-fuelling, which can result in the rated horsepower being exceeded under full throttle is also a problem, however the new generation dual-fuel systems are demonstrating good reliability and typically displace 50% (on average) of diesel fuel with gas.



**COMPRESSED NATURAL GAS AS FUEL  
FOR FIXED AND MOBILE ENGINES**

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For HPDI, Westport Innovations LLC have produced the Westport HD engine, based on a Cummins ISX 15 litre diesel engine, the 550HP model of which is fitted to the IntelliGas demonstration truck. Several other major engine manufacturers have similar engines under development. The Westport design incorporates concentric injectors in which diesel is introduced into the combustion chamber as pilot fuel whilst gas is injected directly into the combustion chamber at the point of ignition. This engine enables displacement with gas of approximately 93% of the diesel fuel such an engine would normally consume.

In all mobile applications, gas may be carried on-board the vehicle as either LNG or CNG. LNG, whilst delivering high energy density relative to CNG has several characteristics that limit its appeal as a fuel. LNG is relatively expensive to produce, is transported and stored in cryogenic containers at an extremely low temperature (-160°C), and is thus difficult to decant and handle. CNG, by comparison, is stored and transported at pressure, but is fully contained in its storage and transport containers and benign to handle compared to LNG. CNG can be produced at any location that natural gas is presently available. The infrastructure to deliver CNG is therefore scalable, and CNG can be produced at locations and in quantities that match the market development.

IntelliGas has developed CNG storage and management systems that replace the LNG tanks and re-gasification systems on mobile equipment, enabling CNG to be directly used with any gas engine to displace the liquid fuel normally used in such applications. Because of the space claim and cost of the IntelliGas systems they are best applied on heavy duty high fuel usage vehicles.

IntelliGas has also developed matched re-fuelling systems that enable the delivery of Cool5000™ 350barg CNG at fill rates that match those of liquid fuels. The IntelliGas system is a 350barg system which will be complementary to the 250barg "standard" CNG delivery system common on service stations in North America. The 250 barg system will fuel the relatively short distance and low usage fleet of passenger cars and light trucks. The IntelliGas Cool5000™ system will take supply from the 250barg system and fuel the long distance, high fuel usage, heavy duty fleet.

Over 2000 CNG re-fuelling stations exist on the highways and byways of the USA, and the number grows each week. AGL has recently announced that it will install seven such stations in NSW as Australia begins to accept natural gas as a vehicle fuel. IntelliGas is building the first Cool5000™ service station at Crestmead in Brisbane to fuel its own demonstration trucks in the first instance, and is in discussion with major players in the gas industry regarding future Cool5000™ service station locations.

The age of natural gas as a viable, efficient and environmentally responsible fuel has arrived. The IntelliGas system enables the owners of heavy duty mobile equipment to power their equipment with a cost-effective and reliable CNG solution - Cool5000™ and the IntelliGas CNG Fuel Pack and Booster.