iGas: break-through application for gas to fuel large highway trucks

By Paul Whiteman, iGas Energy Holdings founder and Chief Executive Officer

The new, patented iGas system could drive a new generation of CNG-fuelled interstate highway trucks, says Chief Executive Officer Paul Whiteman. He tells *Gas Today* all about the technology and its application.

The science

How does the system work?

The key to the iGas process is to maintain pressure in the CNG cylinder as the gas is consumed by the engine. This is achieved by displacing the gas with a liquid in one CNG cylinder at a time; this keeps the CNG at a pressure that allows gas to be directly injected into the engine.

Once all of the gas in a cylinder has been used the liquid injection stops, the valves are shut and the liquid is returned to a low pressure tank. The process is then repeated for the subsequent CNG storage cylinders.

CNG is also a safe fuel and is significantly lighter than air: unlike LPG or liquid fuels, any leaks dissipate quickly. CNG is a well established and well understood fuel in Australia in buses and small trucks, and is extensively used overseas for these applications as well as in cars.

There are four subsystems: the hydraulic pack, the fuel pack, the liquid tanks and the gas drying assembly.

- The hydraulic pack is fitted inside a second battery box on the prototype truck and it comprises a high pressure metering pump which is used to pump liquid into the CNG cylinders. It is powered by a hydraulic motor which in turn is powered by a hydraulic pump fitted in tandem with the truck's power steering pump.
- The fuel pack comprises four CNG cylinders, three air actuated valves per cylinder plus two header valves and a number of manual isolation and re-filling valves. The fuel pack gives a truck the same range as a 450 L tank of diesel in a conventional engine.
- The liquid tanks holds approximately 350 L of a water-based solution that is pumped into the CNG tanks at high pressure to maintain the gas at the required pressure for direct injection into the engine.
- The gas drying assembly contains two filters that remove water vapour from the gas stream and a collection arrangement to return any condensed liquids back to the tank.

The iGas Energy Truck with fuel pack.

Paul Whiteman, former Chief Executive Officer and Managing Director of EDL, is now founder and Chief Executive Officer of iGas Energy Holdings Limited, a new company developing a patented compressed natural gas (CNG) fuel storage and delivery system to enable large high pressure direct injection (HPDI) engined trucks to run on CNG.

He has been joined in the enterprise by Jim McDonald, former Chief Executive Officer and Managing Director of the Australian Pipeline Trust (now APA Group), and Derek Fekete, previously a senior engineer with EDL. The iGas team has been working with Westport to enable CNG to be used as fuel for the Westport GX engine that uses HPDI technology.

What is the range of the fuel pack on the prototype truck?

The prototype has four CNG cylinders with a storage capacity of approximately 1,200 L of natural gas at 350 bar gauge (barg). On an energy equivalent basis this equals approximately 420 L of diesel (105 L per cylinder) or approximately 450 L when the diesel pilot fuel is added; so a typical semi trailer would get approximately 900–1,000 km range and a B double around a 600–700 km range.

We have layouts for up to seven cylinders in configurations that will still pull a maximum length B Double and up to ten cylinders if we stretch the chassis half a metre. Range is not really an issue; it is more about weight and length of the prime mover.

There are a number of refilling options for the fuel pack, depending on the application. The conventional method is to connect the cylinders to a high pressure gas compressor and let the gas flow into the cylinders until the pressure reaches the desired level. This will take around 30 minutes, subject to compressor sizing.

We have also developed a non-conventional method that uses the liquid displacement approach of the iGas process that will allow faster refuelling. In addition, we have developed the concept of a changeover fuel pack; that is where a truck pulls into the refuelling terminal and the empty fuel pack is removed and replaced with a full one. This could reduce the time it takes to refuel a truck to less than five minutes.

How much mass does the iGas system add to a truck?

The prototype truck has a four cylinder fuel pack which weighs approximately 1,200 kg when full of CNG. There is another 100 kg in the hydraulic pack and fuel conditioning system, and the additional liquid for displacing gas weighs approximately 400 kg. The total figure of 1,700 kg is offset by the reduction in diesel fuel load and tanks, so approximately 1.35 tonnes extra weights for this configuration. An eight pack, giving a range of more than 1,300 km for a B Double would add about 2.2 tonnes of extra weight.

Is the prototype running on the road?

The prototype is now registered for road use, and has successfully towed loaded trailers at highway speeds. The CNG cylinders are registered for service in Australia (they are made in the USA) and an independent engineer has certified the system as compliant and suitable for use.

What happens if the truck runs out of gas?

The HPDI injector contains both diesel and high-pressure gas injection circuits. On a typical HPDI truck operating cycle diesel fuel consumption is approximately 5 per cent of the fuel energy, while the rest is gas. To make this work properly the diesel injection circuit is by necessity very small and while it can run without gas, the engine will only deliver about 10 per cent of its rated power for a short time (ten minutes) on diesel alone. So it can run on diesel in a limited manner but cannot pull a load or operate for an extended period of time.

If the truck runs out of natural gas, the engine switches to diesel-only mode and if the truck is on the road the driver will need to pull over and stop. From there, there are a number of options including in-place refuelling or towing the prime mover.

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Will the iGas system work in this application?

Firstly, the Westport engine is proven using LNG as a fuel. In this configuration, the LNG is pumped up to high pressure by a pump submerged in the LNG and then piped to an evaporator where it becomes CNG. It is then pumped to the engine, so the Westport engine is really a CNG engine, as it already runs on CNG in LNG trucks.

Secondly, we have already proven that the injection of liquid into the CNG storage cylinder to maintain gas pressure works. We initially undertook small-scale testing to confirm the concept, and in addition identified examples overseas where the principle has been used in gas compression going back several decades. We are now focused on working through the components and the process to refine everything for absolute reliability and commercial application.

Finally, it has in the past been a challenge to get sufficient CNG storage on a truck because of its relatively low energy density. The iGas system operates at 350 barg (5,076 pounds-force per square inch gauge) which increases the energy density over previous systems by around 40 per cent. We intend that iGas trucks will carry sufficient fuel onboard to travel 1,000 km, and this prototype demonstrates that capability.

Westport's involvement

As the engine supplier for the truck, Westport has modified its control system to allow the iGas system to operate without the LNG tanks, pumps and vaporiser. We have had extensive communications with Westport over the past two years to ensure that we understand the Westport HPDI engine and controls fully, and that they understand iGas.

How do Westport HPDI engines compare with other options?

There is another option known as 'gas fogging'. The Westport engine displaces approximately 95 per cent of the diesel with gas whereas gas fogging systems generally achieve 50–60 per cent.

Gas fogging systems inject gas at low pressure with the combustion air, generally into the turbo inlet, and compress the air fuel mixture in the cylinder. When diesel is injected near the top, dead centre on the compression stroke, it spontaneously combusts, igniting the air/gas mixture.

While this works well if the engine is not heavily loaded and at low percentages of gas relative to diesel, the more gas that is introduced the greater the risk of spontaneous ignition before the diesel is injected due to the heat of compression – something that can have catastrophic consequences for the engine. The more gas that is introduced the greater the potential for detonation.

The other problem with gas fogging is over-fuelling. It is quite difficult to limit the fuel required to meet the rated horsepower of an engine when using gas to supplement diesel in this manner. The sophistication required to do this is often not contained in gas fogging installations.

Bad experiences with gas-fogged engine failures in the industry five to ten years ago have affected the take up of gas to replace or supplement diesel.

Gas fogging does provide greater fuel flexibility. Trucks fitted with a gas fogging system can still run on 100 per cent diesel, however the whole point of the iGas business case is to replace diesel with gas to reduce the cost of fuel for large trucks.

Advantages

Import replacement

From our research we believe vehicles in the initial target market for iGas burn around 4 billion L of diesel fuel annually: almost all of this is either imported refined or produced from imported crude oil. Replacement of this imported fuel with local natural gas has the potential to reduce imports by over $2 billion per year at current oil prices.

Cost and availability

Liquid natural gas is difficult to manage and handle being held at temperatures down to about minus 160 °Celsius. LNG production requires an LNG plant, which is expensive and needs to be of a large scale to be cost effective. LNG also requires insulated transport, as well as expensive insulated storage vessels at refuelling stations.

CNG can be more attractive than LNG in both availability and price. For CNG all you need is a gas supply and a compressor. There are numerous proven products available from a range of manufacturers at only a fraction of the cost of an LNG plant. A CNG refuelling point can be set up almost anywhere there is gas supply.

We envisage a number of re-fuelling stations will be established along the national highway network where gas pipelines and highways intersect. We aim to lower the cost of interstate transport.

Environmental benefits

The Westport GX engine is currently certified to Australian Design Rules (ADR) 80/02 standards and has approximately 50 per cent less particulate matter emissions and 25–29 per cent less greenhouse gas (GHG) emissions relative to an equivalent diesel engine.

While everyone understands GHG emission reduction as a key government objective, the reduction in particulate emissions (soot) from the exhaust stack is also important. This is a major emission and health issue that has been tackled so far by upgrading the diesel refining process to reduce sulphur content in fuel.

Westport has recently certified the GX 15 L engine to ADR 80/03 standards, which comes into force in January 2011. ■

HOW, WHEN, WHERE?

- iGas expects to have two trucks up and running by Christmas 2010.
- Trucks will likely be offered as tow-operator vehicles before the fuel system is available to other parties.
- Patent is approved in Australia, pending for North America and European Union.