Blue-flame trucks

Gas-powered engines are hardly new – some of the very first internal combustion engines were gas-fuelled – but it is only now, with emissions all-important, that natural gas is becoming a viable alternative to diesel power. But what technology will these engines use, and are they likely to take over soon, asks Toby Clark

The main reason for running a natural gas engine is local emissions and air quality; a modern spark-ignition natural gas engine produces much smaller quantities of nitrogen oxides (NOx) and particulate matter (PM) than a comparable diesel, without needing a complex SCR system. The other justification can be reducing carbon footprint, though this depends on the origin of the gas: biogas – methane produced from waste matter or crops – gives a lower net CO_2 figure than conventionally extracted natural gas. Volvo, for example, says that CO_2 emissions of its long-haul LNG truck are between 20% and 100% lower than diesel vehicles, depending on the fuel used. "Natural gas offers clear climate upsides, it is competitively priced in many countries, and there are sufficient reserves to justify large-scale use," says Lars Mårtensson, director, environment and innovation at Volvo Trucks.

There is an economic basis for choosing gas, too. James Walker, commercial director of truck contract hire firm Fraikin, says: "There's certainly a mileage tip-over point." For a tractor doing 100,000 miles a year, he says, "there's a significant saving for the operator," and he reckons that "well over 50% of our customers are looking at alternative-fuel vehicles".

In the 1990s a number of firms introduced spark-ignition (SI) engines fuelled by methane, supplied as either liquefied (LNG) or compressed (CNG) natural gas. There were also experiments with compression-ignition (CI) engines which typically started as a conventional DERV-fuelled diesel, then gradually introduced a proportion of gas to the fuel. Caterpillar built a 12-litre 'dual-fuel' unit which was widely demonstrated, but this never reached full production.

Since then most practical gas engines have had spark ignition, but as Martin Flach, IVECO's alternative fuels director, (pictured above) explains: "It's only recently that we've managed to get a low-compression spark-ignition engine to work with an automated manual transmission."

While diesels moved to direct injection some time ago, most SI gas engines still use indirect injection; this makes an SI gas engine slower to pick up than a diesel, while the relatively low compression ratio means it's slower to slow down.

NEW CONTROL STRATEGIES

However, new control strategies have improved matters, according to Flach. He says: "IVECO's Cursor 9 gave much better direct control. Our Euro V gas engines met Euro VI levels of NOx and PM as was, but at Euro VI there is a requirement to measure the methane coming out of the tailpipe." Methane is itself a formidable greenhouse gas, with 72 times as much global warming potential as CO_2 over a 20-year period.

Continues Flach: "We've been able to monitor the level of methane in the exhaust coming out on every exhaust stroke. At the top of the exhaust stroke we are firing the spark plug and measuring the plasma across the spark plug, so we can instantly reduce the level of methane we are injecting."

Emissions aftertreatment technologies can also help remove

CATCHING THE BUS

Gas drivetrains are also available for bus and coach applications.

This summer, Ipswich Buses trialled a biogas-powered city bus to reduce CO_2 emissions. The double-decker is based on a Scania chassis with ADL's Enviro400 body, and powered by Scania's OC09 9-litre, five-cylinder engine delivering 276bhp at 1,900rpm and 1,350Nm torque at 1,000-1,400rpm. The bus can run on biogas or CNG, and was refuelled using temporary infrastructure provided by Roadgas.

In addition, Mercedes-Benz offers its 8-litre M 936 G natural gas engine rated at 298bhp for Econic municipal vehicles, and its Citaro bus range.

any so-called methane slip, points out Andrew Noble, head of commercial vehicle, off-highway, defence and industrial market sector at engine designer Ricardo Global Automotive, speaking at the 2018 IRTE Conference (for a full report, see this month's included supplement, p16).

Spark-ignition engines would be expected to produce less torque at a given capacity than their compression-ignition counterparts, but some offer performance roughly comparable with a modern diesel. Scania's 12.7-litre OC13 gas engine, rated at 404bhp and with a compression ratio of 12.6:1, produces a maximum torque of 2,000Nm from 1,100rpm, whereas its diesel equivalent (the DC13) has a compression ratio of 20:1 and puts out 2,150Nm from 1,000rpm. Scania also offers 9-litre engines producing 276bhp and 335bhp.

SI gas engines, however, also tend to have shorter service intervals than diesels due to the need to replace spark plugs. Scania has extended these intervals from 30,000km to 45,000km in its latest models.

IVECO's Cursor range of gas engines now includes a 325bhp 8-litre, a 395bhp 9-litre and a 13-litre rated at 454bhp.

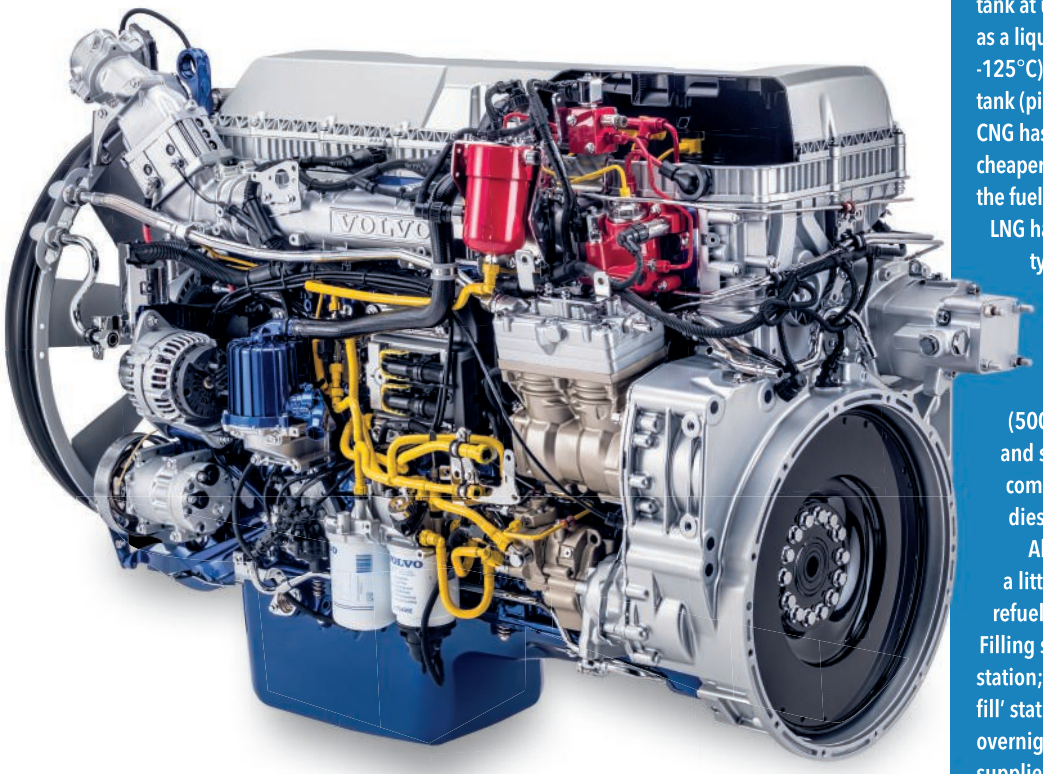
The top-rated engine was launched this summer. IVECO's new Stralis NP 460 (pictured below left) is the first three-axle, 44-tonne truck to operate on 100% liquefied natural gas (LNG). Powered by a 12.9-litre Cursor 13NP engine through a Hi-Tronix 12-speed automated transmission with electronic clutch, the new version relies on dual gas tanks to provide a potential 750km range, while still allowing 22.5in wheels across all three axles. The NP vehicle joins IVECO's 4x2 model, which launched in 2016.

Packaging a gas tank and ancillaries on a 6x2 is tricky, but "having a 6x2 available means we are no longer just selling to supermarkets and parcels carriers – we've got the product that people want", says Flach (see also *https://is.gd/amudep*).

Scania also offers 9-litre, 276bhp and 335bhp gas models that, like others, can be integrated into multiple chassis configurations, including 18-tonne 4x2s, 26-tonne 6x2 and 6x4s, 32-tonne 8x4s, and 32-tonne and 40-tonne 4x2 tractors. However, it has no plans for a natural gas 44-tonner: "If you want a long-haul 6x2 tractor, we recommend a Euro VI diesel,"

"There is still room for improvement on SI engines. Many of the things we're looking at on diesel vehicles can also be done on gas vehicles"

Martin Flach



says David Burke, Scania GB's specialist gas sales executive.

Despite this, Scania has trained 250 specialist gas technicians in anticipation of its vehicles' commercial operations and it believes it now has a range large enough and appropriate for the UK market. Adds Burke: "We are growing at the pace of infrastructure development." (See also p15.)

DIRECT INJECTION

Direct injection of gas in a diesel-cycle engine has long proved elusive, but Volvo recently launched CI gas engines that use high-pressure direct injection (pictured above). However, as this is not sufficient to initiate combustion, to ignite the gas, a 'tiny quantity' of diesel is added at the moment of injection. This is very different from the 'dual-fuel' engines of the 90s, which burned no more than around 60% gas – here the figure is well over 90%.

The thermodynamic efficiency is better than an SI engine, as you would expect – Volvo says fuel consumption is on a par with its diesel engines, and "15-25% lower than for conventional gas engines". The 454bhp version of its G13C gas engine delivers maximum torque of 2,300Nm, the same as the corresponding diesel. There's also a smaller 414bhp/2,100Nm variant. Both are compatible with Volvo's I-Shift automated gear changing system. On the other hand, it's a complicated driveline, which requires a small auxiliary diesel tank as well as SCR and a particulate filter.

While gas engines are intrinsically clean-running, claims of 'no particulates' are a thing of the past. Although the mass emitted by a gas engine is very low, there is still a significant amount of very small (sub-micron) PM. Flach predicts that the future Euro VII emissions standards will impose greater controls on these: not just particulate mass or number, but size as well. Euro VII might also start to look at the speciation of NOx – the proportions of NO, NO_2 and N_2O. The latter, nitrous oxide, is a greenhouse gas with around 300 times the warming potential of CO_2, and is also harmful to the ozone layer. To control emissions, IVECO might need to install particulate filters.

But it won't stop there. "There is still room for improvement on SI engines," concludes Flach. "Many of the things we're looking at on diesel vehicles can also be done on gas vehicles." Waste heat recovery is an example. "It works and it gives a reasonable fuel saving, but the costs don't balance yet." Other developments include 'smart' ancillaries or electronically-controlled valves, but these are only likely to be adopted once 48V electrical systems – so-called 'mild hybrid' systems – appear in trucks. "It may be that these things come in quicker on the gas engines than the diesels." TE

CNG vs LNG

While CNG and LNG are ultimately the same fuel, there are important practical differences. CNG is stored in a pressurised tank at up to 250bar, whereas LNG is stored as a liquid at low temperature (typically -125°C) in an insulated low-pressure tank (pictured in main image, pp10-11). CNG has some advantages: the tanks are cheaper – hence so are the vehicles – and the fuel itself costs marginally less. But LNG has a higher energy density per litre: typically 2.5 times that of CNG. Even so, this is still only around 60% of the energy density of diesel.

Lower energy density means less range: around 750km (500mi) for IVECO's 6x2 LNG tractor, and substantially less for a CNG tractor, compared with well over 1,000km for a diesel truck.

Also, filling up with LNG takes only a little longer than diesel, whereas refuelling with CNG can take a while. Filling speed also depends on the type of station; it is possible to operate a 'slow-fill' station with a small compressor for overnight fills, but the ideal is a station supplied with mains gas at the highest pressure available. For example, John Lewis uses CNG Fuels' public station in Leyland, which supplies gas at around 75bar, according to IVECO's Flach.

Of the engines profiled here, the Volvo G13C uses LNG. IVECO and Scania supply either CNG or LNG, depending partly on axle configuration.