

G-volution Optimiser — Technical Overview



G-VOLUTION™

What is it?

Designed, developed, manufactured and patented in the UK, the G-volution Optimiser is new, award winning, technology (Shell Springboard) which will facilitate the roll out of future “green” multi-fuelling solutions for the commercial transport sector.

A unique system that allows a large diesel engine to operate on a mixture of two (or more) fuels rather than one; the fuels are combusted simultaneously, rather than one at a time.

Using diesel as the primary fuel and Liquefied Petroleum Gas (LPG) as the secondary fuel (currently), the Optimiser provides forward thinking companies with a simple bolt-on solution that delivers significant fuel cost and emission savings straight away.

And, as the fuel market develops, G-volution Optimiser will be the ready and proven path to market for those alternative fuels as they become available, such as: CNG, CBG, LNG, Bio-ethanol, Bio-butanol, Methanol, Hydrogen.

The benefits

By replacing a proportion of the diesel fuel with LPG, this generates a direct cost saving (as LPG is less than half the cost of diesel at current prices). This saving can improve further - if lower cost bunkered LPG is utilised. Also, as these two fuels combust more efficiently than a single fuel, this combustion improvement effectively leads to a reduction in emissions.

Although LPG is a fossil fuel it has a lower Carbon content than diesel; which produces a carbon saving of 5-6% at the current average substitution ratios.

On this basis and its future ability to deliver “greener” multi fuel solutions, the G-volution Optimiser has been accepted into the Carbon Trust incubator scheme.

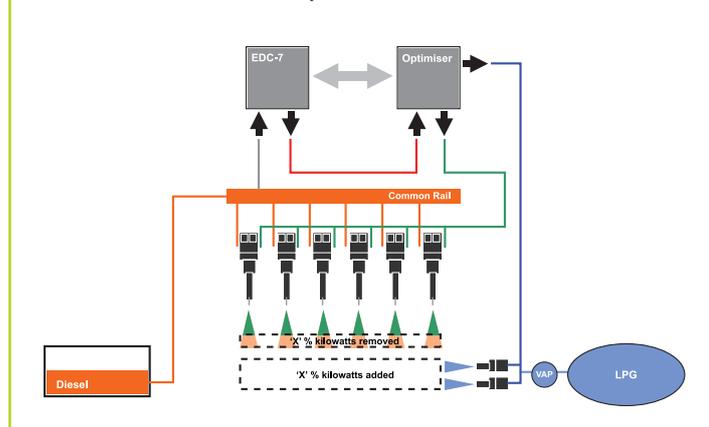
How it works

The diesel fuel is delivered to the engine by the original diesel system; whilst the LPG is delivered by a proprietary gas system that is retrofitted to the vehicle.

The G-volution Optimiser works via a unique patented principle of operation that is actually very simple.

Firstly, it measures the duration of the original diesel injector control signals,

G-volution LPG Dual-Fuel System



and then calculates the expected power output for the engine.

Secondly, the original diesel injector control signals are intercepted and modified to reduce the duration of the diesel injection signal.

Thirdly, the amount of LPG required to replace the power lost by reducing the diesel fuelling is injected into the engine.

Therefore, the power output of the engine is unchanged when operating on two fuels simultaneously.

The ratio of power derived from the two fuels (the substitution ratio) is controlled in real time by the Optimiser's Software.

The Gas System

The controller, pipe work, wiring harnesses and all fixings are all manufactured exclusively for G-volution to our original designs. All other gas components are obtained from standard high quality automotive industry sources, and are, therefore, either BS or LPGA approved.

LPG storage: The LPG is stored normally in the liquid state, in a medium pressure tank. The tank requires clear space to be mounted on the chassis. There is a manual gas valve on the outlet of the tank which can be used by an operator to disable the gas system during maintenance or servicing.

The inlet to the tank is connected to a standard LPG filling bayonet connector (one can be fitted to each side of the vehicle to facilitate easy refuelling in commercial filling stations). The LPG tank is immensely strong and is tested to withstand severe impacts, to ensure there is little danger of a gas leak in the event of an unexpected road traffic accident.

The amount of LPG stored in the tank ensures that, with normal substitution ratios, the range of the vehicle when using two fuels is approximately the same as for diesel-only operation.

The LPG in the tank can be a mixture of liquid and gas depending on the pressure and temperature; typically the pressure of the LPG in the tank will be between 4 and 20 bar. This is measured by an electronic pressure sensor on the output of the tank located after the manual safety valve.

Vaporiser: The LPG in the tank goes to this device via an electronically controlled gas shut off valve (the vaporiser is basically a heat exchanger and a pressure regulator combined). The purpose of the vaporiser is to ensure that all the LPG from the tank is converted into a gas - at a constant pressure. We achieve this using a combination of reduction in pressure and an increase in temperature.

Whenever LPG changes state from a liquid into a gas it absorbs energy; the same principle as used in a refrigeration unit. Therefore, energy in the form of heat must be supplied to stop the vaporiser freezing and the LPG recondensing. This heat energy is obtained from the hot water of the cooling system of the engine.

The connection to the cooling system is close to the water pump (but before the thermostat), to provide a good constant flow under all conditions. The amount of water diverted is small in comparison to the normal cooling system flow and does not affect the operational temperature of the engine.

Gas Injection: The output from the vaporiser is passed through an electronically controlled gas shut off valve. Immediately prior to the gas injectors is a combined pressure and temperature sensor with an

Award winning multi fuelling technology; the G-volution 'OPTIMISER'™ will facilitate the roll out of future “green” multi fuelling solutions to the HGV sector whilst delivering significant operational benefits:

- Reduction in running (fuel) costs
- Reduction in harmful emissions
- Proven reliable technology
- Multi fuel capability

Advanced
Multi-Fuel
Technology



integrated gas filter. For all gases there is a fixed relationship between pressure, temperature and volume. Therefore by measuring the pressure and temperature, the G-volution Optimiser controller can accurately determine the volume of gas that's required to be injected into the engine to generate the required power.

The system uses two electronically controlled injectors. These inject the gas into the engine inlet tract immediately prior to the turbo charger. This point is effectively at constant (atmospheric) pressure, therefore, there is no need to compensate for Manifold Absolute Pressure (MAP). The pipe work is designed to ensure that all of the injected LPG gas passes directly through the turbo charger. By injecting before the turbo charger we ensure the gas is distributed evenly in the air (homogeneous mixture) when it reaches the engine cylinder - thus preventing hot spots and uneven cylinder dosing.

Controller: The system uses an Electronic Control Unit (the Optimiser), which connects into the wiring harness between the OEM ECU and the diesel injectors. This is achieved using mating connectors so that the OEM wiring harness remains intact at all times (it can simply be re-connected if the G-volution Optimiser should ever be uninstalled).

The Optimiser is connected to the electronic gas system components via a wiring harness and connectors. The Optimiser is also connected to a number of the engine sensors, which are used primarily for monitoring the operation of the engine for development purposes rather than functionally.

The Optimiser is entirely self contained and does not require any additional cooling; it is powered by a single connection to the vehicle's +24V supply.

Why it works

The G-volution Optimiser is a sophisticated real time controller designed specifically for this application by experts in the field of diesel engine control. This provides full software control for all the parameters necessary for the implementation of a successful multi-fuel strategy. The software "mapping" in particular is critical in determining the correct substitution ratio and settings for the operational state of the engine.

Master/Slave: The Optimiser connects to the diesel injector control signals; these are outputs from the OEM ECU. The system is only responsible for translating these outputs into control signals suitable for controlling both fuel types. Therefore, the OEM ECU is completely unaffected and continues to operate normally, maintaining

full control of the engine operation and its power at all times.

Substitution Ratio: The substitution ratio varies according to the operational state of the engine between 0 and 49%, therefore, at all times, the engine remains primarily a diesel engine. This is an important distinction from both a regulatory and functional perspective.

The Results

Fuel costs: The G-volution Optimiser produces significant fuel cost savings under all normal operational conditions. This includes all routes, speeds and conditions, not only when cruising on motorways. **The average net fuel cost saving actually achieved can be in excess of 15%.**

The minimum net fuel cost saving of around 9% would typically be achieved with very light loads (including tractor unit only) on easy routes. The maximum fuel cost saving for heavy loads and arduous routes would be up to 20%.

These variations are because it is very difficult to combust large quantities of gaseous fuel efficiently at low engine powers (as the flame front is too small). Obviously, for light loads, a diesel only fuel consumption would be a better solution.

Diesel Reduction: The average diesel reduction is typically between 25% and 40% for an operator when using a mixture of two fuels compared to diesel only.

Comparing the performance of a diesel only engine is actually very difficult to do, when comparing against a mix of fuels in anything other than test conditions. This is because the fuel consumption of a HGV and trailer is affected by a very large number of factors.

One feature of the G-volution Optimiser is its ability to record power logs and statistics for up to a month at a time. These figures enable us to accurately calculate the percentage of diesel reduction achieved on any runs during a set period. It is anticipated that this information could be made available to the operator using an in cab display, or via a telemetry system in the near future.

Safety

LPG is already widely used as an automotive fuel and it is not intrinsically less safe than petrol or diesel when treated correctly. However, the only additional precaution to highlight is that, because it is denser than air, it will tend to collect at the lowest point if discharged.

The LPG is only injected into the air inlet system as and when required, so the concentration of LPG in the inlet system is never high enough to create a volatile or flammable mixture. The maximum transit delay through the manifold for the LPG depends on the rpm of the engine.

At 800 rpm, we calculate this to be a worst case - of 0.3 seconds. Therefore, any LPG in the inlet system is totally purged within a fraction of a second of the injection being stopped. The two electronic gas shut-off valves, located on the input and output of the vapouriser respectively, are fail safe devices; if they are not energised, they will default automatically to the shut off condition.

The G-volution Optimiser implements a diagnostics routine at start up to check the proper functionality of the gas system and gas components. Should a fault be detected, the gas system shuts down and the system reverts to diesel-only operation; the same is true if a fault is detected at any time during normal operation. This includes low LPG tank pressure, so that the system will revert to diesel-only operation if the operator runs out of LPG, or the manual tank valve is turned off for any reason.

G-volution's system ensures that the vehicle operates within the manufacturer's specifications at all times, as it never over-powers or under-powers the engine at any time.

The modified diesel injector control signals are hardware interlocked with the original diesel injector control signals. This means that they can never become active and inject diesel outside of the normal injection window, even under fault conditions.

Operation

The vehicle will always start-off on diesel fuel only. When the vaporiser water temperature has exceeded a preset threshold, and the gas system is within normal parameters, the system will automatically switch to dual fuel operation when a low power threshold is exceeded (this ensures the vehicle remains on diesel-only when idling).

The system will automatically revert to diesel-only operation if the operator runs out of LPG or a fault is detected with the gas system.

The system requires no user maintenance other than regular filling of the LPG tank, normally at the same time as the diesel tank.

The vehicle drives and behaves exactly the same when using two fuels as it does on diesel-only.



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