



SHELL GTL FUEL BENEFITS GUIDE

Shell
GTL Fuel

SYNTHETIC TECHNOLOGY FOR CLEANER AIR

Version 2.6



Benefits stated in this guide may vary according to type of operation, equipment, and operating conditions. All comparisons are with conventional crude derived diesel.

SHELL GTL FUEL IS A LIQUID FUEL THAT IS A CLEANER BURNING ALTERNATIVE TO DIESEL

Shell is a pioneer of Gas-To-Liquids (GTL) technology which manufactures hydrocarbon products from natural gas using the Fischer-Tropsch [process](#). This process breaks down gas molecules and reassembles them into larger uniform molecules in a carefully controlled manner. One of the products is Shell GTL Fuel, an alternative fuel that is cleaner-burning compared to standard diesel. Because this manufacturing process produces more consistent and uniform molecules compared to conventional crude oil refining, GTL Fuel has improved combustion properties inside standard diesel engines and so helps reduce emissions of air pollutants. It is also free of unwanted components such as sulphur, metals, and aromatics, making it non-toxic and therefore less harmful to the environment.

As the world transitions to lower emission mobility, Shell believes that GTL Fuel will be part of the fuel mix that will be needed to power the future, alongside e-mobility, biofuels, LNG, hydrogen, CNG, LPG, diesel, and gasoline.

Shell GTL Fuel can be used in existing heavy-duty and light-duty diesel engines without the need for engine modifications, new infrastructure or vehicle investment. It is particularly well positioned to reduce emissions from heavy-duty engines where the fuel's benefits are largest compared to conventional diesel. GTL Fuel is therefore suitable in the transport sector, for example city utility vehicles, public transport, rail, and inland and offshore shipping. It is also equally suitable in construction machinery and power generation equipment.

It is estimated that there is currently sufficient global supply of GTL fuels to meet around 30% of the UK's entire national diesel demand, or the total diesel demand of any of the Scandinavian countries.

GTL Fuel is part of the family of fuels called "paraffinic fuels". The European Standardisation body CEN [published](#) the final specification for paraffinic fuels, EN-15940, in mid-2016, paving the way for legislators and manufacturers to specifically refer to these alternative fuels in legislation and handbooks.



SHELL GTL FUEL CAN BE USED DIRECTLY IN DIESEL ENGINES, OFFERING MANY POTENTIAL BENEFITS

Shell GTL Fuel offers many potential benefits when compared to conventional crude derived diesel.

- Drop in fuel – Can be used as a direct replacement for conventional diesel fuels without the need for modifications to engines or infrastructure.
- Can reduce the noise levels in some engines thanks to more uniform combustion.
- Better starting performance in cold conditions due to higher cetane number.
- Better safety, handling and storage characteristics due to a higher flash point.
- Reduced emissions of regulated pollutants: Nitrogen Oxides (NO_x), Particulate Matter (PM), Carbon Monoxide (CO), and unburnt hydrocarbons (HC's). The below table gives the estimated benefit range* that can potentially be expected from using Shell GTL Fuel in each of the market segments compared with conventional diesel.

Market	Example Applications	Characteristic NO _x Reduction Range	Characteristic Particulate Matter reduction range	Noise reductions reported by customers
On-Road Heavy Duty	Public buses, city utility vehicles, transport trucks	5-37%	10-38%	Limited benefit reported
Off-Road	Cranes, diggers, power generators, trains	6-25%	10-90%	Benefits reported 3-5dB
Marine	Offshore vessels, inland barges, tourist boats	6-13%	15-60%	Benefits reported around 8dB
On-Road Light Duty	Passenger cars, Vans, Small tractors, etc.	Shell has focused on the Heavy Duty and Marine markets which have a more immediate need to use cleaner-burning GTL Fuel considering increasing emissions-related regulations. Fewer tests have been carried out for Light Duty vehicles. However, the results to date indicate that GTL fuel also potentially offers significant benefits in particulate emissions for Light Duty vehicles.		

* Ranges are used to account for the fact that benefits may vary from engines of different sizes, powers, manufacturers etc. This range is not exact: It represents the maximum variation in results observed in scientific experiments which compared emissions from Shell GTL Fuel with conventional diesel. These trials were conducted by both Shell laboratories and a variety of independent organisations: On-road data was gathered both from Shell in-house laboratories and also in partnership with independent test partners including AVL, TNO, Millbrook UK, NREL USA, among others. Off-Road data was gathered from customers who performed their own independent tests and shared their detailed results with Shell. Marine data was gathered by external test houses like SGS NL BV investigating vessels sailing on GTL, and from independent tests by marine engine manufacturers. Some more details of these tests can be found at the end of this paper.

SHELL GTL FUEL IS NON-TOXIC, READILY BIODEGRADABLE, AND EASIER TO HANDLE

Under criteria recognised by the European Chemicals Agency ([ECHA](#)), Shell GTL Fuel is classified as having health and environmental benefits[†]. This is because it is not harmful if inhaled, fumes pose less risk of eye irritation, there is less risk of skin irritation and it does not cause significant organ damage through prolonged or repeated exposure. In vitro [tests](#) also indicate that the fuel is not materially carcinogenic.

Shell GTL Fuel is more biodegradable than conventional diesel. OECD [301](#) and [307](#) tests have shown that GTL Fuel can be classified as 'readily biodegradable', and was not detectable in soil 51 days after being introduced.

GTL AND CO₂ EMISSIONS

Shell uses the Life Cycle or Well-to-Wheels (WtW) method for comparing GHG emissions, in line with industry practice. On a WtW basis, some GTL products have lower intensity than their conventional equivalents and some higher, but the total emissions are broadly comparable with the equivalent quantity of products from conventional refining. Differences in assumptions and methodologies can lead to variations in the results.

The European Commission has reviewed the CO₂ values for various fuels on a WtW basis. Their evaluation of GTL's carbon intensity, available in Fuels Quality Directive [Annex 7a](#), is 94.3 gCO_{2eq}/MJ, and their value for conventional diesel is 95.1 gCO_{2eq}/MJ.

Certain municipalities and legislations reference Tank-to-wheel (TtW) CO₂ emissions, and many fleet operators report them or are regulated on them. TtW emissions from Shell GTL Fuel have typically been measured at 4% to 5% lower than standard crude-derived diesel[‡]. This is due to the higher energy content and higher hydrogen-to-carbon ratio of the fuel.

[†] When compared with conventional Diesel, which is defined as the fuel derived from the gasoil cut produced during the refining of crude oil

[‡] According to tests conducted by Shell laboratories as well as engine manufacturers, including MTU and Volvo.

EXAMPLES OF WHY CUSTOMERS CHOOSE SHELL GTL FUEL[§]

ON ROAD

Qbuzz Utrecht Public Buses	Groningen All municipality diesel equipment	Van Keulen Amsterdam construction supplier
 <p>Qbuzz is the operator of public buses in Utrecht. They found that switching to Shell GTL Fuel significantly reduced their maintenance costs of after-treatment systems.</p> <p>Read a news article (in Dutch)</p>	 <p>Groningen chose to switch all their municipal vehicles to Shell GTL Fuel to help improve the city's local air quality. Vehicles include garbage trucks, street cleaners, vans, ATV's, tractors, etc.</p> <p>Download their testimonial</p>	 <p>Van Keulen conducts deliveries in Amsterdam's narrow streets. Shell GTL Fuel enables them to reduce their local emissions.</p> <p>Download their testimonial</p>

OFF ROAD

Mammoet Largest Dutch crane company	The Hague Dutch Municipality	DB Cargo Nederland (DBCN) Dutch train operator
 <p>After conducting in-house emissions testing, Mammoet in NL decided to switch 200 cranes and 50 trucks to Shell GTL Fuel.</p> <p>Read their press release</p>	 <p>In order to improve local air quality, The Hague municipality together with BAM, a construction company, selected Shell GTL Fuel to power all diesel equipment used in a large city construction project.</p> <p>Read news article (Dutch)</p>	 <p>DBCN switched to Shell GTL Fuel at their Chemelot plant in Limburg because it reduced their local emissions and helped reduce maintenance and operational costs.</p> <p>Download their testimonial</p>

[§] Note that the stated benefits and results in this section have not been validated or tested by Shell. Benefits may vary according to type of operation, equipment, and operating conditions.

MARINE

<p>Wagenborg Kronborg offshore maintenance vessel</p>	<p>Scylla European River Cruises</p>	<p>BlueBoat Company Amsterdam Tourist Boats</p>
 <p>The first offshore ship in the world to run on Shell GTL Fuel, the Kronborg services unmanned North Sea platforms. If platform workers are downwind of the ship's engine exhaust, Shell GTL Fuel helps to improve the quality of the air that they breathe.</p> <p>Visit the website</p>	 <p>Scylla operates luxury river cruises across Europe. In France, they have switched to Shell GTL Fuel to help to lower emissions and thus improve the air quality for their passengers and residents living near waterways.</p> <p>Read their press release</p>	 <p>BlueBoat Co. operates tourist boats in Amsterdam's canals. They switched 11 diesel powered boats to Shell GTL Fuel to reduce engine noise and emissions for the benefit of the local community.</p> <p>Read their press release</p>

THIRD PARTY PUBLICATIONS

In addition to the large body of research conducted by Shell, a variety of publications have been made by independent organisations that discuss the benefits of GTL Fuel. A summary of these is presented in the table below. Note these results have not necessarily been validated by Shell, and benefits may vary according to type of operation, equipment, and operating conditions. All comparisons are with conventional crude derived diesel.

ON-ROAD MARKET APPLICATIONS

Organisation, Year	Summary of Results	Link
<p>TNO, 2014</p> <p>The Netherlands Organisation for Applied Scientific Research</p>	<p>“For relative simple systems such as Euro III, measurements showed NOx reductions in the range of 5-19% and PM reductions in the range of 10-34%.</p> <p>For engines with more advanced emission control systems, the relative variations in NOx and PM can be larger. For Euro V SCR engines, measurements showed NOx reductions in the range of 5-37% and [total] PM reductions up to 33%.”</p>	<p>Link</p>
<p>Kings College, 2009</p> <p>The Kings College Environmental Research Group modelled the impact on emissions and ambient air quality associated with the switch in London of all diesel vehicles to GTL Fuel.</p>	<p>The emissions and air quality impacts of introducing GTL fuel in London.</p> <p>Shell collaborated with King’s College Environmental Research LAEI Group* in 2007-2009 and funded research to assess the potential impact on air quality of switching most diesel fleets in London to Shell GTL Fuel. Specifically, the study asked: Can GTL, through vehicle emissions reductions, help achieve air quality standards such as the EU limit standards? For example, can it have an influence on ‘non-attainment’ Air Quality episodes?</p> <p>The project simulated fuelling 5 of the 7 London fleet vehicle classes with Shell GTL Fuel, assessing total emissions from vehicles and other sources both before and after the GTL scenario, then producing pollutant (PM and NO₂) concentration maps of London. The model suggests that the use of Shell GTL Fuel can potentially help to reduce Air Quality exceedance areas by 19-39%.</p> <p><small>*This group monitors and models London Air Quality to guide the city transport policy decisions. The LAEI is the London Atmospheric Emissions Inventory and is released by the Greater London Authority.</small></p>	<p>Report available upon request</p>
<p>SAE, 2010</p> <p>Society of Automotive Engineers. Technical Paper 2010-01-2191</p>	<p>Evaluation of Fischer-Tropsch Fuel Performance in Advanced Diesel Common Rail FIE.</p> <p>Research conducted in collaboration with Delphi demonstrating the durability performance of GTL in fuel injectors and pumps is on par with conventional Diesel. The results obtained indicate that the performance of the fuel is at least comparable to conventional hydrocarbon fuels and superior in a number of areas.</p>	<p>Link</p>
<p>SAE, 2009</p> <p>Society of Automotive Engineers. Technical Paper 2009-01-1934</p>	<p>Benefits of GTL Fuel in vehicles equipped with Diesel Particulate Filters.</p> <p>“Results indicated that GTL fuel reduced particulate formation to such an extent that the regeneration cycle was significantly elongated, by ~70% compared with conventional diesel [...].</p> <p>In terms of regeneration behaviour there was broad similarity between the two fuels, indicating that no adaptation of DPF management is required for vehicles operated on GTL fuel.”</p>	<p>Link</p>

OFF-ROAD MARKET APPLICATIONS

Organisation, Year	Summary of Results	Link
<p>Mammoet Europe B.V., 2016 Mammoet is the largest operator of heavy lifting equipment in The Netherlands.</p>	<p>Mammoet conducted their own extensive in-house testing before deciding to switch their entire fleet to Shell GTL Fuel. Watch their video online where they describe the benefit, notably NOx emissions reduced by up to 13%, particulates by up to 22%, and carbon monoxide by up to 28% compared to conventional diesel. More detailed results from their testing are available upon request.</p>	<p>Link to video (Dutch)</p>
<p>Deutsche Bahn, 2012 DB is the German railway company. They tested the benefits of GTL Fuel in a number of their trains.</p>	<p>Engine dynamometer tests of GTL Fuel and Automotive gasoil. Tests took place at Deutsche Bahn maintenance plant in Bremen in October 2012 using a common rail engine. Emission-measurements were conducted by TÜV-Nord, an independent testing institute. Emissions reduction results of GTL Fuel versus conventional gasoil as follows (Rail Cycle/Idling): NOx: 6% / up to 22% PM: 28% / smoke number* up to 54% CO: 14% / up to 32% HC: 11% / up to 21% <small>*Smoke number is a measure of exhaust opacity</small></p>	<p>Presentation available upon request</p>
<p>DB Cargo Nederland, 2014 Nederland N.V. is The Netherlands' largest rail transport operator and a subsidiary of Deutsche Bahn AG. They use GTL Fuel in a number of their locomotives.</p>	<p>"The biggest advantage of Shell GTL Fuel to us is that it burns visibly cleaner than the regular diesel we used before. "In particular, we notice that the exhaust soot (particulate matter) is less. Test results have shown soot reduction in our modern engines up to 60% across the tested two locomotives and two robots compared to the regular diesel used before. In the older engines, we have measured reductions up to 95%. "With the help of Shell GTL Fuel, the total maintenance savings on the six machines were about €75.000 for a period of one year compared to the regular diesel used before. "Furthermore, thanks to the cleaner burning Shell GTL Fuel we no longer use soot filters in any of our shunting locomotives and robots."</p>	<p>Link to report</p>
<p>Sensors Europe GmbH, 2010 Sensors Inc. is a leading designer and manufacturer of gas analysis technology for the transportation industry.</p>	<p>The Effects of GTL Fuel on Local Emissions from Service Vehicles at Dubai Airport. Sensors Inc. measured the emissions benefits of switching different ground equipment to Shell GTL Fuel compared to regular diesel. They tests a mixture of buses and ground handling vehicles. They found that NOx emissions were reduced by between 14 and 27%. Most vehicles showed reductions in soot emissions by over excess of 54%.</p>	<p>Report available upon request</p>

MARINE MARKET APPLICATIONS

Organisation, Year	Summary of Results	Link
<p>TNO, 2014 The NL Organisation for Applied Scientific Research.</p>	<p>The following technical information was available and reviewed for this study:</p> <ul style="list-style-type: none"> ■ Information of earlier TNO publications ■ External technical publications ■ Technical reports with test results with GTL fuel <p>Based on these evaluations, the following is concluded with respect to Shell GTL fuel as replacement for regular diesel fuel (EN590) for the relative conventional ship engines:</p> <ul style="list-style-type: none"> ■ NOx reductions in the range of 8% to 13% ■ [Total] PM reductions in the range of 15% to 60% 	<p>Link to report</p>
<p>Hamburg Port Authority, 2016 Governing body for all vessel movements in Hamburg</p>	<p>HPA conducted trials on one of their harbour vessels, and found that Shell GTL Fuel reduced emissions compared to conventional marine gasoil:</p> <ul style="list-style-type: none"> ■ NOx emissions reduced by 10.5% ■ Particulate emissions reduced by 52.7% 	<p>Link to press release (German)</p>