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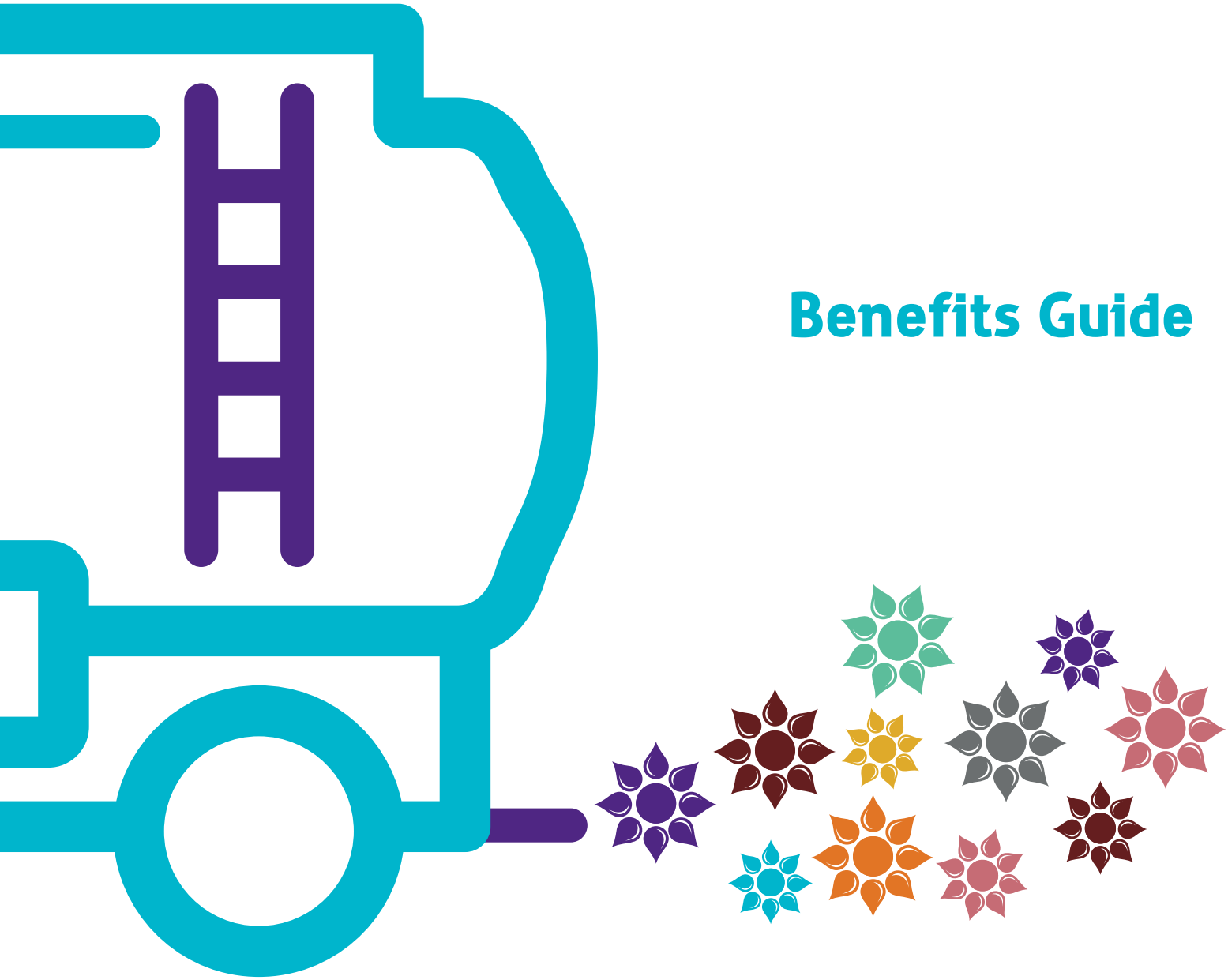
Shell GTL Fuel

Cleaner fuel for cleaner air



Benefits Guide

Shell GTL Fuel

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.

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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 is 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 CO_2 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 CO_2 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) CO_2 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.

† Conventional Diesel 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.

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Examples of why customers choose Shell GTL Fuel*

ON ROAD

Qbuzz - Utrecht Public Buses

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.

Groningen - All municipality diesel equipment

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.

Van Keulen - Amsterdam construction supplier

Van Keulen conduct deliveries in Amsterdam's narrow streets. Shell GTL Fuel enables them to reduce their local emissions.

OFF ROAD

Mammoet - Largest Dutch crane company

After conducting in-house emissions testing, Mammoet in NL decided to switch 200 cranes and 50 trucks to Shell GTL Fuel.

The Hague - Dutch Municipality

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.

DB Cargo Nederland (DBCN) - Dutch train operator

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.

All articles are available in a pdf format. Please speak to one of the team who will be able to help.

* 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.

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
TNO, 2014 The Netherlands Organisation for Applied Scientific Research	**"For relative simple systems such as Euro III, measurements showed NO_X reductions in the range of 5-19% and PM reductions in the range of 10-34%.** For engines with more advanced emission control systems, the relative variations in NO_X 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%."
Kings College, 2009 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.	**The emissions and air quality impacts of introducing GTL fuel in London.** 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? 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 NO_2) 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%. *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.
SAE, 2010 Society of Automotive Engineers. Technical Paper 2010-01-2191	**Evaluation of Fischer-Tropsch Fuel Performance in Advanced Diesel Common Rail FIE.** 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.
SAE, 2009 Society of Automotive Engineers. Technical Paper 2009-01-1934	**Benefits of GTL Fuel in vehicles equipped with Diesel Particulate Filters.** "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 […]. 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."

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OFF-ROAD MARKET APPLICATIONS

Organisation,Year	Summary of Results
Mammoet Europe B.V., 2016 Mammoet is the largest operator of heavy lifting equipment in The Netherlands.	**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.
Deutsche Bahn, 2012 DB is the German railway company. They tested the benefits of GTL Fuel in a number of their trains.	**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% *Smoke number is a measure of exhaust opacity
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.	**"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."
Sensors Europe GmbH, 2010 Sensors Inc. is a leading designer and manufacturer of gas analysis technology for the transportation industry.	**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%.

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For more information on Shell GTL fuels

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