Paraffinic Fuels: Environmental benefits

Equivalence of emissions' performance for different classes of paraffinic fuels (GTL & HVO) meeting the EN15940 (Class A) standard

Paraffinic diesel fuels meeting the EN15940 Class A standard offer cleaner alternatives for transport. Paraffinic fuels are clean, high quality diesel fuels made from a wide variety of feedstocks, and include GTL (Gas to liquid), as well as HVO (Hydrotreated Vegetable Oil). Paraffinic fuels are fungible and can be used at any blending rates up to 100% in current and future diesel engines[1]. Therefore, these fuels can be distributed, stored and used with the existing infrastructure, and are available now.

Paraffinic fuels meet all the fuel quality standards set in European legislation (Directive 2009/30/EC). Paraffinic fuels are also described by EU legislation as fuels that can serve as "substitute for fossil oil sources in the energy supply to transport and which have the potential to contribute to its decarbonisation and enhance the environmental performance of the transport sector", (Article 2 of Directive 2014/94/EU).

ASFE believes it is critical to devise an efficient policy framework to reduce the climate and environmental impact of transport in Europe, and that new policies need to prioritise integrated, coherent and technologically-neutral solutions.

Hence, only a **holistic approach towards alternative fuels** will deliver consistency with regards to the policy framework.

As such, ASFE therefore calls for:

- **Integrating all players in the transport sector** that would have a role in delivering a more sustainable transport, including fuel suppliers, vehicles and engine manufacturers, transport logistics, consumers…;
- **Recognising the potential of paraffinic fuels**, amongst others, in making European transport cleaner;
- **Maintaining a technologically-neutral approach**, allowing all clean transport fuels available to compete in the market at a level-playing field.

The objective of this paper is to demonstrate that **the regulated emissions benefits of all paraffinic fuels, meeting specification EN15940 Class A - including HVO and GTL - are very similar**. Regulated emissions are defined as emissions of Nitrogen Oxides (NOx), Particulate Matter (PM), Carbon Monoxide (CO), and unburnt Hydrocarbons (HC). Such comparable benefits result from the EN15940 Class A specification having more stringent requirements than the conventional diesel specification, EN590, thus defining a tighter and more consistent fuel chemistry for all paraffinic fuels.

[1]To compensate the lower density of paraffinic fuels compared to conventional diesel, adjustment in injection amount may be necessary.

Benefits across all types of paraffinic fuels

Paraffinic fuels are manufactured either from synthesis or via the hydrotreatment processes of a wide variety of feedstock, including natural gas (GTL), and vegetable oils, waste and residues (HVO). A combination of the manufacturing route and the starting material produces more consistent and uniform molecules compared to conventional crude oil refining. The paraffinic fuel specification EN15940 Class A, has the following superior properties compared with conventional diesel: a higher cetane number; lower aromatics content; and lower sulphur content. See Appendix 1 for more info.

As a result of these differences, paraffinic fuels offer several benefits over conventional diesel (see appendix 2 for more details):

- **Drop-in fuels** – Paraffinic fuels can directly replace conventional diesel fuels without the need for modifications to engines or infrastructure.
- **Paraffinic fuels reduce the emissions of regulated pollutants**, including Nitrogen Oxides (NOx), Particulate Matter (PM), Carbon Monoxide (CO), and unburnt hydrocarbons (HC's). The exact benefits vary significantly depending on many factors, such as engine size, age, industry…, but typical NOx and Particulate emissions, compared with conventional diesel, are shown on page 3. They can reduce the noise levels in some engines thanks to a more uniform combustion.
- They have **better starting performance in cold conditions**[2] due to a higher cetane number.
- They are classified as **non-toxic, odourless, readily-biodegradable** and have a low-hazard rating because all molecules are paraffinic[3].
- Paraffinic fuels have **better storage stability**, and thus a longer shelf life, than the equivalent conventional diesel that contains 7% FAME. Paraffinic fuels are FAME-free and hydrophobic, helping prevent fuel decay through microbial growth.

The Trends and Challenges of Emissions Testing

Both Shell and Neste have conducted numerous emissions' tests over the years. Unfortunately, it is not possible to simplify the emissions' benefits down to a single, unequivocal number. This is because, in general, studies performed on vehicle emissions show that:

- Engine and especially exhaust after-treatment device effects on emissions are typically larger than fuel effects
- Levels of emissions vary between engines made by the same manufacturer, and often even more greatly between manufacturers.
- Some engines are more sensitive to fuel effects than others. This is especially true in more modern engines, which employ sophisticated technology to reduce emissions. Anticipating how these technologies respond to different fuels is not straightforward.

[2] This paper refers only Shell and Neste products. Products by other manufacturers won't necessarily have the same cold flow properties and cold weather performance.

[3] Both Shell and Neste recommend a cautious approach and continue to handle paraffinic fuels in the same manner as conventional diesels.

Such conclusions can be found in open literature, e.g. the European Auto Oil process of the mid-1990s (EPEFE), and subsequent vehicle emission studies from bodies such as CONCAWE.

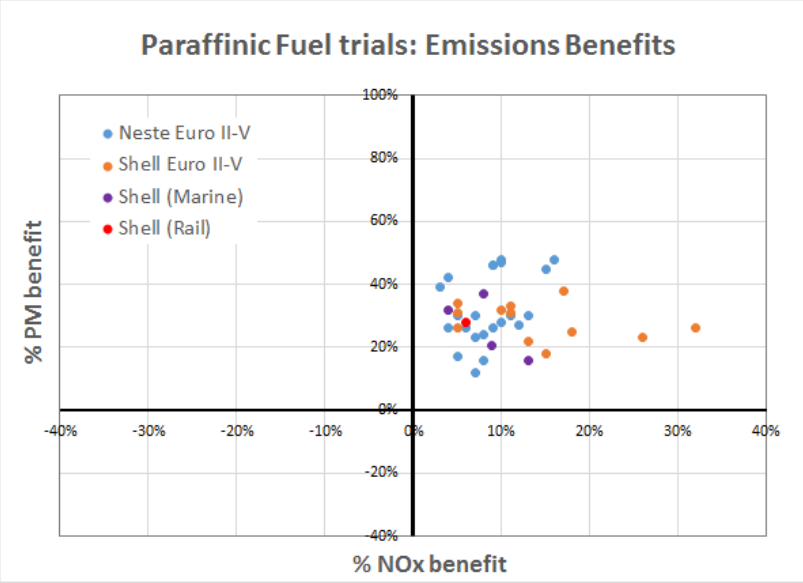
The above-listed trends introduce challenges when assessing the magnitude of emissions benefits from particular fuel, e.g. GTL, HVO, or if attempting to show the equivalence of two fuels. Experiments can be designed which would allow for complete back-to-back testing of GTL, HVO and conventional EN590 fuels in the same vehicles, this is the most reliable way to indicate equivalence. However, in the absence of such experiments, a judicious comparison of a good level of datasets is the next sensible option.

Experimental results demonstrating air emissions benefits for paraffinic fuels

Without going into the details of each test conducted by Shell and Neste (which can however be made available), it is possible to observe the emissions' benefits trends overall. The below chart maps out the results from heavy duty vehicle trials conducted by both Shell and Neste between 2008 and 2017, covering a range of Euro level types from Euro I to Euro V. In addition, examples of off-road data (rail & marine) have been added.

Each dot in the graphic represents the average NOx/Particulate emissions benefit for a given engine and test regime. It is clear from the variety of results that it will not be straightforward to predict the precise emissions benefit in any given engine. However, it is possible to be confident that the benefit will likely fall within a specific range. Ignoring outlier figures, the results point to a clear range of benefits where the majority of tests fall:

- NOx emissions benefits lie within the 3% to 18 % benefit range
- Particulate Matter benefits lie within the 12% to 48% benefit range



Note paraffinic fuels also reduce the emissions of carbon monoxide and unburnt hydrocarbons but these are often a lower priority, since NOx and particulates dominate the concerns about air quality.

It should also be noted that Euro VI vehicles have also been studied. Exhaust emissions of modern heavy duty Euro VI vehicles are very low thanks to the effective exhaust after-treatment systems. To note, heavy duty after-treatments are generally recognised as being effective unlike those in light duty that were revealed by the VW scandal. This paper is only concerned with heavy duty emissions. Paraffinic fuels also have benefits in these vehicles since they reduce engine-out emissions which further reduces burden for the after-treatment system.

Conclusion:

From this data, it is possible to draw several key conclusions:

- Paraffinic fuels consistently **deliver both NOx and Particulate benefits** compared to conventional diesel
- The emissions benefits are not affected by paraffinic fuel type, both Shell and Neste results yield **consistent local air emission benefits.**
- **Emissions results are more strongly affected by non-fuel related factors,** such as: type of engine; application; individual operators; ambient temperature; road and traffic conditions; etc

About ASFE

Launched in March 2006 in Brussels, Paraffinic fuels for Europe (ASFE) is a unique initiative at the European level bringing together car manufacturers and fuel suppliers working towards reducing the environmental impact of road transport through improved energy efficiency and cleaner fuels. The members of ASFE are Shell, Toyota and Neste.

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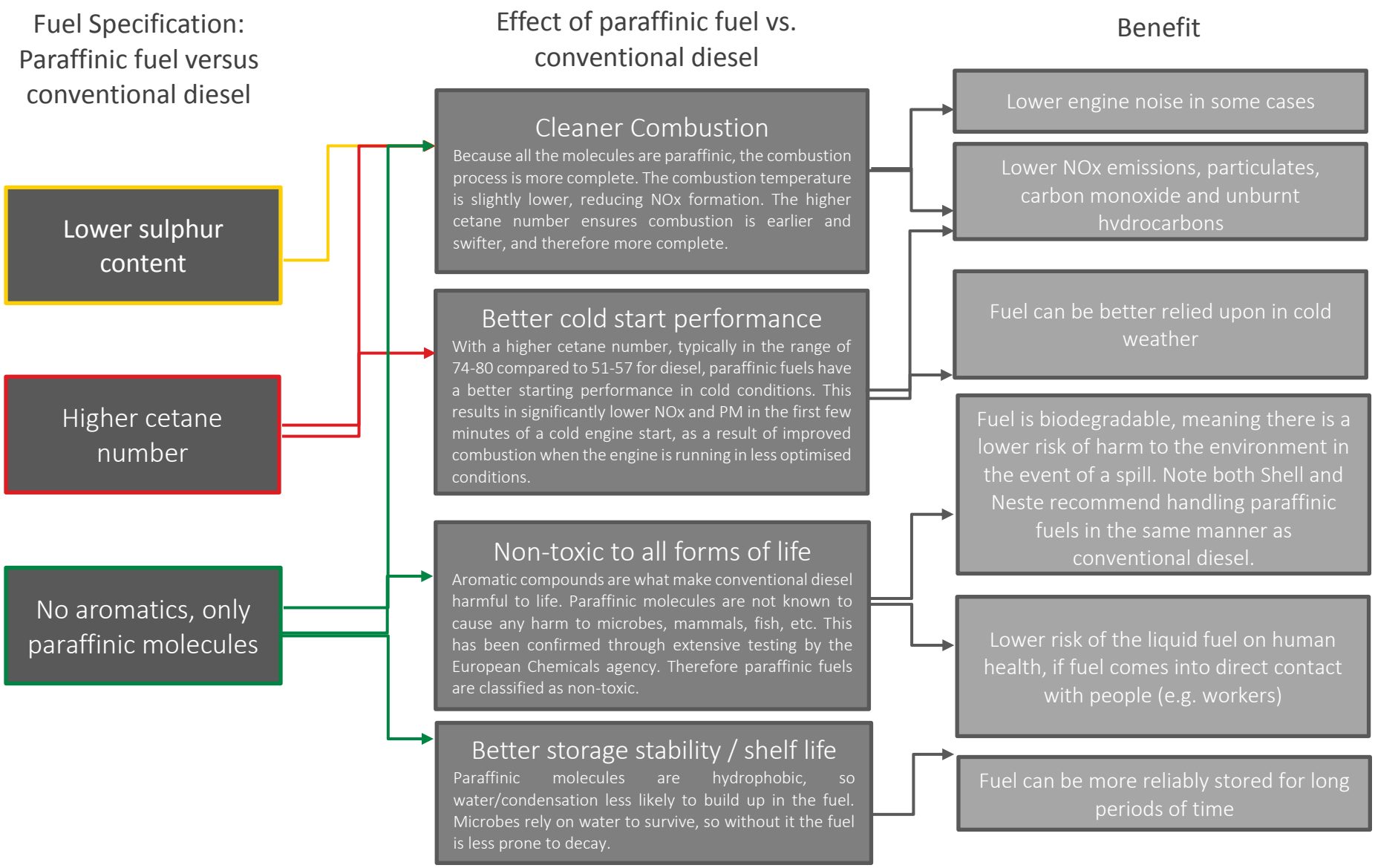
Appendix 1: Comparison of Paraffinic Fuel and Conventional Diesel specifications

Standard fuel specification properties	Paraffinic fuel vs. conventional diesel	Environmental impact of paraffinic fuel
Cetane number	**Higher**	**Better**
Total aromatics content	**Lower**	**Better**
Polycyclic aromatic hydrocarbons content		**Better**
Sulfur content	**Lower**	**Better**
Density at 15 °C	**Lower**	No impact
Flash point	Same	No impact
Carbon residue (on 10 % distillation residue)	Same	No impact
Ash content	Same	No impact
Water content	Same	No impact
Total contamination	Same	No impact
Copper strip corrosion (3 h at 50 °C)	Same	No impact
Oxidation stability	Same	No impact
FAME content[4]	Same	No impact
Lubricity, corrected wear scar diameter (wsd 1,4) at 60 °C	Same	No impact
Viscosity at 40 °C	Same	No impact
Distillation 95 % (V/V) recovered at	Same	No impact
Distillation % (V/V) recovered at 250 °C [(a)]	Same	No impact
Distillation % (V/V) recovered at 350 °C [(a)]	Same	No impact

[4] Both Shell and Nest products are 0% FAME even though the EN15940 specification allows up to 7% FAME in line with the conventional diesel standard EN590. FAME generally increases NOx emissions, so by keeping their products FAME free, Shell and Neste ensure the maximum possible benefit for air emissions. The lack of FAME also reduces ash content, which reduces the lifetime burden on after-treatment systems

Appendix 2: How the EN15940 specification offers operational and air emissions benefits



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