Technical Limits and Technical Potential for Biodiesel

80 Years of Biodiesel

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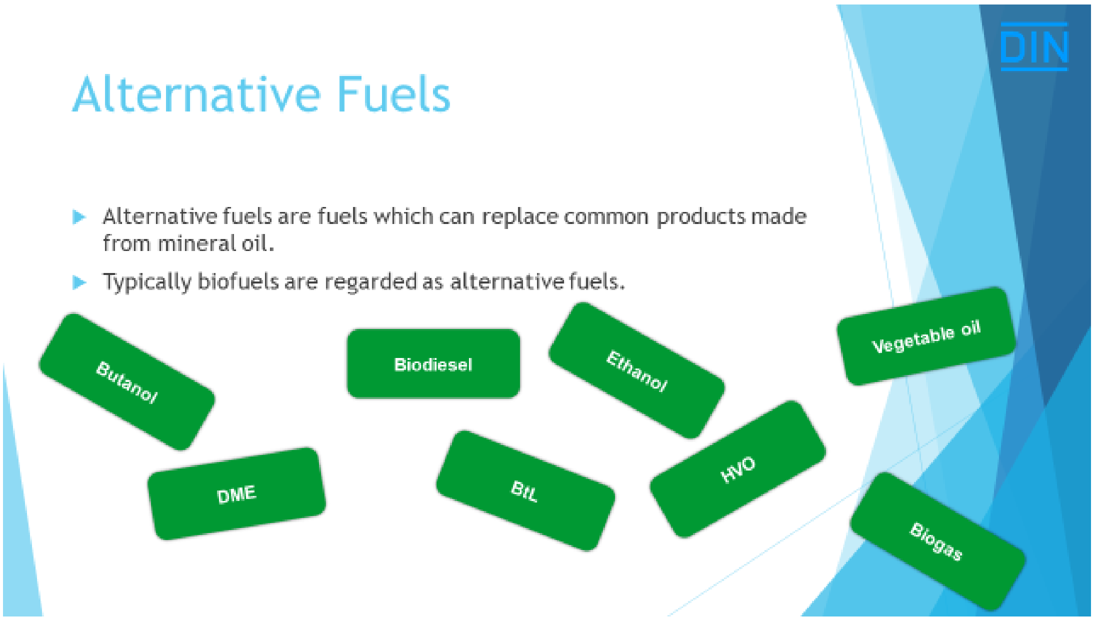
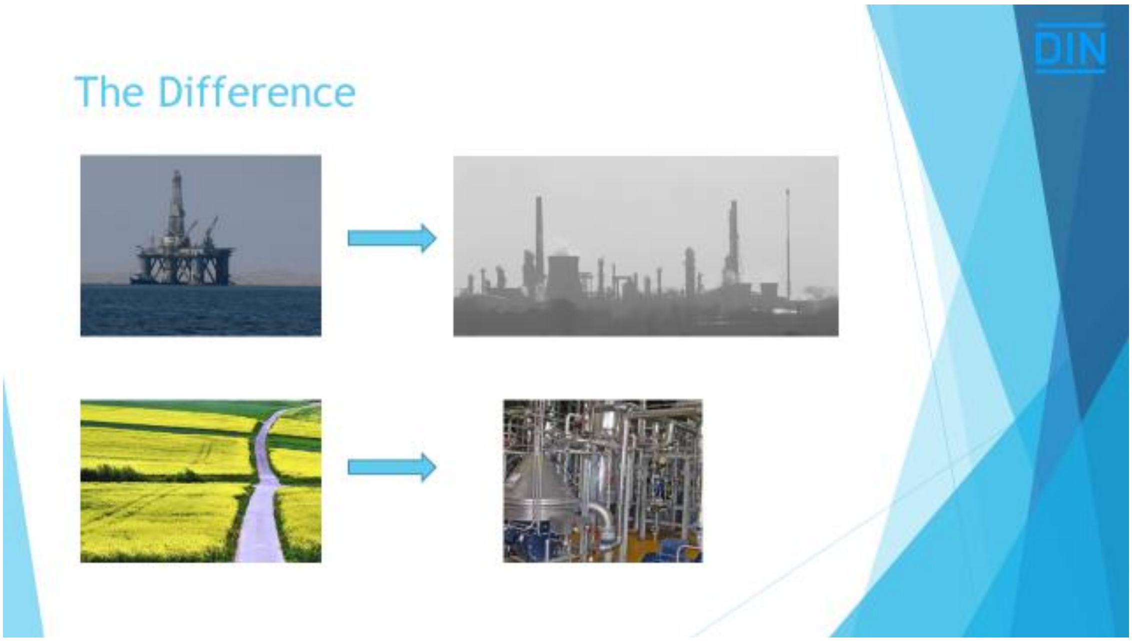


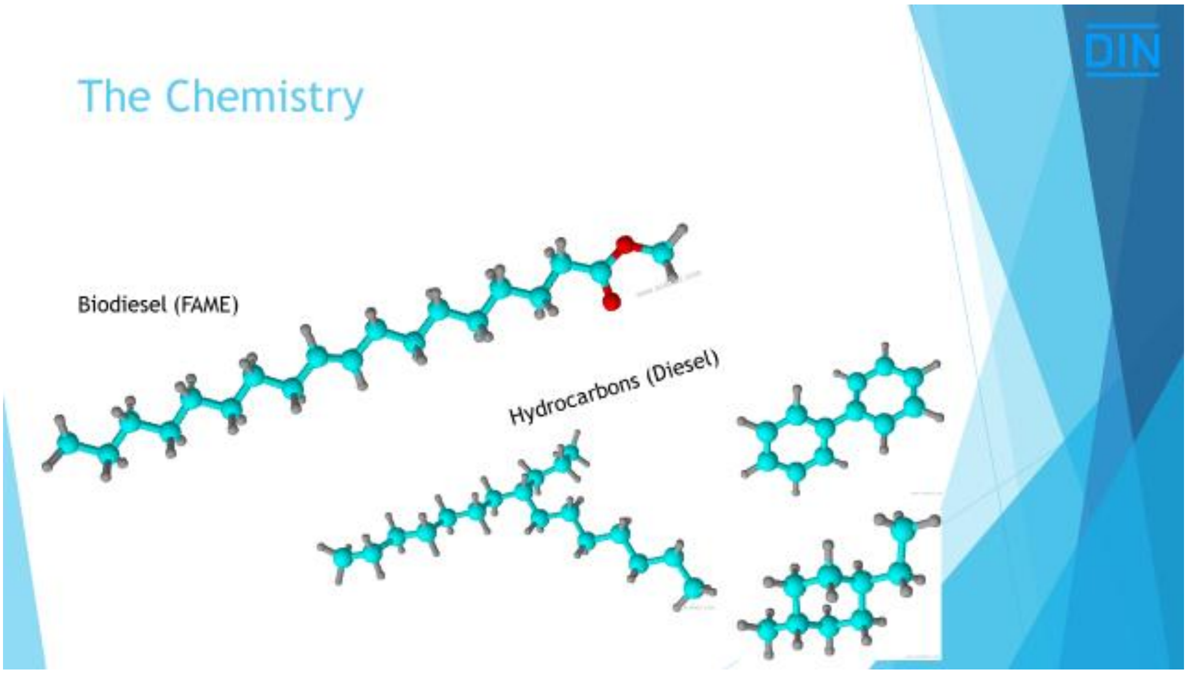
Today, we know a huge variety of so-called alternative fuels which are usually regarded as biofuels, even though this is not always true. Alternative fuels can replace fossil fuels in existing combustion engines running on Diesel fuels or on gasoline type fuels. The term „alternative“ may be related to the raw material, to the production process and/or to the properties of the fuel.

This presentation focuses on Biodiesel, scientifically called FAME (Fatty Acid Methyl Ester); a fuel different in either perspective.

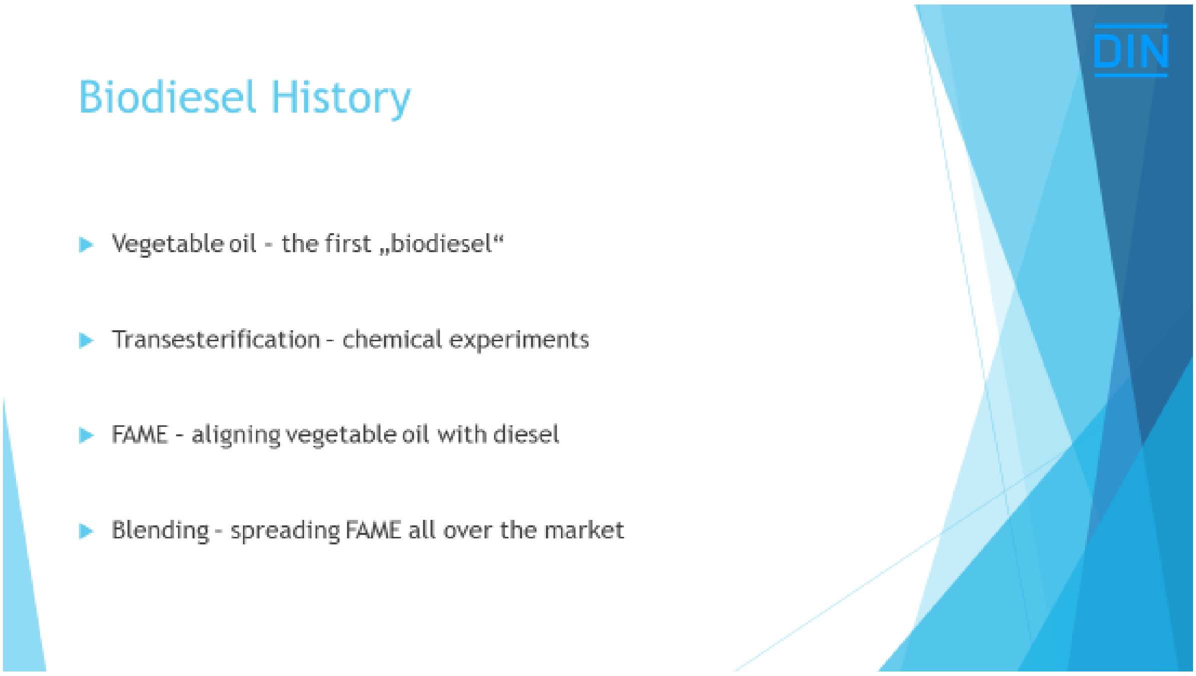


Fossil fuels are produced by refining crude oils. The original process only comprises physical processes, e.g. distillation. Later, chemical processes like catalytic reforming, desulfurization, and hydrotreating were established, with the result of the high quality fuels we are using today.

Biodiesel is based on vegetable oils and fats. These biogenic feedstocks are converted to methyl esters by a simple, usually base catalyzed chemical reaction with methanol, yielding methyl esters and glycerol as a by-product. This process leads to a product whose properties are solely related to the feedstock.



Fuel properties are strongly related to their chemical composition. Biodiesel, or FAME, consists of polar, long chain molecules with the typical ester group. The oxygen content of the fuel, shown by the red dots in the FAME molecule, determines the behaviour of the fuel. Esters are powerful solvents, and so is FAME.
Fossil fuels comprise a ~~huge~~ wide variety of hydrocarbon molecules, e.g. alkanes, cycloalkanes and aromatics with a chemical behaviour different from that of FAME.



The „Biodiesel History“ already started around the year 1900 when the first Diesel engine was run on vegetable oil. It was no biodiesel in the sense of today, but it was the start. In 1937 the first process for the production of vegetable oil alkyl esters was patented by George Chavanne, using ethanol and palm oil at that time.
However, biofuels were forgotten for a long time after those first attempts. However, when the oil crisis started in 1973, people started thinking of renewable fuels again. It was in 1976/77 when Austria made the first steps with a field study on the use of vegetable oil in Diesel engines. In 1982, Biodiesel based on rapeseed oil, so-called RME, was subject of a long term study.

Other tests followed in Austria and in Germany, entailing approvals for trucks and passenger cars:

1982	Long term study with RME in Austria
1988	Fleet test with RME in Austria
1994	Fleet test in Freiburg (Germany)
1995	Approvals for FAME by VW / Audi

After using FAME as a neat fuel, blending of FAME to Diesel fuel was the next logical step in order to broaden the use of FAME. The following list shows the development of Biodiesel blending in Europe.

1990s	Start of FAME blending in France
2004	EN 590 allows for 5% FAME blending
2004	Start of FAME blending in Germany
2007	EN 590 extended to B7
2015	B20/B30 standard
2016	B10 standard

What is the difference between Biodiesel and conventional Diesel fuel?
Why do we have to take technical measures to avoid issues with the fuel?
Due to its chemical composition some important fuel properties are significantly different to those of Diesel fuel. Though different does not automatically mean worse…

Physical properties
higher viscosity, poor cold flow properties, high freezing point, higher conductivity, narrow boiling range
Physical properties have an impact on the injection behaviour of fuel, on combustion and on cold operability.

Chemical properties
Lower stability (oxidative, thermal), solvent properties, polarity, water solubility
Chemical properties of FAME are often related to material incompatibilities. Low stability can lead to fuel deterioration by ageing.

Biological properties
Biodiesel does not show a higher tendency to microbial contamination. Biodiesel is non-toxic, less water hazardous and better biodegradable by far.

Emissions
Higher NO_x emissions, different structure of particulate emissions, organic soluble particles
Biodiesel exhaust gas emissions show a slightly higher NO_x-content due to higher combustion temperatures. Properly adjusted exhaust gas aftertreatment systems can eliminate this problem without any difficulties. The higher share of organic soluble particles can easily be reduced by catalytic converters; in contrary to soot from fossil fuels.

Beside the its use as blend component, Biodiesel can be used as neat fuel in adapted Diesel engines for road transport, with specific potential in environmentally critical applications like forestry, agriculture and water transport due its low toxicity and excellent biodegradability in comparison to fossil fuels.

Fuels are subject to constant modifications and improvements. Developing engine techniques need „fit-for-purpose“ fuels for applications in existing and future engine generations.

There are some challenges concerning Biodiesel which limit the use of this renewable fuel:

Biodiesel is a „static“ fuel. Its properties always depend on the feedstock and its composition, there is no easy way of adjusting the fuel by applying physical processes like there is for petroleum derived fuels, e.g. changing the distillation cut points.

The flexibility of fossil fuels is based on the multiple and well established processes of adjusting their properties to the purpose. The structure and the chemistry of Biodiesel cannot be modified without expensive chemical conversion of the ester molecules to something completely different.

Viscosity, cold flow properties and ignition quality can only be controlled to a very limited extent by the choice of the raw material. The lower oxidation stability of Biodiesel may cause issues during long storage times, e.g. in low consumption concepts like hybrid cars.

The limited availability forces Biodiesel producers to look for new feedstocks with potentially unconventional impurities and properties, creating the need for more efficient refining steps.

Field issues on filterability are often blamed on Biodiesel, even though there is evidence that also conventional fuels show poor performance and operability. Exhaust gas after treatment systems with increased efficiency require „pure“ fuels with extremely low Sulfur, Phosphorus and metal contents.

Like most other fuels in Europe, Biodiesel is subject to European standardization. EN 14214 describes the minimum requirements for FAME used as neat fuel and/or as blend component. After five years of development, the standard came into force in 2003.

European Standards are revised either on a regular basis or in case of need for revision. For Biodiesel additional requirements due to field experience, engine development and legal requirements gave reason to four revisions since 2003, introducing new parameters and stricter limits. Currently, the next revision is under discussion, implementing new test methods and requirements.

In addition, standards for new products around Biodiesel were developed which are EN 16734 (B10) and EN 16709 (B20-30). Ethyl esters, the original Biodiesel of George Chavanne, is not standardized in Europe.

Today Biodiesel has been an integral part of the fuel market for more than one decade and plays an important role in Europe‘s fuel supply as renewable fuel - both as neat fuel as well as blend component.

There is no doubt, however, that Biodiesel has some limitations arising from its nature: physical and chemical properties are significantly different from its fossil counterpart, resulting in issues concerning engine and material compatibility and fuel stability. The wide variety of feedstocks with diverging characteristics can cause quality issues. And, even more important, the political and public acceptance of biofuels has decreased since the beginning of the Biodiesel success story.

Yet there is still potential for the invention of George Chavanne, of course as part of our future fuel supply, offering at least a partial independence from petroleum fuels. Biodegradability and non-toxicity make Biodiesel an ideal fuel for the use in environmentally sensitive areas and niche markets like forestry, agriculture, on water ways and lakes.
And last but not least, as a renewable fuel Biodiesel can contribute to the global challenge of greenhouse gas reduction.