

# Biofuels as an alternative drive for vehicles

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**Abstract:** Due to the increase in the number of vehicles on the roads, the environment is becoming increasingly burdened by exhaust gases produced by the combustion of fuel in internal combustion engine vehicles (ICEVs).

The most significant gases produced by the combustion of fossil fuels in ICEVs are: nitrogen oxides (NO<sub>x</sub>), sulfur oxides (SO<sub>x</sub>), carbon oxides (CO and CO<sub>2</sub>), water steam, particulate matters (PM) and various hydrocarbons (CH).

Alternatives to fossil fuels are increasingly being explored in order to reduce the harmful impact of exhaust gases on the environment.

One of the possibilities of reducing harmful gas emissions is the use of alternative drives and fuels. An alternative to fossil fuels produced from crude oil are biofuels produced from renewable sources.

The use of biofuels in internal combustion engines leads to a significant reduction in the emissions of harmful exhaust gases from vehicles and, therefore, to a reduction in environmental pollution.

**Keywords:** internal combustion engine (ICE), fuel, pollution, emission, alternative fuels.

## INTRODUCTION

We are witnessing the daily increase in the number of vehicles on the roads. With the increase in the number of vehicles, the environment becomes more and more burdened by exhaust gases produced by the combustion of fuel in the internal combustion engines (ICE). In order to reduce the harmful impact of exhaust gases on the environment, alternatives to fossil fuels used in internal combustion engines are increasingly being researched.

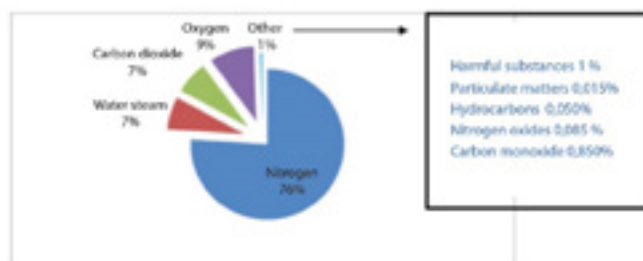
One of the alternatives to fossil fuels for vehicle drives are biofuels. Biofuels are fuels produced from renewable energy sources that can be used to start an engine through internal combustion.

## EXHAUST GASES FROM INTERNAL COMBUSTION ENGINES

As a product of the combustion of conventional fossil fuels obtained from crude oil in internal combustion engines, besides the useful mechanical work, a certain amount of exhaust gases is produced that contain smaller or larger amounts of dangerous harmful substances.

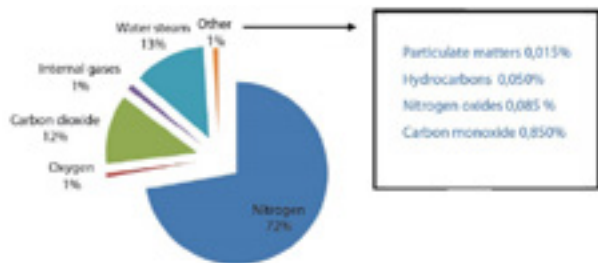
Exhaust gases produced by the combustion of fossil fuels in internal combustion engines are a mixture of: nitrogen oxides (NO<sub>x</sub>), sulfur oxides (SO<sub>x</sub>), carbon oxides (CO and CO<sub>2</sub>), water stream, nitrogen, oxygen, solid particles and various hydrocarbons (CH).

Compared to gasoline engines, in the process of fuel combustion, diesel engines emit more nitrogen oxides (NO<sub>x</sub>) and more particulate matters (PM), which are carcinogenic and harmful to human health. Image 1 shows the composition of diesel engine exhaust gases.



**Picture 1:** Composition of diesel engine exhaust gasses

Compared to diesel engines, gasoline engines emit a larger amount of carbon monoxide (CO) and unburned hydrocarbons (HC). Under normal operating conditions there are no particulate matters (PM) in the exhaust gases of gasoline engines. Picture 2 shows the composition of the exhaust gases of gasoline engines.



**Picture 2:** Composition of exhaust gases from gasoline engines

## ALLOWABLE EMISSIONS OF HARMFUL SUBSTANCES

From the beginning of the 1970s the European countries began to deal with the quality of exhaust gases in the form of homologation regulations, which prescribe the amount of harmful pollutants in the exhaust gases of new vehicles. The maximum permitted amounts of certain harmful substances in the exhaust gases are shown in Table 1.

## REDUCTION OF HARMFUL GAS EMISSIONS

Reduction of harmful gas emissions can be achieved by: optimizing the fuel combustion process in engines, after-treatment of exhaust gases, increasing the quality of used fuel and using alternative drives and fuels.

In the last ten years intensive work has been done on improving the alternative drive of electric powered vehicles, either in combination with a classic internal combustion engine or an independent electric motor.

Biofuels produced from renewable sources represent an alternative to fossil fuels produced from crude oil and their use is one of the realistic possibilities to reduce harmful exhaust gas emissions from vehicles.

The basic criteria important for evaluating the applicability of alternative fuels for drive of internal combustion engines are:

- emission of exhaust gases,
- fuel consumption
- price of alternative fuel
- performance of vehicles powered by alternative fuels
- locations, method of obtaining and reserves of alternative fuel
- costs of conversion or production of vehicles
- ways and possibilities of fuel storage in the vehicle
- general vehicle safety

The three most promising alternative fuels for internal combustion engines are:

- biofuels
- natural gas and
- hydrogen on its own fuel cells

## ELECTRIC VEHICLE DRIVE

An electric vehicle is a vehicle that is powered by an electric motor, using electricity stored in a battery. One of the limiting factors for the mass use of electric cars is their price and limited autonomy of movement.

Currently, the price of an electric vehicle is higher than the price of a vehicle powered by an internal combustion engine.

**Table 1:** Maximum permitted amounts of certain harmful substances

Standard	Year of entry into force	CO	HC	HC + NO <sub>x</sub>	NO <sub>x</sub>	PM
Diesel engines (g/kg)						
Euro 1	1992	3,16	-	1,13	-	0,18
Euro 2	1996	1,00	-	0,70	-	0,08
Euro 3	2000	0,64	-	0,56	0,50	0,05
Euro 4	2005	0,50	-	0,30	0,25	0,025
Euro 5	2009	0,50	-	0,23	0,18	0,005
Euro 6	2014	0,50	-	0,17	0,08	0,005
Gasoline engines (g/kg)						
Euro 1	1992	3,16	-	1,13	-	-
Euro 2	1996	2,20	-	0,50	-	-
Euro 3	2000	2,30	0,20	-	0,15	-
Euro 4	2005.	1,00	0,10	-	0,08	-
Euro 5	2009.	1,00	0,10	-	0,06	0,005
Euro 6	2014.	1,00	0,10	-	0,06	0,005

The main advantage of electric powered vehicle is the reduction of air pollution because electric powered vehicles do not release harmful substances into the environment during movement. The negative impact of electric vehicle on the environment is the disposal of used up batteries. Components of batteries are heavy metals: lithium, nickel and copper, which if disposed of irresponsibly have a harmful effect on the environment.

Electric motors are more efficient in converting stored energy into the energy needed to move the vehicle than internal combustion engines. Electric vehicles do not waste energy while stationary, and part of the energy lost during deceleration and braking is reused to charge the battery. Hybrid vehicles use two or more energy sources as drives, those are gasoline or diesel engine and an electric motor. Compared to conventional vehicles, hybrid vehicle emission of harmful gases is reduced, and nowadays great importance is related to their production and use.

## BIOFUELS FOR INTERNAL COMBUSTION ENGINES

Biomass is an organic matter created by the growth of plants and animals. Renewable biofuels can be produced from biomass.

There are several types of biofuels, depending on the source of production materials, production technology, price and carbon dioxide emissions.

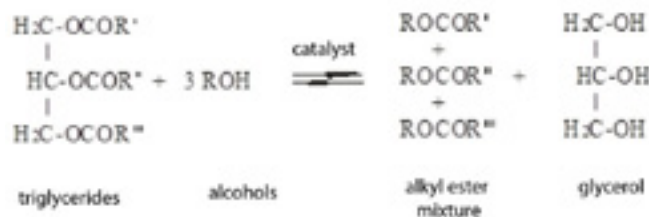
Biofuels are divided into three groups:

- First generation - the same raw materials are used for production as for food production (sugar, starch, vegetable oils or animal fats). The most important biofuels of the first generation are: ethanol, biodiesel and biogas.
- Second generation - agricultural and forest waste is used for production. The most important biofuels of the second generation are: bio-hydrogen, bio-DME (biodimethylethene), bio-methanol, DMF (dimethylformamide), HTU diesel (Hydro Thermal Upgrading diesel), Fischer-Tropsch diesel and alcohol mixtures.
- Third generation - is produced by using algae. Based on laboratory tests, algae can produce up to thirty times more energy per hectare of land than cereals. With the increase in the price of fossil fuels, there has been an increasing interest in growing algae for fuel production.

## BIODIESEL

Biodiesel - methyl ester of fatty acids (MEMK) is a biodegradable fuel, which is obtained by the reaction of transesterification of oils (vegetable oils, animal fats and waste edible oils) and alcohol. Biodiesel can be used in internal combustion engines in two ways:

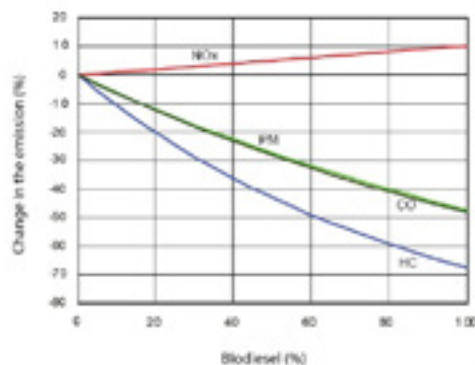
- as an addition to fossil diesel, by mixing it with fossil fuel in certain proportions and
- as pure biodiesel



The use of biodiesel compared to fossil diesel fuel leads to a significant reduction in environmental pollution. In particular, the emission of carbon dioxide is reduced as well as the emission of sulfur oxides, suspended particles and carbon monoxide, while the emission of nitrogen oxides increases slightly, as shown in Table 2 and Image 3.

Table 2: Changes in emissions by using biodiesel

Emission type	B 100 (%)	B 20 (%)
Carbon monoxide (CO)	-48	-12
Unburned hydrocarbons (HC)	-67	-20
Solid particles (PM)	-47	-12
Nitrogen oxides (NOx)	+10	+2



Picture 3: Changes in emissions by using biodiesel

The advantage of biodiesel over fossil diesel fuel, from an environmental point of view, comes from a more favorable carbon dioxide balance. The basis for the production of biodiesel is the oil of an oilseed crop. The plant consumes a certain amount of carbon dioxide for its growth, while the carbon dioxide produced by fossil diesel fuel is constantly accumulating in the atmosphere. A closed cycle of carbon dioxide is created by growing an oilseed, producing fuel, burning it, and re-growing it.

The disadvantages of using biodiesel as a fuel are as follows:

- Biodiesel is more expensive than normal fossil diesel fuels

- Possibility of injector clogging on a diesel engine
- Difficult fuel injection and its dispersion, which results in poorer mixing with air, i.e. incomplete combustion;
- Lower energy value than ordinary fossil diesel
- Due to the increased demand for raw materials for the production of biodiesel (oilseeds), which are also used for food production, the oilseed price has also increased
- Biodiesel in older vehicles can affect the dissolution of paint and the decomposition of plastic materials used as construction materials for fuel storage and distribution

## ALCOHOLS

The most important alcohols used as biofuels are ethyl alcohol or ethanol ( $C_2H_5OH$ ) and methyl alcohol or methanol ( $CH_3OH$ ).

All organic compounds that can be broken down to simple sugars, which the yeast can use for its metabolism, can serve as raw materials for the production of alcohol. The mentioned sugars and polysaccharides are very widespread in plants, so there is a large number of potentially possible raw materials for the production of bioethanol.

Raw materials for production of bioalcohol can be: sugar (sugar beet, sugar cane and molasses), starch (grains and various crops) and lignocellulosic materials (wood, old paper, corn, straw and similar agricultural by-products).

A limiting factor in the use of alcohol for internal combustion engine propulsion can be the low density and incompatibility of alcohol with engine construction materials.

## BIOGAS

Biogas is a renewable source of energy that is created by anaerobic processes of converting biomass into a gaseous state and the resulting product is a mixture of methane and carbon dioxide.

## HYDROGEN

Hydrogen is a renewable fuel. It can be produced from water, but the energy consumption for hydrogen production is higher than the amount of energy obtained from hydrogen.

## CONCLUSION

With the increase in the number of vehicles on the roads, the environment becomes more and more burdened by exhaust gases produced by the combustion of fuel in the internal combustion engines. The most significant

gases produced by the combustion of fossil fuels in internal combustion engines are: nitrogen oxides ( $NO_x$ ), sulfur oxides ( $SO_x$ ), carbon oxides ( $CO$  and  $CO_2$ ), water stream, particulate matters (PM) and various hydrocarbons (CH).

One of the possibilities of reducing harmful gas emissions is the use of alternative drives and fuels. An alternative to fossil fuels produced from crude oil is biofuels produced from renewable sources. The use of biofuels in internal combustion engines leads to a significant reduction in the emissions of harmful exhaust gases and to a reduction in environmental pollution.

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