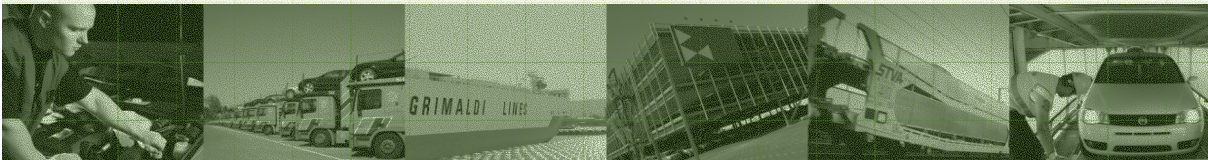




Alternative Fuel Trucks

An ECG report on the available
manufacturers' offer of alternative fuel
trucks

Patrycja Kulesza



The Association of European Vehicle Logistics
Diamant Building, Bd. Auguste Reyers 80
B-1030 Brussels

Tel.: +32 2 706 82 80
Fax: + 32 2 706 82 81

E-mail: info@eurocartrans.org
www.eurocartrans.org

Introduction

At present oil is still the major source of energy for transport (98%). EU imports 76% of its oil and this figure will grow in the next 20 to 30 years. In the light of decreasing availability of oil, increased need for clean fuels and until quite recently accentuated high price of oil, the need for alternative sources of fuel grows rapidly.

Many truck companies develop its offer in order to meet demand for trucks on alternative fuels and environmental requirements. This paper provides an overview of the available options.

The existing alternatives such as biofuels are controversial due to the use of food crops and interesting mainly at the local level. However the second generation of biofuels, derived from non-food products offer better possibilities. Natural gas engines offer only limited benefits in terms of reduced emissions and their use is therefore limited. The options the most interesting in the short to medium term are hybrids. The hydrogen driven vehicles are expected only in 2020/2025.

Existing alternatives:

1. **Bio-fuels.** Biofuels offer the possibility of producing energy without a net increase of carbon into the atmosphere because the plants used to produce the fuel have removed CO₂ from the atmosphere, unlike fossil fuels which return carbon which was stored beneath the surface for millions of years into the air. Biofuel is therefore more nearly carbon neutral and less likely to increase atmospheric concentrations of greenhouse gases (though doubts have been raised as to whether this benefit can be achieved in practice). Examples biodiesel, bio-ethanol, methanol, DME (dimethylether), RME (Rapeseed Methyl Esther), synthetic fuels (BTL-Biomass to Liquids).

Some biofuels (first generation – derived from sugar, starch, vegetable oil, or animal fats using conventional technology) have been available on the market already since 2006.

Extracting fuels from biomass (waste, grain, the stalks of wheat, straw, woodchips etc) should become the standardized fuel in 2008.

The big advantage of biofuels is that they can be used with all the classic engines. The current generation of diesel engines can cope with the addition of 5% biodiesel without any problems. Subject to a few engine modifications, this could be increased to 30% or even 100%. Despite this advantage biofuels still cannot replace fossil fuels, only partially.

Renault Trucks gives manufacturer's guarantee of two years for the use of biodiesel (FAME – Fatty Acid Methyl Ether) mixed with diesel up to 30% in its trucks for all engines (Euro 3, 4 and 5). The guarantee is subject to two conditions:

- the intervals for the change of oil should be divided by 2 compared to the intervals envisaged for the normal use
- if RME (rape seed biodiesel) is used, it should comply with the European norm EN 14214.

Renault Trucks does not provide guarantee for blends exceeding 30% of biofuel. It also does not advise the use of the pure vegetable oil.

Scania has given the green light to the use of pure rapeseed oil (RME) as a fuel for its engines equipped with unitary injectors, without any supplementary modifications to the engine being needed. The use of RME will require more frequent oil changes, due to its lower energy value. Production of rapeseed oil in Europe is therefore limited and the most likely solution is the use of a 5% mixture of rapeseed oil.

Volvo is another manufacturer to explore various fuel types, and prides itself for being able to produce trucks to run on either bio-diesel, bio-gas, a bio-diesel/bio-gas combo, DME (dimethyl ether), hydrogen/bio-gas, methanol/ethanol. It has developed 7 trucks running on 7 different renewable fuels. However the company considers it will take time before a good volume of alternative fuels can be achieved. The focus therefore is more on energy efficiency and the development of hybrid vehicles.

Daimler considers vegetable oil-derived hydrated fuels (HVOs) as the most promising fuels from renewable resources. Later, they will be joined by BTL (biomass to liquid) fuels. In cooperation with the oil company OMV and the vehicle fleets of two of its customers (DHL and SSB-Stuttgart), Daimler has now commenced fleet testing of HVO fuel in Mercedes-Benz trucks (10 Mercedes Benz Actros and Atego) and buses (7 Mercedes Benz Citaros). Biodiesel (FAME) has been commonly used in Mercedes-Benz trucks for the past ten years.

2. **Natural gas:** CNG (Compressed Natural Gas –methane), LNG (Liquified Natural Gas), LPG (Liquified Petroleum Gas – propan, butan), Bio Gas (CNG +Bio).

Natural gas is commercially produced from [oil fields](#) and [natural gas fields](#). Natural gas can be used with conventional gasoline engine, but special storage and injection equipment is needed. Compressed natural gas (methane) is a cleaner alternative to other automobile fuels such as [gasoline](#) (petrol) and [diesel](#). The energy efficiency is generally equal to that of gasoline engines, but lower compared with modern diesel engines. CNG-specific engines, however, use a higher compression ratio. Compared to Euro 5 diesel engines, CNG engines do not offer any particular emission levels benefits.

Renault Trucks does not offer LPG solutions because it is a fossil fuel, nor LNGs due to the difficulties of storage. In its offer it has a range of vehicles running on compressed natural gas, but mainly for urban use and refuse trucks or for short distance distribution.

Since 2007 Renault Trucks offer CNG distribution trucks with the following engine models :

- Midlum Cummins Gas Engine
- Premium MG9 Gas Engine
- Puncher Cummins Gas Engine

DAF does not have any gas engines, nor does it intend to develop any. From its perspective modern Euro 5/EEV diesel engines already meet the most stringent emissions standards and in some cases even surpass gas engines. This however, with lower cost of ownership and higher durability and reliability. Also the company considers that operational costs of gas engines are up to 60/80%

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higher than of modern diesel engines. In addition, gas engines have other disadvantages, such as a radius of action which is not sufficient for international transport applications.

Comparison of diesel engine and gas engine emissions:

	Diesel engine				Gas engine
	Euro 3	Euro 4	Euro 5	PR EEV	EEV
CO	5,45	4,0	4,0	0,05	3,0
HC	0,78	0,55	0,55	0,1	0,40
NOx	5,0	3,5	2,0	2,0	2,0
PM	0,16	0,03	0,03	0,015	0,02
Rook	0,8	0,5	0,5	0,1	0,15

Source: DAF Trucks

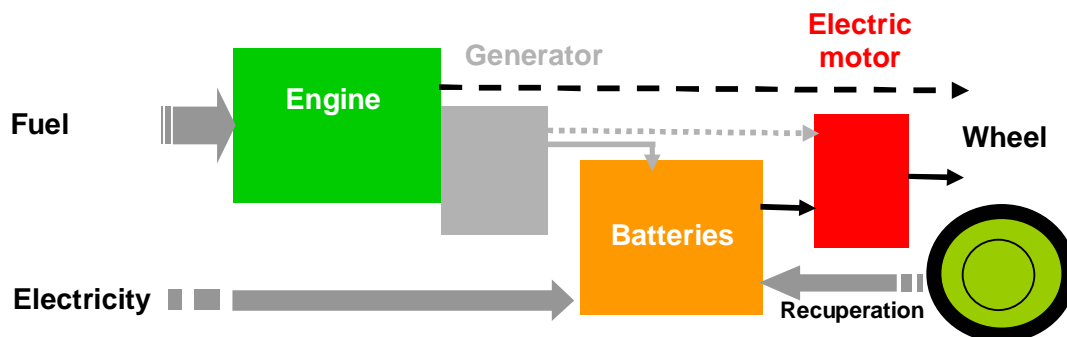
Volvo does not offer any CNG or LPG trucks. Both LPG and CNG are fossil fuels and, according to Volvo, studies have shown that these fuels have higher climate effect than diesel. Therefore LPG is not interesting at all, but CNG can be an alternative to diesel due to the available amounts and not for environmental reasons. A Euro V diesel engine has today regulated emissions on the same levels as CNG so the emission benefits of CNG are low or none. Volvo currently has a CNG bus offer.

Mercedes-Benz has been producing and delivering buses and municipal vehicles that run on compressed natural gas (CNG) for the past ten years.

Short to medium term alternatives:

Hybrid vehicles

Hybrid vehicles are characterized by the combination of internal combustion engine with an electric motor. This allows the internal combustion engine to operate exclusively in its optimum combustion range and hence to cut down on emissions. The vehicle can run on electric power in sensitive areas and for relatively short trips with no emissions at all.



Source: Renault Trucks

There are two different types of possible hybrid solutions with the electric motor and internal combustion engine **in parallel or in line (serial)**. In the case of parallel hybrids, the existing drive-train is used with a combustion engine assisted by an electric motor/generator. With the parallel hybrid the vehicle can be powered just as well by the electric or the diesel motor, or both together. The biggest advantage is the simplicity of the system compared to the serial hybrids.

With a serial hybrid, the vehicle is always powered electrically. The combustion engine is only used when stationary in order to enable the batteries to remain charged. The advantage is that combustion engine remains at its most economical operating regime. The big disadvantage is the complex layout and the loss of energy during the transformation of kinetic energy into electricity and vice-versa and the capacity of the batteries.

Hybrids promise low emissions, potential to save on average 30% of fuel, exceptionally quiet operation when travelling in towns and other emissions-sensitive areas. Other advantages include an unrestricted operating range thanks to the internal combustion engine, familiar operation which is largely the same as for a conventional vehicle and a high level of operating safety. On the other hand there is an additional cost and weight of vehicles that need to be taken into account. Hybrid vehicles cost one-third more than today's diesel vehicles. Although the overall cost of ownership of hybrid vehicles is substantially improved by their fuel savings, incentives will be needed for at least a few years following the market launch.

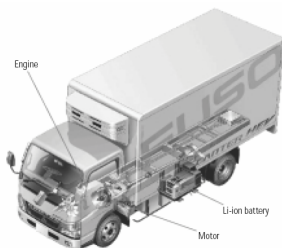
Hybrid vehicles are of benefit primarily to companies frequently operating vehicles in city centres and suburban areas with residential centres. In the city centre they can operate on virtually no emissions and recharge their batteries on trips outside the city.

Volvo could be the first HGV manufacturer to be able to deliver a serial production hybrid truck by December 2009 (Volvo FE Hybrid). It carried out the last phase of practical trials of a pre-series of vehicles of this type. And will start production next year. **Volvo FE Hybrid** will be a cost effective truck for city distribution and refuse handling.



Iveco has a long experience in producing hybrids. Its 'Iveco Daily Hybrid' was first shown in the European Road Transport Show in Amsterdam in 2007. Courier express company FedEx is soon to operate in Europe 20 Daily vans with Iveco diesel engines and hybrid propulsion system. Iveco wishes to commercialise its vehicles from now until 2010. It also announced that additional trials will take place in Paris in autumn this year.

Mitsubishi exhibited its hybrid version of the **Canter** in IAA in Hanover in 2007. The hybrid version is fitted with a 3 litre diesel engine and an electric power unit. Emissions of particulates are 46% lower and those of nitrogen oxides 41% lower. The resulting fuel consumption is around 20% lower. Mitsubishi Fuso Canters Eco Hybrid, the trucks, which have been on sale in Japan for 18 months, will enter European hauliers' fleets next spring.



Mitsubishi Fuso Canter Eco Hybrid is being used from the beginning of this year by Deutsche Post World Net.

DAF and **Daimler** have supplied test models for practical trials.

DAF has shown its **LF prototype** with hybrid technology for the first time in 2007 in European Road Transport Show in Amsterdam in 2007. The vehicle uses a parallel diesel/electric hybrid system, in which it is driven by the diesel engine, the electric engine or a combination of both. The prototype is equipped with the new 4.5-litre PACCAR FR (Euro 5) diesel engine with a maximum output of 136 kW/185 hp and is linked to a computerised Eaton six-speed gearbox (Autoshift). Between the clutch and the gearbox, an electric engine has been installed, which can provide the drive and also functions as a generator. Energy released during braking is stored in the lithium-ion batteries for re-use during acceleration. From this year DAF is testing its first prototypes in normal conditions with clients.

Daimler, in 2005 exhibited hybrid versions of the **Sprinter** commercial van and certain truck models. In the plug-in hybrid drive system in the Mercedes-Benz Sprinter, an electric motor with an output of 70 kW is combined with the conventional diesel engine. It obtains its energy from a nickel/metal hydride (NiMH) battery with a capacity of 14 kWh. This allows an operating range of up to 30 kilometres under purely electric propulsion. The battery is recharged from the mains power supply, e.g. overnight, with a recharging time of approximately six hours. The energy generated when braking is also used to recharge the battery. A hybrid-drive Sprinter with no recharging socket is also planned. A reduction in diesel fuel consumption of between 10% and 50% depending on the type of operation can be achieved.

At the beginning of this year Deutsche Post World Net put the first hybrid HGV's into service, precisely the **Mercedes-Benz Atego Blue Tec Hybrid**.

MAN and **Renault** have shown prototypes.

MAN has developed a diesel hybrid system initially destined for urban buses. Several buses have undergone practical tests, but only a few HGV's. In collaboration with ZF a TGL diesel electric is undergoing experiments. The fuel consumption of 10% is claimed.



Renault Trucks has shown its hybrid distribution prototype named **Hybris**. The principle of the Renault hybrid distribution revolves around the recuperation of kinetic energy in the form of electricity during braking, with storage of this in batteries. This energy can be used for propulsion or for operating ancillary equipment. The parallel hybrid technology that features on this prototype vehicle, will find its way into production trucks in the medium term. Renault Trucks plans field tests from 2008/2009 and

production from 2010. Main target are waste refusal cars, followed by distribution cars.

Nissan also has its hybrid powered unit based on the new **Cabstar** (a 3 liter diesel engine plus 54hp electric motor).

Scania focuses on the urban buses during the development stage of a hybrid drive-train; Very interesting is Scania's combination of alternative fuels such as ethanol for powering the diesel engine within the diesel electric system.

Long term alternatives:

Fuel cells and hydrogen engines

The energy stored in the hydrogen can be harnessed with the help of the new technology such as fuel cells. A fuel cell is an electrochemical conversion device.

Hydrogen is considered by many the fuel of the future. However it may take another 20 years before hydrogen engines trucks can be widely available.

In the meantime there are numerous prototype or production cars and buses based on fuel cell technology being researched or manufactured. Research is ongoing at a variety of motor car manufacturers.

In 2004 **Iveco** introduced its **Irisbus Iveco City Class bus**, the first hydrogen powered, passenger-carrying vehicle approved for use in the streets of Italy. Following extensive development in the laboratory and on the test track, the fuel cell bus has been type-approved and can now be seen traveling along city streets.

Daimler carried out in the world's largest fuel cell vehicles field test, which involved **30 Mercedes-Benz Citaro buses**. They proved their suitability for day-to-day operations. The vehicles were driven more than two million kilometers in over 125,000 hours of operation. However, the fuel cells' service life needs to be substantially lengthened and their cost drastically reduced before they can be used in series-produced commercial vehicles.

A **Dutch based group presented** in Amsterdam in 2007 hydrogen-powered prototype truck. The **Hytruck C8HE** is based on a Mitsubishi Canter 7.5-tonner, but its manufacturer says its technology can be mated to other makes and models. To create the vehicle, the company replaced the existing diesel motor, gearbox, differential and fuel tanks with a completely new-concept driveline, called the Hytruck H2E. It has fuel cells mounted under the cab producing 16kW, that draw hydrogen from the 227-litre fuel tank containing 5.8kg of hydrogen at a pressure of 350bar. The energy from the fuel cells is transferred to the batteries, which are mounted where the diesel fuel tanks used to be. The fuel cells provide continuous charge to the batteries. Hytruck has already signed up three companies to take part in vehicle trials in Holland, including Corus and a major supermarket.

A **British technology company, ITM Power**, based near Saffron Walden, Essex, has recently unveiled a converted Ford Focus, which runs on hydrogen, but can switch back to petrol if the hydrogen supply is exhausted. The firm has also developed a home refuelling station, capable of producing the gas from water and electricity. ITM's demonstration vehicle, which has completed successful urban commuting trials, can travel 25 miles on a single recharge of hydrogen. Although the initial demonstration vehicle is a car, vans and trucks will also be able to use the new fuel system.

Many challenges associated with the use of hydrogen as an alternative source of fuel have already been surmounted. The distribution of 'compressed' hydrogen appears to be under control, filling up with hydrogen has become just as easy as filling up with diesel or petrol, the first trial stations (in Berlin) are enjoying trouble-free operation, in terms of hydrogen storage special hydrogen tanks are available, capable of withstanding pressures up to 700 bar.

Despite the progress there are still some key factors which prohibit the hydrogen engines from being widely available. These are: developing the vehicles at the reasonable price, developing the product that meets customers demands for power and fuel savings, finding the ways to directly converse the chemical energy, in the form of hydrogen into mechanical drive energy by using existing internal combustion engines, developing technology integrating into vehicle mass production.

A number of European projects are currently carried out in support of hydrogen engines development. One of them is HYICE project.

Conclusion:

Despite the increasing environmental pressures, users of trucks operate in a highly competitive cost-driven environment and are therefore interested in alternative fuels trucks solutions, which are commercially viable. Such commercially viable hybrid trucks are still five years away, hydrogen solutions up to 20 years away. Biodiesel will play an increasingly important role, especially when produced in a different manner i.e. second generation biofuels from non-food crops. For the time being diesel remains the fuel of today, tomorrow and probably the next decade. Truck manufacturers keep developing their diesel engines in order to meet the Euro 5, Euro 6 and EEV norms. The current Euro4/5/6 and EVV vehicles offer very interesting reduction in fuel consumption and significant reduction in emissions, in many cases better than the natural gas alternatives.

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