Evaluation of alternative fuel for motor burn

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ABSTRACT

The motor future belongs to alternative fuels. This work aims at generally used and alternative fuels for motor burn. The characteristics, infrastructure needs, advantage and disadvantage as well as environment and costs of the alternative fuels[1] (natural gas, auto gas, methanol, rapeseed oil, hydrogen, ethanol etc.) are first examined. Then the evaluation of the alternative fuels is accomplished and compared with tables and with illustrations.

Keywords: Modern alternative fuels, methanol, ethanol, hydrogen, auto gas, natural gas

1. INTRODUCTION

Today into traffic almost exclusively gasoline and Diesel fuels are world wide inserted for the enterprise by petrol engine and diesel engine vehicles. In the last years, world wide considerations were aroused due to the oil crisis for the substitution of the Diesel and carburetor fuels. In addition, the application of alternative fuels was intensively discussed with the search for possibilities for the reduction of the traffic-dependent pollutant emissions, carbon dioxide emissions, etc. The following takes place in the analysis based on the criteria: Environment and energy balance, availability, infrastructure, security, tank volume and weight as well as costs.

2. ALTERNATIVE OF FUELS

2.1 AUTOGAS (LIQUID GAS LPG)

LPG is called internationally Liquefied Petroleum Gas (LPG). LPG consists of easily liquefiable hydrocarbon connections (CnHm) with three or four carbon atoms (C). The main parts from liquid are: Propane (C3H8); propen or propylene (C3H6, with C-double bond); butane (C4H10); buten or butylen (C4H8, with C-double bond). The mixing proportion of propane and butane is different in Europe: 95 volume % propane or 45:55-Mischung (propane : butane). Contrary to natural gas or hydrogen, which are easier than air, liquid gas exhibits a density quotient to air of LPG/air=1.55. In vehicles LPG in liquid form in metal cylinders is stored. Running data of LPG compared with gasoline are listed in table 2-1.

Table 2-1 Characteristics of LPG compared with Benzin[3]

		Propane	butane	ISO butane	LPG	gasoline
Specific weight liquid (15 K)	Kg/l	0.50-0.51	0.57-0.58	0.55-0.56	0.53-0.55	0.72-0.73
Lower heat value H	MJ/kg MJ/l	46.1 23.3	45.5 26.2	45.4 25.0	45.8 24.5	43.0 31.2
Research octane number		112	94	100		90-99
Number of engine octane		97	89	98	>89	80-90

2.1.1 Burn Property

Table 2-2 Characteristic values of fuels [Schö dl, 1998]

	Density (kg/l)	HU heat value (kJ/l)	Vstoech air requirement
Propane	0.53	23.6	15.6 (kgAir/kgKr)
Butane	0.58	26.5	15.4
Diesel	0.83	35.4	14.5
Premium fuel	0.76	32.8	14.7

The fuel must mix itself with oxygen and/or the ambient air, so that it can come to a burn of liquid gas. An explosive mixture is present only if the relationship of fuel and air within certain borders, which finds so-called ignition borders. Ignition borders in volume %: Propane=1.7-10.9; Butane=1.4-8.5; natural gas=6.0-16 gasoline=1.5-7.5; hydrogen=4.0-7.5.

2.1.2 Advantages and disadvantages

Advantages

- It can be used well in the alternate enterprise with gasoline fuel;
- LPG is considered as low-pollution fuel;
- LPG forms a good mixture and good cold weather starting characteristic with air;
- LPG is suitable well for Flurfoerdzeuge in closed workshops;
- LPG has a relatively large range with a tank filling compared with other alternative fuels;
- LPG can be stored with lower pressure than natural gas or hydrogen;
- Only a small load of the engine oil arises, which could cause a viscosity reduction

Disadvantages

- By the lower power density of the LPG and the increased consumption (ca. 10% more) of the LPG vehicles ca. 30% smaller range in the pure LPG enterprise for today assigned LPG passenger cars with regard to gasoline passenger car;
- LPG is heavier than air and collects themselves at the soil;
- LPG does not evaporate as fast as comparatively natural gas or hydrogen;
- LPG is not reequipped with all models of all automobile-manufacture.

2.1.3 Environment and costs

The emission behaviour of LPG passenger car is tendentious more favourable than from gasoline passenger car.

Table 2-3 Comparison of different fuels

	Gasoline with Kat.	LPG with Kat.	Diesel	vegetable oil	hydrogen
Suitability	0	0	0	0	0
Costs	0	0	+	-	---
CO	0	+++	+	+	+++
HC	0	+++	+	+	+++
NO_x	0	++	-	-	++
CO_2	0	++	+	++	+++
Particle	0	+++	-	---	+++
Much better than average: +++ ; better than average: ++; somewhat better than average: +; average: 0; somewhat worse than average: -; worse than average: --; much worse than average: -- [DVFG/RG, 1999]					

Environmental advantages of LPG opposite gasoline with the limited pollutant emissions: (1) reduction of CO_2 over up to 15%; (2) reduction of HC over up to 60%; (3) reduction of CO over up to 80%; (4) reduction of NO_x over up to 80%; (5) particles not discharged with LPG.

The selling price at the public gas stations amounts for a litre liquid gas in Germany to 0.4 EUR to 0.6 EUR; In the Netherlands 0.25 EUR to 0.35 EUR and in France 0.3 EUR to 0.4 EUR. Taxation per litre fuels from 01.01.2000: Gasoline 0.55 EUR, Diesel 0.37 EUR, liquid gas* 0.12 EUR (*: pro kg, the year 2000).

2.2 NATURAL GAS

2.2.1 Characteristics of natural gas

Natural gas is a fossil source of energy, it exists from methane predominantly. For storage in fuel tanks and fast filling of them is consolidated to 200 bars. The further main parts of natural gas are ethane and propane as well as nitrogen (see table 2-4).

Table 2-4 characteristics of natural gas compared with premium fuel [Scholten, Langen, 1995]

	H-gas (Russia)	**L-gas** (Holland)	**Premium fuel**
Mixture heat value	3040 kJ/m^3	2540 kJ/m^3	3440 kJ/m^3
Filling*	-9%	-10%	-2%
Octane number of RON	ca. 140	< 140	98
Laminar flame speed	0.43 m/s	0.41 m/s	0.46 m/s
Stoichiometric air requirement	16.87 m^3/kg	13.97 m^3/kg	14.2 m^3/kg
* Theoretical estimation of the decrease at combustion air in the cylinder, caused by gaseous fuel			

2.2.2 Advantage and disadvantage

Advantages:

- natural gas burns more pollution free than gasoline;
- the world-wide reserves is according to estimations clearly larger than with the crude oil;
- the energy consumption of natural gas engines is over 5% smaller than with gasoline enterprise;
- thanks of the high knocking greasiness, the compression ratio and the charging can be increased compared with petrol engines, whereby a higher engine efficiency is obtained

Disadvantages:

- natural gas vehicles are suitable due to their small range for the person and short-distance freight traffic;
- there is still no surface covering gas station net;
- the storage capacity of the tank sizes usable with usual cars is however nevertheless so small in particular that the radius of action hardly goes in the gas operation beyond 200 km.

2.2.3 Environment and costs

The output of the reactive hydrocarbons is reduced over up to 80 per cent and from carbon monoxide by approximately 75 per cent. Sulfur dioxide, soot and other particle emissions with natural gas are almost completely avoided and all this with practically same engine performance and high travelling comfort.

It is worth for both active environmental protection and an interesting fuel price. Natural gas costs on the average about 0.5 to 0.6 EUR per kilogram, which corresponds to a gasoline price from 0.40 to 0.5 EUR per litre[1].

BMW (1995):	3.580 EUR	(As bivalent vehicle)
Small transporter:	5.000 EUR	
Bus:	35.800 EUR	
CNG gas stations (1993):	3.580 EUR	
Compressor (1995):	from 200.000 to more Million	

2.3 LIQUID FUELS-METHANE OIL

2.3.1 Characteristics of methane oil

Methane oil is the simplest alcohol. It has structure CH_3OH and the elementary composition: Carbon 37.5 wt %; oxygen 50.0 wt %; hydrogen 12.5 wt %; Methane oil can be reproduced from fossil primary energy carriers.

Table 2-5 Characteristics of methane oil fuels compared with gasoline

		Pure methanol	premium fuel
Density	kg/m^3	795	750
Heat value	MJ/kg	19.7	43.5
Stoichiometric air requirement	kg/kg	6.5	14.7
mixture heat value	MJ/m^3	3.44	3.75
anti-knock quality	ROZ	115	98
boiling temperature	°C	65	30-180
heat of vaporization	kJ/kg	1119	420
Steam pressure after Reid	bar	0.33	0.78
C/H relationship	wt %	3.00	6.87

2.3.2 Advantage and Disadvantage

Advantages

- employment in the petrol engine
- 10-15% higher achievement
- 20% lower fuel consumption
- with gasoline well mixed
- better cold starting characteristics
- employment in Diesel engine

Disadvantages

- poisonous
- low heat values
- adjustment to the corrosion behaviour

2.3.3 Environment and costs

Methane oil petrol vehicles are characterised opposite gasoline petrol vehicles by lower emission at No_x, CO and VOC at the engine. The VOC emissions of vehicles with methane oil engines and later gear changing three-way catalyst can lie more favourably than with gasoline vehicles. The development for methane oil seems to be still more difficult than for gasoline, since the short tracked hydrocarbons can be oxidized with difficulty catalytically.

With vehicles, which can be driven with different methane oil mixture and which are equipped with a fuel tank only, on methane costs of approximately 250 EUR are counted.

2.4 RAPESEED OIL

2.4.1 Characteristics of rapeseed oil

Table 2-6 Characteristic of rapeseed oil

Density (20°C)	0.90-0.92 kg/l
Power density	9.2 KWh/l
Kinematic viscosity (20°C)	60-80 mm^2/s
Flash point	> 220 K
Melting point	-8 ~ 18 K

2.4.2 Advantages and disadvantages

Rapeseed oil owns itself for the employment in diesel engines. Rapeseed oil is characterised opposite Diesel by the viscosity higher around the factor 10. Therefore rapeseed oil can be used in the direct injecting diesel engines usual within the commercial motor vehicle range. But the employment of pure rapeseed oil leads to an increase of the hydrocarbon and carbon monoxide emissions. Diesel engines could be adapted to the special requirements of the rapeseed oil, but remain the in any case worse cold starting behaviour. Rapeseed oil methyl ester (RME) can be used in today's standard diesel engines without changes at the engines.

With RME conventional passenger car Diesels lose only slightly at torque and achievement. The lower heat value becomes partly balanced by the higher density, so that volume-metric consumption worsens only little. Supposed still improvements can be attained with consumption and emissions by an adjustment of the engines at RME. This was confirmed by fleet tests in penalties and passenger car.

2.4.3 Environment and costs

With same energy consumption, the application of RME shows up lower VOC- and CO emission with use of RME in vehicles than with diesel engine. By the use of oxidation catalysts, and so that by the employment of RME no sinking of the direct VOC emission is to be expected opposite Diesel passenger car. The small sulfur content in the exhaust gas facilitates the use of oxidation catalysts.

At present offer in Germany ca. 300 gas stations RME on. The prices lie mostly slightly over those for Diesel fuel. Approximately 5000 vehicles drive in the middle of 2002 into Germany with rapeseed oil.

2.5 HYDROGEN

2.5.1 Characteristics of hydrogen

Hydrogen with the chemical indication H is a gaseous element, which arises in nature only in chemical compounds. It forms water together with oxygen. But it occurs also in coal, oil or natural gas.

Table 2-7 Characteristics of hydrogen[4]

Density (gaseous)	0.09 kg/m^3
Point of condensation	-252.77 K
Freezing point	-259.14 K
Flame temperature	2318.00 K
Lower heat value	133 MJ/m^3

2.5.2 Advantage of Hydrogen

Hydrogen is an ideal renewable source of energy. It can be transported as compressed gas or frozen liquid easily and stored relatively simply. It stands to all daily and seasons for order and is present as a component of the water in large quantities. One can use it also in particular to the mobility, since hydrogen is not dependent on the sun as for example a solar cell. A further advantage is that with its burn (power production) again pure water develops, and therefore does not contribute hydrogen to the greenhouse effect.

2.5.3 Hydrogen-claimant vehicle

With the burn hydrogen delivers its chemically stored energy in the form of warmth, in the gas cell in the form of current and warmth.

The pressure wave caused by the explosion presses a piston downward. The piston is again raised during a flywheel and consolidated again in the meantime over the valves changed gas mixture.

The entire procedure is repeated starting from this point. The piston and the flywheel are connected with a crankshaft, which is brought by the movement of the piston in rotation. This crankshaft propels the drive wheels of the appropriate vehicle during gears. Thus the chemically stored energy of the hydrogen is converted as with the petrol engine operated with gasoline by burn and mechanical translations into kinetic energy of the vehicle.

Daimler Chrysler, BMW and Ford, etc. built the hydrogen-claimant cars. This car drives with a maximum speed from 226 km/h and can reach in 9.6 seconds 100 km/h.

Table 2-8 Current hydrogen-claimant vehicle concepts[5]

Manufacturer	Model (appearing year)	propulsion principal
BMW	-BMW 750hL (1999) -BMW 745h (2001) -MINI Cooper Hydrogen (2001)	hydrogen combustion engine, liquid hydrogen hydrogen combustion engine, liquid hydrogen hydrogen combustion engine, liquid hydrogen
Daimler Chrysler	-NECAR 4 (1999) -NECAR 4 Advanced (1999) -NECAR 5 (2000) -Jeep Commander (1999) -Jeep Commander 2 (2001)	gas cell, liquid hydrogen gas cell, hydrogen gas gas cell, methanol gas cell, gasoline gas cell + metal hydride battery, methanol
Ford	-Ford Focus FCV (2001) -Ford Focus FCV (2001) -Ford Focus FCV (2001) -Ford P2000 H21CE (2001)	Gas cell, hydrogen gas Gas cell, Methanol Gas cell, Gas cell hydrogen combustion engine, hydrogen gas
Honda	-Honda FCX-V3 (2000) -Honda FCX-V4 (2001)	Gas cell, hydrogen gas Gas cell, hydrogen gas
Mazda	-Mazda Premacy FC-EV (2000)	Gas cell, Methanol
Opel	-Opel HydroGen1 (2000) -Opel HydroGen3 (2001)	Gas cell, liquid hydrogen Gas cell, liquid hydrogen
Toyota	-FCHV-3 (2001) -FCHV-4 (2001) -FCHV-5 (2001)	Gas cell + metal hydrid battery, metal hydride hydrogen reservoir Gas cell+Metallhydrid-Batterie, Gas cell Gas cell, liquid hydrogen
VW	-VW Bora HyMotion (2001)	Gas cell, liquid hydrogen

2.5.4 Possibility of the hydrogen reservoir

One large problem with the production of hydrogen-claimant vehicles is the storage of the fuel. Hydrogen as gas is extremely volatile and has only a very small density.

Nowadays there are three kinds of storage: (1) storage in liquid condition (LH2); (2) storage in gaseous condition (GH2); (3) storage as metal hydride

2.6 OTHER ALTERNATIVE FUELS: ETHANOL (CH_3-CH_2-OH)

Similarly as with the enterprise with methane oil, the engine missions are lower with ethanol vehicle around 50% than with comparable gasoline vehicles. Here advantage is in particular the small portion of the polyzyklischen hydrocarbons and the small Ozonbildungspotenzial, whereby however the acetaldehyde missions fail more strongly. With Ethanol vehicle show a more favourable energy consumption than vehicles with gasoline enterprise. With a series production, it costs almost the same as for gasoline vehicles.

3. COMPARATIVE EVALUATION

3.1 EMISSION COMPARISON

The smaller direct VOC emissions can be reached with alternative fuels and drives opposite gasoline and/or Diesel passenger car.

Table 3-1 Change of the direct emissions by employment of different drives and fuels [2]

	VOC	CO	NOx	Particle
In relation to change today's BFZ [#1]				
Improved BFZ	- 60% to 80%	++	++	
Improved petrol	-15%	+	+	
LPG	-60%	+	+	
Methanol	-20% to 50%	+/-	+/-	
Ethanol	-50%	+	+	
Natural gas	0% NMVOC: -90%	++	++	
Hydrogen	Almost no Emission	Almost no Emission	Little Emission	
In relation to change today's DFZ [#2]				
Improved DFZ	-30%	++	++	++
Improved Diesel fuels	-30%	+	+	++
RME (diesel engine)	+/- 0%	+/-	+/-	+/-
+ smaller emissions than today's passenger cars; ++ very many smaller emissions than today's passenger cars.				
#1: BFZ: Gasoline vehicle, by combination of measures in the area " improved BFZ" , the emission behaviour of the vehicles with alternative vehicles can be e.g. further improved; #2: DFZ: Diesel engined vehicle				

3.2 COMPARISON OF THE CHARACTERISTICS OF ALTERNATIVE VEHICLE CONCEPTS

The regarded alternative vehicle concepts differed over their use characteristics, the technical level of development and the cost (Table 3-2).

Table 3-2 Comparison of the characteristics of alternative vehicle concepts between 1990 and 2010*

	LPG	methanol	ethanol	RME	CNG	electrical	hybrid	LH_2	gas cell
Technical level of development production stage development need	+ mid	+ mid	+ mid	+ mid	- mid /high	- high	- high	- high	- very high
Range pay	+/- +/-	+/- +/-	+/- +/-	+/- +/-	+/- +/-	- +/-	- +/-	- +/-	- +/-
load/utilizable volume handling	- +/-	+/- +/-	+/- +/-	+/- +/-	-- -	--- --	--- --	--- --	--- --
characteristics	+/- +/-	+/- +/-	+/- +/-	+/- +/-	+/- +/-	- +/-	- +/-	- +/-	- +/-
security	- -	- -	+/- +/-	+/- +/-	- -	+/- +	+/- +/-	-- -	-- ?
availability primary energy carrier	+/- +/-	+/- +/-	- -	-- --	+/- +/-	+ +	+ +	+ +	+ +
infrastructure needs	- +/-	-- +/-	-- +/-	-- +/-	- +/-	- +/-	--- -	--- -	--- -
costs	- +/-	-- -	-- --	-- --	-- -	--- -	--- -	--- -	
* on the assumption that a technical development takes place +, ++, +++ means more favourably than gasoline passenger cars; -, --, --- means more badly than gasoline passenger cars.									

4. SUMMARY

There are more advantages of the alternatives fuels (auto gas, natural gas, methane oil, rapeseed oil, hydrogen, etc.) than gasoline and Diesel

- The characteristics and uses of alternatives fuels were investigated
- Comparative evaluation of the different alternatives of fuels was given with gasoline and Diesel
- small pollutant emissions;
- small fuel consumption
- The alternative vehicle concepts were details discussed inclusive of environment, energy balance, availability, infrastructure and security

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CHINA UEBERHOLT JAPAN

China hat Japan als groesstem deutschen Handelspartner in Asien jetzt den Rang abgelaufen. Im Vergangenen Jahr wurden Waren im Wert von insgesamt 14,5 Mrd. € nach China exportiert, 19,6 Prozent mehr als 2001. Die Ausfuhren nach Japan gingen laut Statistischem Bundesamt dagegen um 7,1% auf 12,2 Mrd, € zurueck. Bei den Importen liegt China mit 21,1 Mrd., ebenfalls vor Japan (19 Mrd. €).