

Alternate Automotive Fuel and Advanced Technology in Vehicles

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Abstract:

Alternative fuels and advanced technology vehicles are seen by proponents as integral to improving urban air quality, decreasing dependence on foreign oil, and reducing emissions of greenhouse gases. However, major barriers — especially economics — currently prevent the widespread use of these fuels and technologies. Because of these barriers, and the potential benefits, there is continued congressional interest in providing incentives and other support for their development and commercialization. High crude oil and gasoline prices over the past few years have led to increased interest in the fuel supply. Recent interest has focused on alternatives to petroleum, ways to improve the efficiency of the transportation sector, and ways to improve the stability and security of the petroleum supply and refining sectors. Key components of federal policies to reduce fuel consumption include the promotion of alternatives to petroleum fuels and the promotion of more efficient vehicles.

1. Introduction:

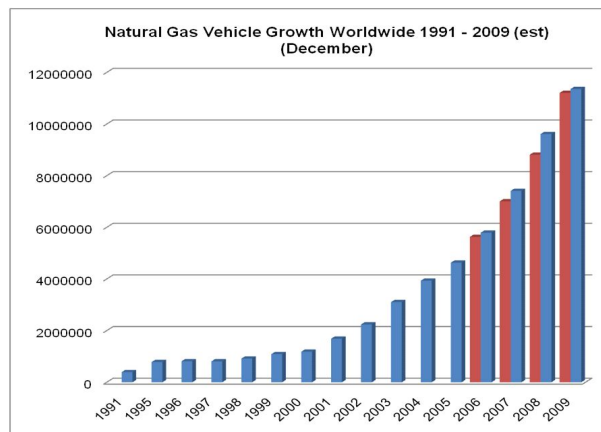
Alternative transportation fuels, especially methanol and ethanol, have been researched extensively for more than two decades, due to their potential economic, national security, and environmental benefits. Moreover, substituting neat alcohol fuels in place

of petroleum-based fuels in the transportation sector would also give lower emissions of greenhouse gases, evaporative hydrocarbons. These benefits notwithstanding, neat alcohol fuels have seen only limited success over the last ten years, due to their high cost relative to gasoline on a unit energy basis, as well as many supply and infrastructure challenges. An important step toward increasing alcohol fuel demand, then, may lie in providing economical engine technology options that utilize such fuels more efficiently, to compensate for the lower fuel energy density. The FFVs produced today, however, use fairly typical gasoline engines, which, because they must retain dual-fuel capability, are not able to take full advantage of the favorable combustion characteristics of alcohols. Engines optimized for alcohol fuel use, on the other hand, may yield efficiencies that exceed that of state-of-the-art diesel engines—or, about one third higher than that of FFV engines. It may represent a long-term market-sustainable option, which might one day foster more widespread alcohol fuel usage.

1.1 Alternative motor fuels

1.1.1 Natural gas

Natural gas consists of 90% methane (CH_4) and, depending on the origin gas fields, a mixture of other gases such as ethane (C_2H_6), propane (C_3H_8), carbon dioxide (CO_2) or hydrogen (H_2). As a fuel, natural gas has two major advantages when compared to petroleum products: 1. The range of its availability is estimated to be distinctly longer than for crude oil and 2. The relationship of hydrogen / carbon is, with 23% for natural gas, much more favourable than for crude oil, meaning that during combustion, less carbon dioxide is emitted than when using petroleum products. There are two technologies for the direct use of natural gas (CNG and LNG) and a third technology which is used in the transformation of natural gas into a liquid fuel (GTL).



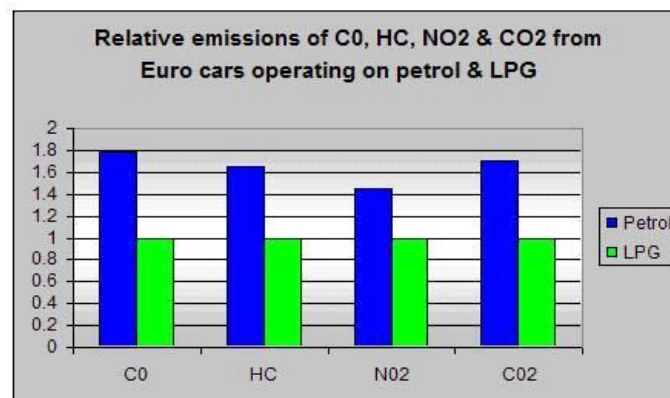
1.1.3 Compressed natural gas (CNG)

The term CNG (Compressed Natural Gas) stands for natural gas which is compressed at a pressure of 200 bar. The filling stations use natural gas from the supply grid, compress it and pump it into the pressure tanks in the car.

CNG has a lower energy content per litre than gasoline or diesel. Thus, the range of the bivalent vehicles is clearly increased. In some cars, the CNG tank is put into the boot. At the same time, a number of mono- and bivalent CNG cars exist in which the tank is integrated in the bottom of the vehicle (see Figure 2), without loss of boot space.

1.1.2 Liquefied natural gas (LNG)

LNG is not a specific automotive fuel, but a favourable form in which natural gas can be transported. LNG is liquefied natural gas transported and stored at -165°C and at a pressure slightly above atmospheric. In the condensed liquefied form, natural gas can be transported very efficiently, e.g. in trucks or railway wagons. Once it arrives at its destination, LNG can be transformed into gaseous CNG. Furthermore, the heat transfer from the environment into LNG through the insulation material, leads to a continuous evaporation of the liquefied gas into the gaseous phase (boil-off). This gaseous natural gas is often brought into the atmosphere through “open rack” evaporators which have a strong effect on climate change: 1 kg of natural gas (i.e. methane) has a climate change potential which is 32 times higher than 1 kg of carbon dioxide.



1.1.4 Gas-to-liquids (GTL)

The development of gas-to-liquid fuels (GTL) is only in its infancy. Details of this process are given in chapter 3.2.2 “Current research activities in the alternative fuels and automotive technologies”.

1.2.1 Bio-fuels

1.2.2 Biodiesel (RME)

Biodiesel is produced by mechanically extracting natural vegetable oils from seeds, such as rape, and reacting the oil with methanol in the presence of a sodium or potassium hydroxide catalyst. Valuable by-products are produced during the

production including straw (which can be used as a fuel), oilseed cake (a protein rich animal feed) and glycerol used in the production of soap and as a pharmaceutical medium. The production of biodiesel, such as rape methyl ester, is still done on a small scale and does not presently enjoy the economies of scale available to the production and distribution of diesel.

However, the extreme temperature of -165°C for LNG requires an excellent resistance to cracking from those materials with which it comes into contact. Furthermore, the heat transfer from the environment into LNG through the insulation material, leads to a continuous evaporation of the liquefied gas into the gaseous phase (boil-off).

1.2.3 Biomass-to-liquid (BTL)

The development of biomass-to-liquid fuels is only in the beginning phase. Thus, the details are given in Chapter 3.2.1 "Current research activities in the alternative fuels and automotive technologies". Other biofuels Biomass can be used as an automotive fuel through a number of different processes and products, e.g. as bio-ethanol, bio-methanol, biogas or through the gasification of wood and other biomass. As these biofuels cover only niches or regionally limited markets (e.g. ethanol in Brazil) and will have a limited importance on the world market.

2. Hydrogen:

Hydrogen sources and methods of production Hydrogen is abundant in our world in its chemically bound form. Energy is needed in order to isolate it in its elementary form from its sources. The main sources are water, hydrocarbons and coal. In 1988 the annual world hydrogen production was $5 \times 10^{11} \text{ Nm}^3$ (Appl, 1997). This includes hydrogen produced on purpose and hydrogen received as a by-product. In 1988, the sources of hydrogen, by decreasing order of importance, were • natural gas (48% of world production), • oil (30% of world production), • coal (18%), and • electrolysis (4%). The electrolytic hydrogen was mainly derived as a by-product of chlorine-alkali electrolysis (Appl, 1997). Hydrogen is often economically recovered from the hydrogen-rich off-gases of other processes, especially in refineries. For capacities above $1000 \text{ Nm}^3/\text{h}$, the production of hydrogen from hydrocarbons in dedicated plants is generally preferred. The main production processes are steam reforming and partial oxidation.

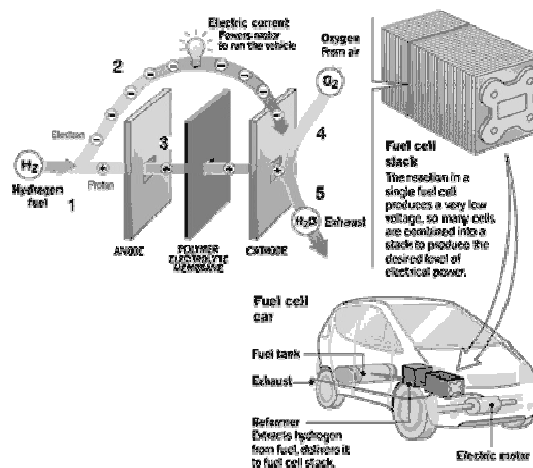
3. Alternate Propulsion Technique:

There are a great number of other propulsion technologies besides those combustion engines which operate according to Otto and Diesel principle. There is also the possibility of combining different propulsion technologies in one vehicle (hybrid vehicles). An example of this is the combination of a conventional internal combustion

engine, a generator and an electric, battery-powered drive, e.g. for more environmentally-friendly propulsion in inner cities.

3.1 Fuel Cell:

The basic physical principle behind a fuel cell can be characterised simply as a “reverse electrolysis”. Whereas hydrogen and oxygen are produced along with electricity through the electrolysis of water, a fuel cell produces power with the “cold burning” of both these gases in a reverse process. This is made possible by letting the two gases react separately in the different compartments (the electrodes) of the fuel cell. As a result hydrogen and oxygen cannot directly react with each other, which would lead to an explosion, but are forced to release their energy in a “tamed” reaction whilst being separated from one another. The products of this reaction are electricity and, when pure hydrogen is used for fuel, water vapour. The two “reaction chambers” of the fuel cell are called the cathode, which is supplied with oxygen or air, and the anode, which is fed with fuel gas. Both are separated by a gas-tight, ion-conducting layer, hence the name: electrolyte



At the anode, the entering fuel gas (mostly H₂) is catalytically separated into a positive proton (H⁺) and an electron. On the cathode side, the oxygen (mostly from air) can react with the electron from the anode side. Both reactions are thermodynamically favoured and are exothermic – meaning they occur without external energy input. Depending on the material of the electrolyte, either the negatively charged oxygen containing ion from the cathode side or the positively charged hydrogen ion (proton) from the anode side can travel through. The electron itself has to pass through the electrical circuit to power an external load. At this point, most of its available energy has been already harnessed by the “travelling” of the electron through the load and only the remaining small amount of energy associated with the ions is released without the effects of a hydrogen / oxygen reaction. A fuel cell (also called a stack) is a modular technology (compared to an internal combustion

engine). This modular design with many single elements is necessary to obtain the high internal surface area that is required to reach a high enough outputs. Also, the voltage from a single cell is too low for standard operational uses and consequently several cells have to be put together.

4. Conclusion

Substantial improvements in brake thermal efficiency have been demonstrated with neat alcohol fuels in a cost-effective port-fuel injected, spark-ignited engine configuration. This work to include alcohol-gasoline blends, showing significant benefit with fuels containing 30% alcohol, so concluded

1. Over 40% brake thermal efficiency can be obtained in a high compression ratio, PFI SI engine using neat methanol and ethanol fuels, resulting from the favorable combustion properties of alcohols.:
2. Decreasing the fuel alcohol content generally gives lower brake thermal efficiency and some what decreased load range
3. High efficiency was demonstrated with fuel blends down to 30% alcohol content. Such fuels may present a more economical and efficient means of utilizing alcohol fuels, and provide a path toward their more widespread, long-term use.

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