Briefing

FRIENDS of the earth
for the planet for people

Cleaner Cars and Fuels

Introduction

Advances in vehicle design and fuel quality mean cars can be made cleaner and more efficient. Lower emissions of carbon monoxide (CO), nitrogen oxides (NOx), sulphur dioxide (SO_2), particles (including the fine dust and soot - PM_{10}) and hydrocarbons (HCs) - also known as volatile organic compounds (VOCs) - will lead to better urban air quality and less summertime smog. Lower emissions of carbon dioxide (CO_2), from better fuel efficiency, will lower the risk of dangerous climate change. This briefing examines these advances and looks at the benefits alternative fuels may provide for vehicle emissions in the future.

Petrol vs Diesel

Most cars run off petrol and diesel and people often ask which is better for the environment. This is a very difficult question to answer. The simple truth is that both fuels have advantages and disadvantages.

Petrol engines are less efficient than diesel engines and therefore emit more carbon dioxide. They also emit more carbon monoxide and hydrocarbons.

Diesel engines produce more nitrogen oxides, sulphur dioxide, black smoke and particles (such as PM_{10}). As these pollutants are particularly associated with poor urban air quality, Friends of the Earth does not recommend that people who drive in cities buy diesel cars.

However, both petrol and diesel fuel can be reformulated in ways which will cut emissions. Similarly changes to engine design and the fitting of catalytic converters can cut emissions from both petrol and diesel engines. These are examined in more detail below.

Reformulated Fuel

Reformulated petrols and diesels are simply petrols and diesels that have had their 'recipe' changed. The detailed composition of the fuels has been changed. Reformulated fuels are marketed as City Diesel, City Petrol, Clean Diesel, Clean Petrol, Low Sulphur Petrol, Ultra Low Sulphur Diesel, Low Benzene Petrol, and so on.

Reformulated diesels, such as City Diesel or Clean Diesel, contain less sulphur than ordinary diesel. This cuts emissions of particles, NOx and CO. It is especially effective at cutting emissions from buses and lorries.

Emission reductions are particularly high when low sulphur diesel is combined with new catalysts or filters. These can be fitted to existing lorries and diesel cars but need low sulphur fuel to work effectively. Oxidation catalysts and filters can cut CO and HC emissions by about 50-70 per cent and particles by over 90 per cent, if used with low sulphur fuel.

Likewise, reformulated petrol offers reductions in vehicle emissions. A recent study found that lowering the sulphur levels in petrol resulted in reductions of 52 per cent for hydrocarbons, 43 per cent for CO and 20 per cent for NOx in tests on rural roads and motorways. The reductions were not so great for tests incorporating city driving but sulphur reduction still led to an 8.6 per cent cut for HC, a 9 per cent cut for CO and a 10 per cent cut for NOx.[1]

Vehicle Design

Besides reformulation of petrol and diesel fuel, emissions from petrol and diesel can be cut through a variety of catalysts and changes to engine design.

Catalytic converter technology

Catalytic converters are fitted between the engine and the exhaust pipe. They convert most of the exhaust into less damaging gases via chemical reactions. Since 1993, European law has required that catalytic converters be fitted to all new cars. The most common catalyst is the 3-way catalyst or 'cat'.

3-way cats, as the name suggests, work by converting the 3 main pollutants CO, NOx and HC into less harmful gases. Carbon monoxide is turned into carbon dioxide, nitrogen oxides into nitrogen and hydrocarbons into water. In tests they have been found to reduce NOx by 95 per cent, hydrocarbons by 90 per cent and carbon monoxide by 80 per cent.[2]

However 3-way cats do not work effectively when the catalyst is cold. This means that the catalyst is not effective for short trips or for the first few miles of long ones. One way manufacturers are overcoming this problem is to develop heating systems which will pre-warm the catalyst so that it works effectively as soon as the engine is switched on.

Oxidation catalysts

Oxidation catalysts can be fitted to diesel and petrol vehicles though they are more common on diesels. They reduce HC, aldehydes, CO and particles. They do not however reduce NOx. Yet they may help to provide further reductions in emissions if used in combination with reformulated fuels. Tests from London Transport show that compared with untreated buses, use of ultra-low sulphur diesel and oxidation catalysts eliminates smell and black smoke. It also reduced particles by around 75 per cent, NOx by 25 per cent and CO and HC by 80-90 per cent.[3]

Lean burn

Conventional combustion engines use oxygen to burn fuel. Most engines use a ratio where there is just enough oxygen to burn all the fuel. This is called a stoichiometric ratio. However, if you increase the air to fuel ratio, mixing more air with the fuel, there will be a leaner mixture. This provides a lean burn of the fuel giving higher fuel efficiency and therefore providing greater fuel economy. Car manufacturers are taking advantage of this and Toyota have claimed that this improvement to fuel economy could be around 20 per cent.[4]

Direct injection engines

Like lean burn, direct injection is a technique to improve the way fuel mixes with oxygen. By controlling the way fuel is injected and maximising efficiency, improvements to fuel economy can be gained. Car manufacturers have claimed that direct injection petrol and diesel engines could provide about 25 per cent better fuel economy than conventional petrol engines and reduce CO_2 emissions due to improved fuel control and leaner air to fuel mixtures.[5]

European Emissions and Fuels Directives

Legislation controlling fuel quality, such as reformulation, and vehicle design is set at European level. Over the past 25 years the EU has set progressively tighter emission standards for all road

vehicles. The latest of these EU Directives adopted in 1998 sets emissions standards for all new cars. It will tighten the limits for CO, HC, NOx and particles. The directive also requires the fitting of on-board diagnostics on all petrol cars from 2000, on all diesel cars from 2003, and on all vans from 2005 so that the driver can be warned if the emissions control system breaks down.

This trend for even tighter emissions standards for all petrol and diesel vehicles is set to continue and will have to be achieved by car manufacturers, giving further the incentives for more investment in research and the development of cleaner and more efficient vehicles.

Similarly new EU fuel quality directives have banned the sale of leaded petrol, cut the sulphur content of petrol and diesel and cut the amount of the carcinogenic benzene in petrol. Further cuts in sulphur in petrol and diesel will come into effect in 2005.

Alternative Fuels Available Now

In addition to technology to control emissions from petrol and diesel vehicles (including cleaner fuels) there are alternative fuels that could cut vehicle emissions.

Natural gas (NG)

Natural gas can be used as a fuel in either one of two forms, Liquefied Natural Gas (LNG) which is stored at very low temperatures, or Compressed Natural Gas (CNG) which is stored at high pressure. The nature of the liquefaction process for LNG makes this fuel much more complex to store and distribute, and as a result it's also more expensive than CNG. So CNG seems a much more favourable option.

CNG

CNG generally burns better than petrol and diesel and has better combustion properties making it operate very efficiently. The fuel also has lower carbon content producing lower CO_2 emissions. It produces virtually no particles.

The vehicles most suited to run on natural gas are buses and lorries. The reasons for this are firstly the sheer size and weight of the CNG tank and secondly because emission savings are greatest when CNG replaces diesel. A CNG tank for a typical family size car would take up the whole back seat. The weight of the tank would reduce the efficiency of the car, which could then offset any emissions savings that CNG may provide. However, the weight of the tank is far less significant for larger vehicles. Recent tests have shown that CNG fuelled vehicles reduce CO by 97 per cent, hydrocarbons by 81 per cent, NOx by 86 per cent and particulate matter by 94 per cent. Also, the engine is four times quieter than diesel.[6]

Within the UK, switching to natural gas would be fairly easy given the existence of the national gas grid. There would, however, need to be a huge increase in the number of refuelling points around the country.

Liquid Petroleum Gas (LPG)

Liquid Petroleum Gas (LPG) is a by-product of petroleum refining and natural gas processing. It comes in the form of propane and/or butane, and is perhaps better known to us as the bottled gas used for cooking and heating.

LPG has a higher octane number than regular petrol. This means that the fuel burns better and can be more efficient with the potential to emit less pollution.

In general, the most modern LPG vehicles (Generation III) tend to have slightly lower CO_2 emissions and much lower CO emissions than petrol vehicles. For HC, emissions were also lower, though studies have shown that emissions could actually increase in congested traffic conditions.[7] It has also been shown that NOx emissions can be much higher than from petrol engines.

In comparison to diesel engines, emissions of particles and NOx were much lower. However, compared to diesel vehicles, LPG had higher CO and HC emissions.

As with CNG vehicles the weight of an LPG storage tank is quite significant. LPG is not therefore ideal for smaller vehicles like vans and cars. However, heavy duty vehicles are less affected by the size and weight of the tank and so LPG is suited to them. That is however

not to say that smaller cars could not run on LPG with some success. Research has shown that a modern LPG car could meet California's tough Ultra Low Emission Vehicle standards.[8]

The distribution of LPG would be relatively simple as it could be sold through conventional filling stations using high pressure pumps. However the pipes must be pressurised throughout. This makes the process expensive and cumbersome.

In summary introducing LPG cars, wouldn't offer great benefits over modern petrol engines, meeting Euro 2000/2005 standards. However, LPG does provide benefits as a replacement to heavy duty diesel vehicles, especially in urban areas where the need to reduce problem pollutants such as particles is of great concern.

Electric vehicles

Electric Vehicles (EVs) are 'pollution free' at point of use. They emit no toxic pollution from their exhaust pipes and are perfect for heavily polluted areas. However, EVs are not really pollution free as energy is needed to create their electricity. This energy ultimately comes from power stations and power stations emit pollution, especially if powered by fossil fuels.

EVs can provide other clear benefits over conventional vehicles. They are extremely efficient. For example, while braking or decelerating down hills, modern EV engines can recapture energy and store it in the battery for later use. They do not use any energy while stationary, unlike petrol or diesel engines, and are perfect for stop-start traffic in urban areas. EVs also have an added benefit of being extremely quiet, another useful characteristic for urban areas.

Yet three major concerns have always hindered the development of electric vehicles; the bulkiness of the battery system; the time taken to re-charge batteries and their poor range. Research and development is taking place to solve these problems and manufacturers seem keen to promote developments. Toyota claims its RAV4 EV, for example, can cruise for 200km on a single charge.[9]

Progress is slowing down, however, and many companies are now dis-investing from EV production for more investment in hybrid and fuel cell technology.

Hybrid cars

Hybrid vehicles use a combination of conventional fuel (petrol/diesel) with electricity to power a vehicle's engine. Electric power is used at lower speeds, particularly for urban stop start driving, where the car uses electricity to automatically start up and shut down. This means there is no idling of the engine, unlike regular vehicles which still pour out pollution even when standing still. Conventional fuel is then used to drive outside urban areas, or where better performance is needed for higher speeds or more acceleration.

The benefit of having a hybrid engine is that the power needs of a vehicle are split so that it can be more energy efficient with lower emissions. What's more the vehicle doesn't need to be recharged at a power point, unlike EVs, because the conventional fuel used powers a generator within the engine that then creates electricity.

Car manufacturer Honda has just launched a two seater hybrid car, the Insight. The Insight boasts a fuel consumption of 51 miles per gallon in city driving conditions and 58 miles per gallon under motorway conditions. Honda also claims that the vehicle meets California's Ultra Low Emission Vehicle standard.

Many car manufacturers agree that the hybrid vehicle could provide an alternative while they develop longer term vehicles such as those powered by fuel cells.

Long Term Developments

Fuel cells

Fuel cell technology has been in the spotlight lately, and for very good reason - fuel cells have the potential to be emission-free. But how do they work?

Fuel cells produce energy in the form of electricity by mixing hydrogen with oxygen taken straight from the air. These react in the cell to produce water and electricity, that then powers the vehicle. The major benefit of fuel cells is that the only by-product to be released from its exhaust is water vapour.

Fuel cells can use other fuels containing hydrogen to power an engine. These include methanol, ethanol, natural gas and even petrol and diesel.

Although similar to the battery, fuel cells are quick to refuel (unlike batteries that need recharging over many hours). They have a longer range, so therefore can go longer between refuelling; are very quiet, making them ideal for urban areas; and have a performance similar to that of a petrol/diesel engine. Fuel cells are also extremely efficient devices that would reduce CO_2 emissions.

In March 1999 DaimlerChrysler unveiled its NECAR 4 a fuel cell version of its Mercedes small A-class car. The car can do 90mph and has a range of 280 miles, more than twice that of "zero-emission" battery-electric cars. What's more DaimlerChrysler, and other major car manufacturers like Honda and Toyota have pledged to have a viable, commercial fuel cell vehicle available by 2004, and are heavily investing in research and development of fuel cell vehicles.[10]

Hydrogen

Hydrogen is produced by a variety of processes from water, natural gas, oil or coal. The major advantage of hydrogen as a fuel is that when it is burnt it emits only water vapour and a small amount of NOx. For this reason its potential as a clean fuel for the future is very promising.

The production and distribution of hydrogen does have serious problems, however, and this could seriously hamper its future potential. At present there is no distribution infrastructure and the safety aspect for using hydrogen is a major concern. Hydrogen is very flammable and runs a much greater risk of explosion compared to natural gas. Storage for the fuel is also difficult as it has a low energy density which means that much fuel is needed to provide a reasonable range for a vehicle, resulting in the need for larger and heavier fuel tanks.

There are current examples of projects using hydrogen. In North America buses are running on hydrogen in Vancouver and Chicago and projects have been set up in Europe. Car manufacturer BMW has also made some progress in developing hydrogen as a fuel and has said that, in trials, a medium sized passenger car was able to go up to 250 miles on a 132lb tank.[11]

Research into production, handling and storage continues but costs in the foreseeable future are likely to remain extremely high preventing the technology from making in-roads into the market.

Biofuels

A biofuel is a fuel that has been produced from crops or vegetation of one sort or another. There are two main groups of biofuel: alcohols (ethanol and methanol) and biodiesel.

The primary advantage of biofuels is that they are non-fossil fuels. The plants used to make them take up CO_2 when grown, therefore off-setting the CO_2 that is released when the fuel is burned. However, using biofuels is not quite as simple as that. The production and processing of the crop to manufacture the fuel often turns out to be energy intensive, therefore not off-setting the CO_2 balance. Secondly, the amount of land needed to produce the crop would be vast. Thirdly, growing the crops could have huge environmental consequences, such as soil erosion.

Ethanol

Ethanol is produced from a range of crops. It has a number of draw backs - it corrodes metal parts, removes lubricating oil and can be expensive to produce. It brings limited reductions in local emissions of some pollutants. Emissions of both volatile organic compounds (VOCs) and nitrogen oxides are lowered when it is used in light duty vehicles and there are no particulate emissions.

Methanol

Like ethanol, methanol fuel suffers the same effects. Emissions of VOCs and NOx are somewhat reduced and particles are eliminated.

Biodiesel

Biodiesel is produced from a variety of vegetable oils but oil-seed rape is the most suitable crop for the UK climate. Rape methyl ester (RME) is produced through a chemical process of the rapeseed oil and can be used directly in a diesel engine. It can also be blended with regular diesel fuels. RME has been shown to reduce slightly the emissions of VOC but increase emissions of

NOx and particles.

Conclusion

Advances in cleaner fuels, engine technology and alternative fuels clearly have a role to play in cleaning up vehicle emissions and cutting greenhouse gases.

Petrol vs Diesel

Given the choice between petrol and diesel vehicles Friends of the Earth would suggest that a petrol vehicle with a 3-way catalyst would cut emissions compared to current diesel vehicles, especially in polluted urban areas.

Reformulated Fuel and Vehicle Design

Replacing regular fuel with reformulated fuels will cut emissions immediately, even if no further technical fixes are fitted to existing vehicles. In addition, improved engine design and converter devices such as 3-way catalysts and oxidation catalysts can further aid improvements in emissions and fuel efficiency.

Alternative Fuels Available Now

In the longer term alternative fuels like CNG and LPG have great potential in offering cleaner emissions. They would play a particularly important role in replacing larger diesel vehicles such as lorries and buses. With more refuelling stations planned around the country, the possibilities seem favourable for their development.

The potential for biofuels, particularly in Britain, is not as promising as some other alternative fuels. Though studies of their overall environmental impact are inconclusive, the production of vast amounts of crops for vehicle fuel alone could be extremely damaging and impractical.

Electric vehicles have always offered benefits for local air quality as they have no tailpipe emissions. However, they do need energy which ultimately comes from power stations that, if powered by fossil fuels, could have serious implications for increasing climate changing greenhouse gases. The dis-investment in electric vehicles, in favour of development of hybrids also makes electric unlikely to offer potential for the future. Hybrid vehicles on the other hand have been seen by car manufacturers as filling the gap between current technology and more advanced developments.

Long Term Developments

It's not until we examine the longer term developments in alternative fuels that we start to consider fuels that may provide the potential to offer zero-free emissions or near zero emissions. Fuel Cells and hydrogen fuel are being researched by the major car manufacturers and being promoted as fuels for the future.

In summary, it is clear that alternative fuels play a vital role in reducing pollution levels and improving poor air quality in urban and rural areas. Alternatives have, however, some way to go before providing a real alternative to conventional fuels. For alternative fuels to be practical, they need to be available in large amounts, easily distributed and relatively cheap.

What You Can Do

The best contribution you can make to cutting pollution from traffic is to cut the amount of journeys you make by car. Always use alternatives where possible by walking, cycling and using public transport.

If buying a car choose a small fuel efficient petrol car with a 3-way catalytic convertor and use reformulated fuels such as Clean Petrol. Information on fuel consumption and emissions is available from the Vehicle Certification Agency which publishes a booklet showing emissions from all new cars. In addition, all new cars will soon be clearly labelled to show their CO_2 emissions and fuel efficiency which will make it easier to know which vehicles are more efficient.

Further Reading

Fuelling the Debate FOE (1996). £4.00 Quote ref. T408.

"Leaded or Unleaded - What Sort of Petrol to Use?" FOE (1999). Free briefing

"Summertime Smog" FOE (1997). Free briefing Quote ref L424.

"Road Transport, Air Pollution and Health" FOE (1997). Free briefing

"Road Transport & Air Pollution" FOE (1999) Free booklet quote ref. T445

FOE publications available from FOE Publications

Despatch, 56-58 Alma Street, Luton, LU1 2PH. Tel. 020 7490 1555.

"New Car Fuel Consumption and Emission Figures". Vehicle Certification Agency. Available from: Vehicle Certification Agency, 1 The Eastgate Office Centre, Eastgate Road, Bristol BS5 6XX.

www.roads.detr.gov.uk/vehicle/fuelcon/index.htm

Acronyms

CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide
EV	Electric Vehicle
HCs	Hydrocarbons
LNG	Liquefied Natural Gas
LPG	Liquid Petroleum Gas
NG	Natural Gas
NOx	Nitrogen oxide
RME	Rape methyl ester
SO_2	Sulphur dioxide
VOCs	Volatile organic compounds

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