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Petrol cars versus diesel cars: making a choice based on climate and health considerations

Introduction

Most people are probably aware of the recent news story involving certain models of Volkswagen diesel cars and emissions testing.

VW has admitted that it cheated in vehicle pollution emissions tests. Software installed on the vehicles meant that some of the mechanisms designed to reduce air pollution (in particular nitrogen oxide or 'NOx' emissions which affect human health) were only turned on when the vehicle was being subjected to an emissions test.

Consequently the vehicles in question passed statutory NOx emissions tests but often significantly exceeded NOx emissions limits during normal real world driving. This is likely to have been done because more fuel is used with the emission controls on so the car could not achieve the advertised miles per gallon – a major selling point especially for diesel cars.

Emissions of the important greenhouse gas carbon dioxide (CO_2) have been reduced since the oil crisis in 1974 as manufacturers achieved a dramatic increase in cars miles per gallon through improved engine design. In recent years there has been progress in reducing carbon dioxide emissions from cars as required by EU and American regulations.

However, it has long been known that some manufacturers' claims for CO_2 emissions are often much less than what is actually achieved during real world driving. By autumn 2015 the 'gap' in these emissions had reached 35% and was expected to continue growing.

In the UK there has been a trend towards more diesel cars and fewer petrol cars on the road because diesel cars tend to deliver more miles per gallon which, other things being equal, also helps to meet climate change targets. This document aims to assess the current differences between the exhaust emissions from petrol and diesel cars and their impacts on climate change and human health.

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What are the emissions from petrol and diesel cars?

Car exhausts contain some gases that are partially burned, some gases that have reacted with others and nitrogen oxides (NOx) which are gases resulting from nitrogen reacting with oxygen. Most cars run on either petrol or diesel (including biodiesel). The exhaust gases vary slightly but importantly between the two fuels.

Many cars are also fitted with catalytic converters which remove most of the NOx and some other pollutants from the exhaust. Catalytic converters in petrol engines only operate correctly once they have been warmed up.

In diesel cars, the catalytic converter mainly reduces incompletely burnt fuel while further stages, including a diesel particulate filter (DPF), reduce the NOx gases and particulate matter (PM). Diesel engine catalytic converters tend to warm up more slowly. Once PM trapped in the DPF reaches a certain level the PM is burned off either passively, by driving at over 40 mph for 10 minutes, or actively, whereby the process of adding extra fuel to the engine is controlled by the engine management computer.

The main exhaust products from fully warmed up petrol and diesel engines are CO_2, water vapour (H_2O) and N_2. CO_2 is not toxic but is a significant and long-lived greenhouse gas. Water vapour is also a greenhouse gas but is removed from the atmosphere as rain or snow.

The amount of NOx produced in engines increases as the combustion temperature rises while, at the same time, the engine efficiency increases thereby lowering fuel consumption.

NOx gases are an irritant and can cause long-term breathing problems. One of them, NO_2, may be directly harmful since it worsens heart and lung disease. NO_2 is also a key component in the formation of ozone (O_3) in bright sunlight.

While O_3 in the upper atmosphere protects us against dangerous ultraviolet radiation, at ground level it is toxic to plants and animals. In humans O_3 irritates the eyes and airways and may cause damage to the airways at high concentrations. NOx can also contribute to the production of fine particulate matter also damaging to health.

Diesel exhaust also contains particulate matter (PM) which is mainly clumps of unburnt carbon (a form of soot) combined with other pollutants such as poisonous metals and sulphurous compounds. PM is thought to be responsible for, or to contribute to, numerous conditions including both heart and breathing problems. Modern diesel cars contain diesel particulate filters which go some way to reduce these emissions.

PM is generally classified by size (PM10 refers to particulates less than 10 millionths of a metre in size and PM2.5 to particulates less than 2.5 millionths of a metre in size). The smaller, more dangerous particulates (PM2.5) can pass through the lining of the lungs into the blood stream. PM can also influence climate change since soot, although relatively short-lived in the atmosphere, can decrease the reflectivity of snow and ice, causing it to melt.

How and why do petrol and diesel engines differ?

The way fuel is burnt in petrol engines differs from diesel engines. In a (4-stroke) petrol engine fuel and air are mixed in a ratio that ensures all the fuel and oxygen is burnt. In a diesel engine fuel is injected in measured quantities and ignites automatically in the presence of hot compressed air already in the cylinder.

Consequently diesel fuel is burned more completely and at a higher temperature than petrol resulting in greater efficiency – diesel engines are typically around 32% efficient while petrol engines are typically 24% efficient. But this higher temperature also means that more NOx is created in diesel engines than petrol engines. Diesel engines also tend to produce a lot more particulate matter than petrol engines.

What are the climate and human health implications of petrol emissions?

Petrol engines impact climate change through their emissions of the greenhouse gas CO_2. Petrol engines mainly affect human health through their emission of NO_2 although to a much lesser extent than diesel engines due mainly to the greater efficiency of the catalytic converters in petrol cars.

What are the climate and human health implications of diesel emissions?

Diesel engines also impact climate change through their emissions of the greenhouse gas CO_2 but to a significantly lesser extent (in grams per kilometre) than petrol cars. Diesel engines affect human health, mainly through their emission of NO_2 and PM. There is a trade off in diesel engines between minimising fuel consumption and increasing NOx production.

How measurable are the effects of car emissions on climate and health?

A car's annual CO_2 emissions are calculated by multiplying the kilometres driven by the grams CO_2 per kilometre for that make and model. In theory the latter figure depends on date of manufacture and model of the car and can be found in manufacturer's literature based on a standard test, the New European Driving Cycle (NEDC). However, the style of driving and other real world conditions contribute as well.

Despite rapid falls in the official CO_2 per kilometre emissions of new cars sold in the UK in recent years, evidence of a growing 'gap' between official and real-world driving CO_2 emissions for new cars has received much attention. The gap for new cars in 2014 is estimated to have been about 35%, although there is evidence that this varies between makes and models, and was expected to increase up to 2020.

It is clear that care is required in calculating the emissions from a single car because of the gap between manufacturers' and real world CO_2 emissions per kilometre. In any event it is always better to reduce such emissions by employing so-called eco-driving (low acceleration, gentle braking, correct tyre pressure, lower motorway speed etc.).

According to the Society of Motor Manufacturers & Traders (SMMT) cars are responsible for only 14% of the UK's total NOx emissions, a figure not dissimilar to that for CO_2 emissions, and this is attributable to the one in three cars that have diesel engines.

However such figures must now be in doubt given the revelations from VW. It has been said of VW cars that on the open road NOx emissions are up to 35 times higher than in the test. An official at the European Environment Agency is quoted as saying that real life NOx

emissions can be four or five times higher than in the test. Diesel cars made by Mercedes-Benz, Honda, Mazda and Mitsubishi have also been implicated in emitting significantly more NOx on the road than shown up in tests. This means that in practice NOx emissions from these makes of cars can be at least as great, and even several times as great, as from large buses and lorries. It also helps to explain why NOx is at illegal levels in the atmosphere of many EU countries including the UK.

These alarming results are not necessarily the fault of manufacturers (excepting VW), who insist they obey the law, but of the poorly designed, and soon to be replaced, NEDC test.

From a climate change perspective we have to consider the warming impact on the atmosphere of the various gases that occur in car exhausts and their chemical derivatives. However, on a global scale the climate change impact of car exhausts is principally caused by CO_2.

It appears that buying a diesel car today, although attractive from the fuel efficiency viewpoint and (possibly) a consequent smaller contribution to global warming, is a poorer choice than a petrol car from the perspective of human health.

Overall, if one plans to drive mostly in crowded urban areas it is better to use a petrol car to avoid the NOx and PM emissions from diesel engines that cause air pollution. Conversely, given the significantly lower CO_2 emissions per kilometre of diesel cars, the use of such a car on long journeys will minimise CO_2 emissions.

What is the role of legislation in the EU?

The Euro 6 standard for exhaust emissions of NOx and other pollutants is now (September 2015) in force for all new cars. The new Euro 6 regulations set different standards for petrol and diesel cars. For diesel cars, the permitted level of NOx emitted is down to a maximum of 80 milligrams per kilometre. The limit for NOx from petrol cars remains at 60 milligrams per kilometre.

CO_2 emissions from cars are controlled by the European Commission. Regulations require each manufacturer to limit the average CO_2 emissions of their vehicles. The fleet-average limit for new cars reduces over time – in 2015 the limit was 130 grams CO_2 per kilometre reducing to 95 grams CO_2 per kilometre in 2020. Each individual manufacturer must meet the 2020 target by 2021.

However, because of the recent revelations, until the New European Driving Cycle tests are replaced in the EU by the more stringent Worldwide Harmonised Light Vehicles Test procedure in 2017 car owners will be faced by the inherent uncertainty in the reliability of many manufacturers' current emissions figures.

Meanwhile car manufacturers will be forced to deliver technical improvements so that their new models really do meet the current regulations for NOx and CO_2 emissions in real world driving as well as under the new test to be brought in in 2017 and against the new targets for 2020/2021.

Conclusions

Given the different impacts of car exhausts on health and greenhouse gas emissions it remains very difficult to decide whether it is better to drive a petrol or a diesel car. The principal use to which a car is put (urban versus extra-urban driving) is also significant.

In fact, given the need to use a car at all, in contrast to walking, cycling or using public transport, other, better options may be available in the not too distant future. For example, electric cars may be charged from low-carbon or renewable electricity.

In the light of the revelations in autumn 2015 it seems that only after the new Worldwide Harmonised Light Vehicles Test procedure (WLTP) has come into force within the EU in 2017 will drivers be able to regain faith in manufacturers' published emissions figures before choosing which make and model of car to drive.

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