The contribution of road transport to a cleaner environment

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Introduction

The Earth is fragile. Its atmosphere is threatened by the build-up of greenhouse gases which, in turn, are causing global warming.

We can all play a part in reducing the emissions which form the greenhouse gases. The truck industry, as one of the sources of those emissions, has already made, and is continuing to make, considerable progress in reducing the emissions from the diesel engines which power the vehicles it produces.

This booklet is an introduction to the way that the truck industry is rising to this challenge. It is in four parts:

Part 1

There is direct correlation between the emissions of carbon dioxide from a diesel engine and its fuel consumption. This is equally true for a small car as for a 44 tonne DAF XF105. The principal key to reduced CO_2 emissions is therefore improved fuel consumption: the better the fuel economy, the smaller the carbon footprint. This section examines how that might be achieved.

Part 2

The truck industry has already made very considerable progress in reducing emissions of nitrous oxides (a greenhouse gas and a source of acid rain) and particulates (an atmospheric pollutant that can cause respiratory problems). We look at how Europe's legislators and truck manufacturers have combined in a continuous programme of noxious emission reductions.

Part 3

This section looks at the future: how emissions can be reduced using today's technology and the savings arising from alternative power sources. Fossil fuels are a finite resource and there is considerable research into how they might be replaced by renewable, carbon neutral fuels.

Part 4

Lastly, we consider how a fully laden, maximum weight truck, operating at optimal efficiency compares with other forms of transportation on the road and rail.

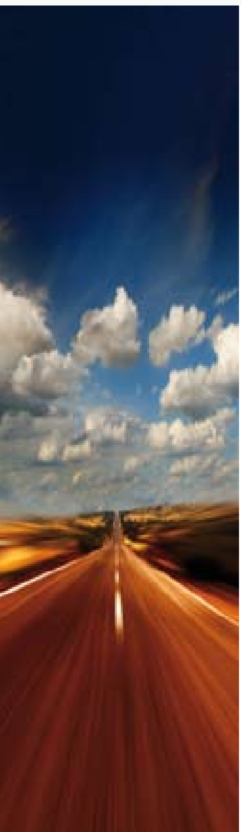
We hope that this booklet provides an insight into the industry's commitment to a cleaner environment.

Tony Pain
Marketing Director – DAF Trucks.

The role of the truck as a good citizen

There is widespread recognition that we are citizens of a global community.

Citizenship brings responsibilities, the most urgent of which is to temper the demands of consumerism with the need to reduce our emissions of carbon dioxide and other greenhouse gases.



Transport has a major role to play. 84% of all goods transported in the UK are delivered by road. Trucks play an indispensable part in the nation's economic life: they are rightly said to deliver the UK economy. Like industry, households and commercial institutions, road transport has a carbon footprint and it is everyone's interest to make that footprint as small as possible.

The consumption of one litre of diesel fuel, from whatever source, releases a given amount of CO_2. It is here that everyone can make a contribution to realising the goal of lower carbon emissions: we can all minimise our usage of fossil fuels and, in so doing, we can, of course, save on our expenditure.

What part is the truck industry playing? The answer, is that the industry has already made giant strides in reducing the noxious emissions from diesel engines. There is also total agreement amongst all the players in the industry that further reductions in CO_2 emissions will come primarily from the striving to maximise fuel economy. New technology plays a key role but there are means, right now, by which fuel consumption can be reduced.

Fuel savings that reduce carbon emissions today

By specifying aerodynamic aids, for example, fuel consumption can be influenced by 5 to 10%; correct gearing can influence consumption by 2 to 3%, the correct coupling distance can influence consumption by 2 to 4% and specifying the right engine can influence consumption by 1 to 3%.

The maintenance of the truck can also have significant effects on fuel savings. Running on the right tyre pressures, for example, can make a difference of between 5 and 10% in fuel consumption. The correct axle alignment can also influence consumption by 5 to 10% and brake adjustment can make a difference of up to 5%.

There is a further major influence on fuel consumption and that is the driver's driving style: an 8 to 10% impact on fuel economy. Driving at optimal speeds can influence consumption by 3 to 5% and minimising idling time can influence consumption by up to 5%.

Protecting the environment

The greenhouse gases in the Earth's atmosphere that are the source of global warming, and the resultant climate changes, represent the most potent threat that our environment faces today. It is incumbent on all of us to play a part in meeting this challenge.

Part One

First, we will address the issue which is generating the most concern: the concentration of carbon dioxide in the Earth's atmosphere with the resulting global warming, and the role of the truck as a contributory factor.

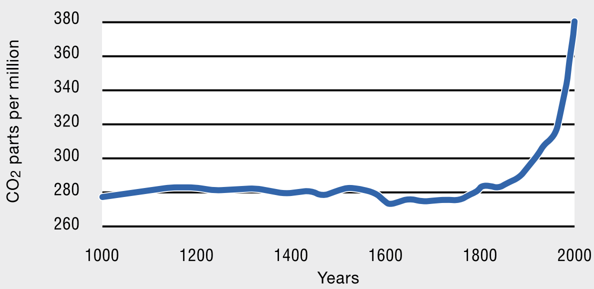
Carbon dioxide and global warming

Carbon dioxide (CO_2) is the most natural thing on earth. It is an essential part of the balance between animal/human life and plant life that has created the biodiversity of Earth's environment. CO_2, in balance with oxygen, is carried in blood. It is exhaled by animals and humans - a person's breath is approximately 4.5% carbon dioxide. Plants require carbon dioxide for photosynthesis, which enables them to thrive and develop.

If CO_2 is such a fundamental element of life on Earth, what is the reason for the concern so widely expressed, regarding its role in global warming? It's because human activities have caused the amount of CO_2 in the atmosphere to rise to levels where it has become one of the most significant greenhouse gases that are affecting the temperature of the Earth's surface. Carbon dioxide is particularly concerning because of its ability to absorb many infrared wavelengths of the Sun's light and because of the length of time it stays in the Earth's atmosphere - 100 years. As the Earth's surface heats, the climate of the planet is altered, giving rise to potentially disastrous consequences.

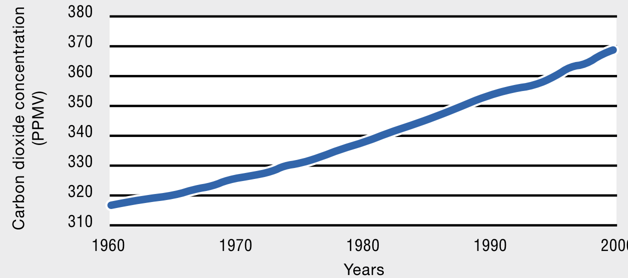
Due to human activities such as the burning of fossil fuels and their derivatives (coal, oil, gas, petrol and diesel) and deforestation, the concentration of atmospheric carbon dioxide has increased by about 35% since the beginning of the Industrial Revolution in the second half of the eighteenth century.

CO_2 in the atmosphere



Data: United Nations Environment Programme

Atmospheric Carbon Dioxide measured at Mauna Loa, Hawaii

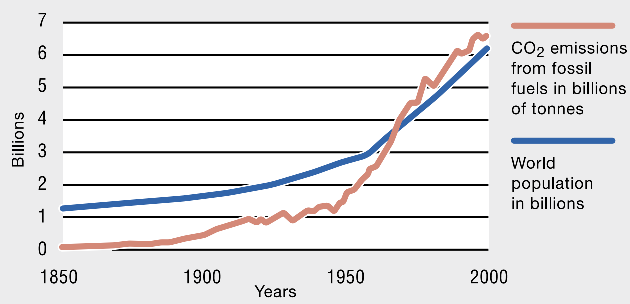


CO_2 in the atmosphere is accelerating. In 1960 it was approximately 315 parts per million by volume: today it is at a globally averaged concentration of approximately 385 parts per million. Amounts above 800 ppm are considered unhealthy, amounts above 5,000 ppm are considered very unhealthy, and those above about 50,000 ppm are considered dangerous to animal life.

As further evidence of the impact of human activities on the level of atmospheric CO_2, there is close correlation between CO_2 emissions from fossil-fuel burning and world population.

There is a body of opinion that argues that the concentration of atmospheric CO_2 is a natural phenomenon similar to the climate changes, catastrophes and extinctions that have characterised the Earth's cycles. There is, however, sufficient evidence in the extremes of weather, melting Polar ice and glaciers, and oceanic current changes, that global warming arising from carbon emissions, is now an accepted fact.

CO_2 emissions and population



Data: United Nations Environment Programme

What is a carbon footprint ?

A carbon footprint is a measure of the impact human activities have on the environment. It is made up of the sum of two parts, the direct / primary footprint and the indirect / secondary footprint.

1. ***The primary footprint is a measure of our direct emissions of CO_2 from the burning of fossil fuels including domestic energy consumption and transportation.***
2. ***The secondary footprint is a measure of the indirect CO_2 emissions from the whole lifecycle of products we use - those associated with their manufacture and eventual breakdown.***

A carbon footprint is usually expressed as grams of CO_2 equivalents.

In terms of trucks, the primary footprint is by far the most significant – it represents 96% of total emissions, compared with 4% emitted during manufacture and disposal (3% and 1% respectively).

Diesel fuel and the release of carbon dioxide

Diesel is derived from petroleum: it is a mixture of about 75% saturated hydrocarbons and 25% aromatic hydrocarbons, obtained in the distillation of crude oil. The carbon content released during the energy conversion process reaches the atmosphere as a greenhouse gas.

There is a direct relationship between diesel fuel burnt and carbon dioxide released: each litre of diesel consumed releases 2.6304 kg of CO_2. (Source: DEFRA).

It doesn't matter how that litre is consumed: in a Ford Fiesta, the latest Land Rover or a 44 tonne XF105, one litre of diesel releases exactly the same amount of CO_2. Therefore to minimise the release of CO_2, either the diesel fuel should not be burnt at all, or it should consumed in the most efficient way – by minimising the quantity of diesel consumed in every journey.

So that means miles per gallon is almost the sole determinant of the amount of CO_2 released. The more miles to the gallon, the smaller the carbon footprint.

It follows that if you have to burn fuel, it should be in the most productive way. In a car it means maximising the number of passengers carried; in a truck, there are a number of factors involved (see below), but one principal measure is to minimise empty running. There has been distinct progress between 1970, when empty running accounted for 34% of all journeys, and 2003 when empty running had fallen to 25%. The largest trucks, in terms of payload and volume carried, when running full are by definition the most productive.

Increases in truck productivity

Trucks are substantially more productive than they were in the 1970s. If we take maximum gross weight vehicles, and look at payload, average speed and average miles per gallon of trucks at that weight, we can arrive at a productivity factor that can be compared over time.

Typical maximum-weight truck

Year	Payload Tonnes	Av Speed mph	Fuel mpg	Productivity
1977	20.5	39	7.0	5,596
1992	25.0	42	8.0	8,400
2007	29.5	47	8.4	11,647

In 1977, the typical maximum-weight truck carried a payload of 20.5 tonnes at an average speed of 39 mph with a fuel consumption of 7.0 mpg. By 2007, payload had risen to 29.5 tonnes, speed had risen to 47 mph and fuel consumption had improved to 8.4 mpg. (2007 information: Commercial Motor magazine 13th September. DAF CF85.460 road test.)

The productivity factor in 1977 was 5,596. By 1992, it had improved to 8,400 and today, it's 11,647. So trucks are 2.1 times more productive than they were thirty years ago.

What factors underlie this improvement?

The maximum gross vehicle weight has increased over the period from 32 tonnes to 44 tonnes so trucks are carrying significantly heavier payloads. At the same time, improving technology has meant that engines are more efficient so fuel consumption has improved and the average speed of the trucks is higher. It means that trucks are carrying more goods, more economically, more quickly.

Total weight of loads

Road transport is vital to Britain's gross domestic product. As the consumer economy has grown over the last fifty years, the total weight of goods carried by road has grown five fold – from 32 billion tonne kilometres in 1953 to 163 billion tonne kilometres in 2005. Economic growth and the expansion of manufacturing and trade on a global scale are responsible for the rapid growth in road transport in both developing and developed countries.

Fewer trucks on Britain's roads

Despite the five fold increase in goods carried by road over the last fifty years, it is extraordinary that over that same period, the number of trucks carrying those goods has actually decreased. In fact, there are no more trucks on the road than there were seventy years ago. In 1937, there were 435,000 trucks on the road; in 1957 numbers peaked at 470,000, since when there has been a decline to today's total of 433,000. So fewer trucks are carrying more goods, more economically.

Smaller carbon footprint

As we have seen, truck fuel consumption is directly proportional to carbon dioxide emissions. If we look at the fuel consumed by the average truck in the mid 1980s compared with today, there has been a 45% reduction per tonne of goods carried – and that means an identical decrease in carbon dioxide emissions (see page 17).

CO_2 emissions: heavy trucks versus light vans

We need to address the argument that it would be better for the environment if heavy trucks were taken off the roads altogether and their loads were carried by smaller vehicles instead.

Taking the payload of a maximum weight, 44 tonne, truck and relating that to litres of diesel per 100 kilometres results in a figure of 3.0 kilogrammes of CO_2 produced per tonne of payload per kilometre. The comparable figure for a light van is 45.0 – indicating that the heavy truck is 15 times more efficient in its carbon footprint. Using light vans to carry the loads currently carried by heavy trucks would lead to a massive increase in CO_2 emissions.

Truck and van CO_2 emissions per tonne payload per kilometre

	GVW (tonnes)	Payload (tonnes)	Litres per 100 km (litres)	Kilogrammes of CO_2 per 100 km (kg)	Kilogrammes of CO_2 per tonne km (kg)
Heavy truck	44	29.5	33.6	88.4	3.0
Heavy truck	32	19.0	28.25	74.3	3.9
Medium truck	18	10.0	20.18	53.1	5.3
Light truck	7.5	3.5	15.69	41.3	11.8
Heavy van	3.5	1.2	10.85	28.5	23.8
Light van	1.5	0.5	8.55	22.5	45.0

So far we have considered the role of trucks as a contributory factor in the concentration of carbon dioxide emissions in Earth's atmosphere. But what is their relative role compared with other sources of CO_2?

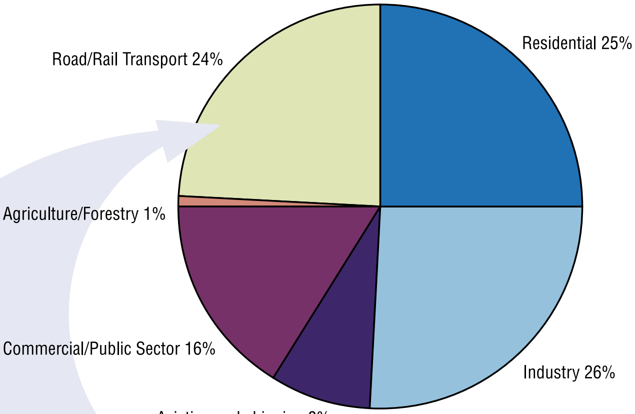
Truck emissions related to other sources of CO_2

Looking at UK CO_2 emissions, the two largest sources are industry at 26% of the total and domestic users at 25%. Road/rail transport accounts for just under a quarter of UK CO_2 emissions.

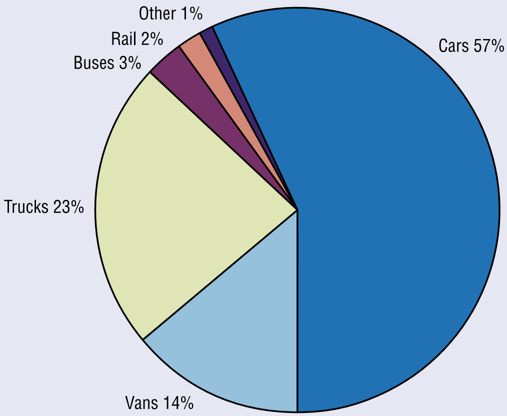
Breaking road/rail transport down by type shows that cars, at over half of road/rail CO_2 emissions, are the largest source while trucks represent less than a quarter.

Trucks are therefore the source of only 5% or so of the UK's total carbon dioxide emissions.

UK CO_2 emission by end user



CO_2 emissions from road and rail transport by vehicle type



Source: DEFRA 2007; Commission for Integrated Transport

Part Two

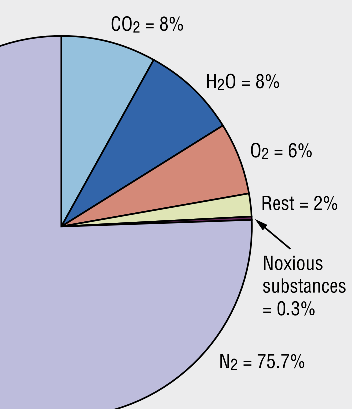
It is evident that, over time, improvements in truck productivity have had a favourable effect on the emission of carbon dioxide. But CO_2 is not the only emission from diesel engines: very significant progress has already been made in reducing emissions of noxious substances.

Reductions in emissions of noxious substances from truck diesel engines

Carbon dioxide emissions are the focal point of the concern regarding global warming but the commercial vehicle industry has already made substantial strides in cutting other emissions.

All engines – petrol, propane and natural gas, as well as diesel, produce exhaust emissions. They mostly occur when fuel does not burn, or burns only partially. Diesel engines, in fact, burn fuel more efficiently than petrol engines – fuel consumption is better so CO_2 emissions are proportionately less than those from petrol engines.

Composition of exhaust emission



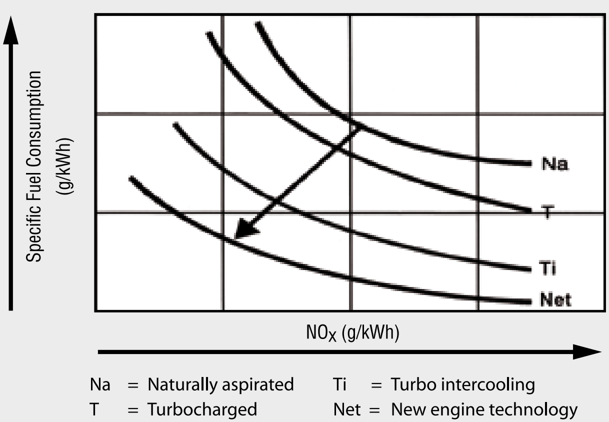
With a diesel engine, 8% of the emission is carbon dioxide. The remaining exhaust gases are clean apart from 0.3% that is noxious. This noxious element includes carbon monoxide, hydrocarbons and sulphur dioxide but the major part is a gas which is created when the high temperature and pressure levels present in the internal combustion engine cause a reaction between the nitrogen and oxygen in the air, to form nitrogen oxides (NO_x). NO_x is a greenhouse gas and a source of acid rain. Diesel engines also produce 'particulate matter' or, as it's more commonly called, 'soot'. It is an atmospheric pollutant that can cause respiratory conditions.

It is a problem which faces every engine designer that the reduction of one of the noxious elements almost inevitably leads to an increase of the others. Reducing fuel consumption and therefore reducing CO_2 emissions means the fuel/air mix in the combustion chamber must burn more efficiently – that is, at a higher temperature and pressure. But the higher the pressure and temperature, the greater the NO_x emissions. Equally, the way to reduce NO_x is to lower the pressure and temperature in the combustion chamber. But lower temperatures result in increased particulate matter and increased fuel consumption – which means higher CO_2 emissions.

There is, therefore, a trade-off between the emission of NO_x, CO_2 and particulates. Engine designers have tried to achieve the optimum balance by introducing ways to allow cooler combustion while, at the same time, maintaining fuel consumption levels. For example, before combustion, intercooling has been introduced; during combustion, high pressure fuel injection and electronic control of the combustion process have been introduced. They have all contributed to a cooler burn and therefore lower NO_x emissions.

But European legislation – Euro 4, which came into effect in October 2006 - required a dramatic reduction in both particulates and NO_x and the answer was to develop new technology to achieve the necessary standards.

Reducing NO_x emissions at a certain level of engine technology can imply an increase in fuel consumption

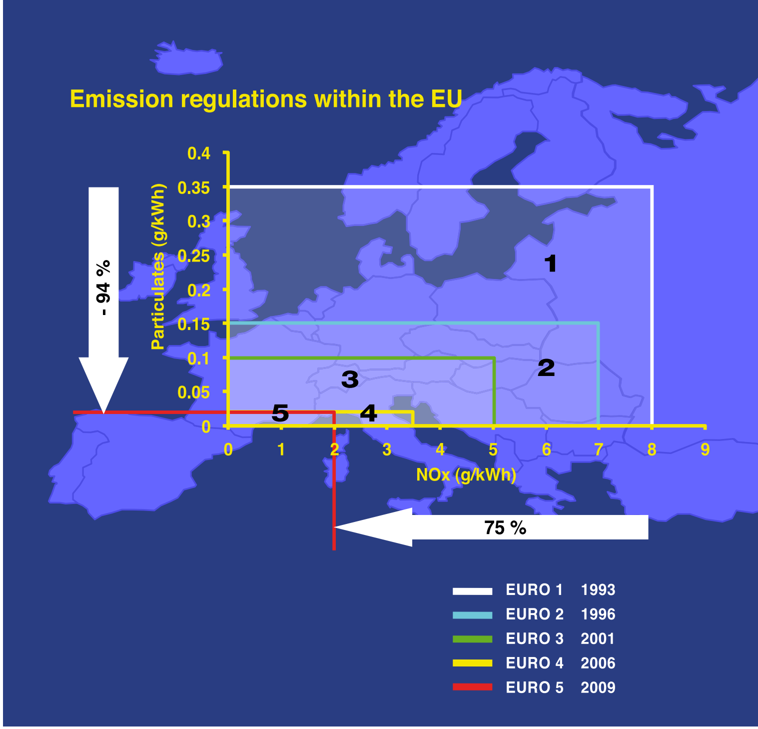


The European Union's initiative on truck engine emissions

In response to the growing awareness of greenhouse gases, and their implications for the Earth's climate, the European Union introduced a phased programme aimed at dramatic reductions in nitrogen oxides and carbon particulate levels emitted by truck diesel engines. Legislation was introduced from 1993 onwards. Euro 1 level was followed by Euro 2 in 1996 and Euro 3 in 2001.

To achieve Euro 1,2 and 3, the industry focused on the combustion process but, as we have seen, achieving Euro 4 needed the application of new technology. The industry adopted two different solutions. The majority of manufacturers introduced Selective Catalytic Reduction (SCR), while others used an alternative technology, Exhaust Gas Recirculation (EGR).

SCR is also the means by which the required NO_X levels in Euro 5, for implementation in October 2009, is being met by most manufacturers. There are incentives for operators to purchase Euro 5 vehicles now – the UK government, for example, re-introduced Reduced Pollution Certificates for early adopters of Euro 5 that provided operators of heavy trucks a reduction in Vehicle Excise Duty for every year of a truck's life. There are therefore Euro 5 vehicles on Britain's roads now – well ahead of the legislation date.



From Euro 1 to Euro 5, particulates have been cut by 94%, NO_X by 75%, and carbon monoxide by 69% - a remarkable result which is a tribute to the EU's far sighted strategy and the truck industry's innovation.

Reduction in gases and particulates 1988-2009

	CO g/kWh	HC g/kWh	NO_X g/kWh	PM g/kWh	Smoke m-1
Euro 0 1988	12.3	2.6	15.8	-	-
Euro 1 1993	4.9	1.23	8.0	0.35	-
Euro 2 1996	4.0	1.1	7.0	0.15	-
Euro 3 2001	2.1	0.66	5.0	0.1	0.8
Euro 4 2006	1.5	0.46	3.5	0.02	0.5
Euro 5 2009	1.5	0.46	2.0	0.02	0.5

ESC/ELR Test Cycles

CO *Carbon monoxide*
HC *Hydrocarbons*
NO_X *Nitrous oxides*
PM *Particulate matter*

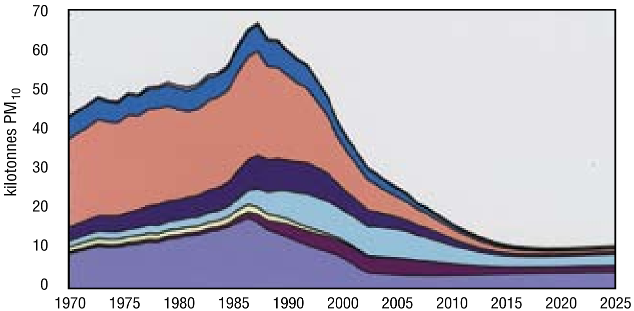
The role of trucks in the reduction in emissions from road transport

The UK Government has published a paper addressing road transport emissions over a 55 year period. These graphs are an extract from that document.

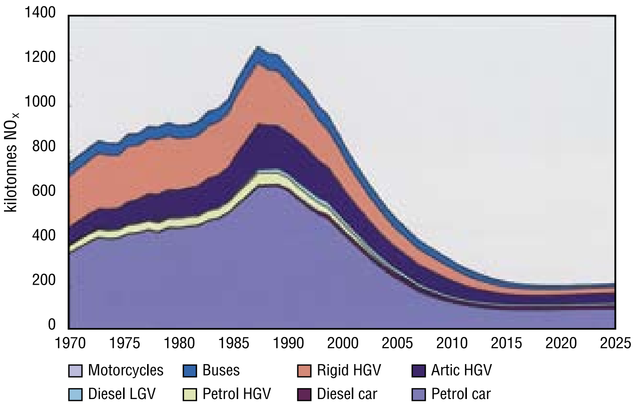
The graphs show the trend in emissions from road transport over the period 1970 to 2025. They dramatically illustrate how emissions of particulate matter and nitrogen oxides reached a peak in 1990 and have subsequently reduced as a direct result of the EU Directives.

It is evident that trucks have made a very significant contribution to this reduction.

UK particulate emissions from road transport 1970 – 2025



UK NO_X emissions from road transport 1970 – 2025



A dramatic reduction in CO_2 and other emissions

Few other industries can compare with the environmental efficiency that commercial vehicles have achieved over the last 30 years.

We'll take an actual example: a typical journey of 200 miles in 1977 compared with today.

In 1977, a maximum weight 32 tonne truck used 130 litres of diesel and put 342 kg of CO_2, or 16.7 kg per tonne of payload, into the atmosphere. It also emitted 380 grammes of particulates and 10.6 kg of NO_X. The journey took five hours and 25 minutes plus a 45 minute break to conform to legislation on drivers hours, making a total of 6 hours and 10 minutes.

In 2007, a maximum weight DAF XF105 at 44 tonnes gross, did the identical trip, It used 103 litres of diesel (21% less than 1980) plus four litres of AdBlue. It put 271 kg of CO_2 into the atmosphere (21% less), equivalent to 9.19 kg per tonne payload (45% less), plus 14 grammes of particulates (96% less) and 1.36 kg of NO_x (87% less). The journey took 4 hours and 15 minutes, (33% quicker than in 1977).

And the single XF105 produced one twelfth of the noise produced by the 1977 truck.

A 200 mile journey in 2007 compared with 1977

	Truck GCW (tonnes)	Diesel consumption (litres)	CO_2 emissions (kg)	CO_2 per tonne of payload	Particulate emissions (grammes)	NO_X emissions (kg)	Journey time (hrs.mins)
1977	32	130	342	16.7	380	10.6	6hrs 10min
2007	44	103	271	9.2	14	1.4	4hrs 15min
Saved		21%	21%	45%	96%	87%	33%

Part Three

The future for truck emissions

Longer Heavier Vehicles (LHVs)

We have seen that, over time, fewer trucks are carrying more goods, more economically. There is a way that this trend can be continued.

Some consideration, principally in Continental Europe, has been given to an increase in gross weight to 60 tonnes and an extension in overall length from 18.75 to 25.25 metres. At the moment, three maximum length 16.5 metre long articulated vehicles travelling with the recommended 40 metre gap between them and other traffic, can carry 41 cubic metres of load, taking up 169.5 metres of road space. Two 25.25 metre long LHVs, however, could carry 43 cubic metres of goods in just over 130 metres.

In practice there would be a significant impact on UK roads and infrastructure. There would also have to be strategically located distribution centres where loads would be split down for separate deliveries. Add these reservations to the fact that drivers would have to meet special requirements and pass a supplementary test, and LHVs currently represent a long term prospect in the UK.

Operating efficiencies

Continuing the trend for greater operating efficiencies, there is scope right now to achieve substantial fuel and CO_2 savings using current technology

Significant fuel savings can be achieved through operating efficiencies – for example, by running fully laden on both legs of a journey – a mode of operation that has, as we have seen, been increasingly adopted over recent years but has further potential. Correct axle alignment and tyre pressures will also improve fuel efficiency. Fitting aerodynamic aids such as roof spoilers, and side skirts and collars, can also reduce fuel consumption by over 10%. But the driving style of the driver is the largest single factor affecting fuel consumption. By adopting a more economical mode of driving – achievable through training where appropriate – the driver can save up to 15% of his vehicle's diesel usage.

At present, the diesel engine is the key to the future

The diesel engine has been at the heart of improvements in emissions to date and it will be the cornerstone of future developments.

DAF's Enhanced Environmentally-friendly Vehicle (EEV) engines will be introduced shortly. These engines will have even lower emission levels than those required by the stringent 2009 Euro 5 standards. By combining DAF SCR technology with a passive soot filter, particle emissions are reduced to levels even lower than those of gas engines – almost achieving zero noxious emissions. Besides lower particulate emissions, DAF's EEV diesel engine has many intrinsic advantages over alternative propulsion systems such as gas. These include a higher efficiency, higher reliability and durability, and lower operating costs.

Hybrid vehicles

DAF has targeted significant improvements in vehicle fuel efficiency for selected applications in the near future and hybrid technology is a contributor to achieving this objective, benefiting both customers and the environment.

A prototype hybrid LF45 7.5 tonne model was shown at the 2007 Commercial Vehicle Show. It features a state-of-the-art parallel diesel/electric hybrid system. An electric engine can provide the drive and function as a generator. As the hybrid system is used to accumulate energy generated during braking, it is particularly useful for stop-and-go city distribution applications and makes significant fuel savings possible. Energy is stored in the lithium-ion batteries for re-use during acceleration. Depending on the fill ratio of the batteries, a central computer determines when the diesel engine provides the drive and to what extent the electric engine is used.

Extensive field trials are currently being carried out and the placement with customers of the first limited prototypes is currently planned for 2008.

Hybrids reduce both fuel consumption and CO_2 emissions.

Biofuels

The government has announced that in April 2008 it will introduce a Renewable Transport Fuel Obligation (RTFO) that will require transport fuel suppliers to ensure a proportion of their sales are from renewable sources. The proportion will be 5% by 2010/2011, saving one million tonnes of carbon dioxide in 2010 - the equivalent of taking one million cars off Britain's roads. EU policy states that the targets for road fuels are a biofuel content of 5.75% in 2010 rising to 8% in 2020.

Biofuel is liquid or gas derived from biomass, used primarily in the automotive industry. Biofuels are used globally: biofuel industries are expanding in Europe, Asia and the Americas. Biofuel can be produced from any carbon source that can be replenished rapidly – plants, for example. Many different plants and plant-derived materials are used for biofuel manufacture.

Biomass is material derived from recently living organisms. It includes plants, animals and their by-products. It is a renewable energy source based on the carbon cycle, unlike other natural resources such as petroleum, coal, and nuclear fuels. Agricultural products specifically grown for biofuel production include corn and soybeans, primarily in the United States; rapeseed, wheat and sugar beet primarily in Europe; sugar cane in Brazil; palm oil in South-East Asia; and jatropha in India.

Biofuels aim to be carbon neutral. This means that the carbon released during the use of the fuel – through the combustion process, for example - is reabsorbed and balanced by the carbon absorbed by new plant growth. These plants are then harvested to make the next batch of fuel. Carbon neutral fuels lead to no net increases in atmospheric carbon dioxide levels, which means that global warming need not get any worse. In practice, biofuels are not necessarily carbon neutral when the energy required to grow crops and process them into fuel is taken into account. **In fact some biofuels are relatively inefficient in terms of their carbon neutrality, when considering their Life Cycle Analysis (LCA).** They do, however, provide significant greenhouse gas emissions savings when compared to fossil fuels such as petroleum and diesel.

A further consideration is the land on which the crops are grown. If it used to be a (tropical rain-) forest, the carbon absorption of this forest should be deducted from the greenhouse gas savings. This implies that the net effect of burning biofuels is an increase in greenhouse gases. Cutting down a forest to produce biofuels obviously makes no sense at all.

Biodiesel

Biodiesel is a first generation biofuel – a term referring to biofuels produced from sugar, starch, vegetable oil, or animal fats using conventional technology. A variety of oils can be used to produce biodiesel – most commonly virgin oil feedstock; rapeseed and soybean oils (soybean oil alone accounting for about ninety percent of all fuel stocks). It can be obtained from other crops such as mustard, flax, sunflower, palm oil and hemp. It can also be made from used vegetable oil - from deep fat fryers, for example, which can be filtered and processed into biodiesel.

Biodiesel is the most common biofuel in Europe. Pure biodiesel is available at many fuel stations in Germany and a 5% biodiesel blend is widely used and is available at thousands of fuel stations in Continental Europe.

Biodiesel is safe, biodegradable, contains almost zero sulphur, and reduces air pollutants, such as particulates, carbon monoxide and hydrocarbons. While varying enormously, it typically produces about 60% less net lifecycle carbon dioxide emissions than petroleum-based diesel as it is itself produced from atmospheric carbon dioxide via photosynthesis in plants.

Operators should refer to manufacturers' guidelines as there are wide variations in allowed biodiesel usage and maintenance requirements depending on both chassis manufacturer and engine type. Items include the halving of oil drain intervals, the regular checking of rubber hoses, and not allowing biodiesel to stand for long periods as it has a tendency to attract water from the atmosphere. There is also reduced cold start performance at low ambient temperatures. Biodiesel has one major environmental disadvantage: due to its high oxygen content, it produces higher NO_X levels during combustion.

DAF guidelines regarding the usage of biodiesel by DAF engine type

Biodiesel and mixtures of biodiesel/standard diesel can be used in DAF models as shown below.

Model	Emission Level	Current Max Biodiesel Percentage
LF CF65	Euro 3	20%
	Euro 4 and 5	5%
CF75 CF85 XF95 XF105	Euro 3	100% Only from chassis number E552891
	Euro 4 and 5	100%

Over 5% - Special maintenance considerations should be adhered to.

Full specification details are included in Sales Engineering Information 4.04 11th Sept 2007. All the requirements of Fuel Standard EN590 for standard diesel and EN14214 for biodiesel must be met. Failing to meet these standards, or failing to manage the storage of biofuels, could have a severe impact on engine and exhaust durability.

Fuel produced from straight vegetable oil (SVO) or Pure Plant Oil (PPO), one of the possible derivative products, is not allowed.

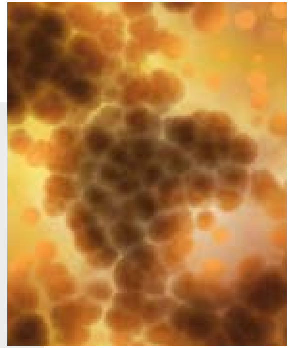
Second generation biofuels

Second generation biofuel production, using biomass-to-liquid technology, is in development.

This allows biofuel to be derived from any sources of biomass, not just from the seeds of food crops such as corn and soy beans. These include the stalks of wheat and corn, wood, special energy or biomass crops (e.g. Miscanthus) and waste biomass. These processes could utilise the waste products of current food-based agriculture to manufacture fuel sustainably. HTU (High Temperature Upgrading) diesel is produced from particularly wet biomass stocks using high temperature and pressure to produce an oil. Much research is being done about the use of microalgae as an energy source, with applications for biodiesel, ethanol, methanol, methane and hydrogen.

Second generation processes, compared with first generation, can provide more biofuel, with better environmental gains.

Alternative fuels



Biomethane is a second generation biofuel that is produced by converting organic biomass wastes such as municipal solid waste, sewage sludge, crop residues, wood and wood residues, energy crops and manure into combustible gas. The process by which biomass is broken down by bacteria naturally occuring in the waste material is anaerobic digestion – commonly used for sewage treatment and for managing animal waste. The biomethane gas which is produced by anaerobic digestion is burnt to generate electricity and can be cleaned and compressed to provide vehicle fuel. Methane is the main constituent of Natural Gas (NG), and biomethane, which is chemically identical to NG, can be used either as a substitute for NG or in combination with it. As a vehicle fuel, biomethane has virtually no noxious emissions, including extremely low emissions of NO_x and particulates.

Despite these characteristics, diesel engines have numerous advantages over gas engines. Purchase and maintenance costs are lower, fuel consumption is lower and workshops don't have to be modified for servicing (and parking) as they do for gas vehicles. As we have seen, the diesel engine is also continuing to evolve and to become progressively cleaner. DAF's EEV engine has particle emission levels even lower than those of the NG engine.

Ethanol fuel is ethyl alcohol, the same type of alcohol found in alcoholic drinks. It can be used as a fuel, mainly as a biofuel alternative to petrol, and is easy to manufacture and process. Current interest lies primarily in bioethanol, produced from the starch or sugar in a wide variety of crops – principally sugar cane, corn and wheat.

Although there is research on the use of bioethanol as a substitute for, or a blend with, diesel fuel, there are major concerns relating to the large amount of arable land required for crops. The effects are likely to worsen the growing imbalance between land grown for crops and that for fuel – which is impacting on the price of food.

Hydrogen power: a further avenue of research is into a power plant which converts the chemical energy of hydrogen into mechanical energy (torque). It is done in one of two methods: electrochemical conversion in a fuel cell or combustion. The internal combustion engine can be converted to run on gaseous hydrogen however, the more energy efficient use of hydrogen involves the use of fuel cells and electric motors. Hydrogen reacts with oxygen inside the fuel cells, which produces electricity to power the motors.

The research is currently based on the passenger car and there are very considerable problems to overcome. Hydrogen would be produced from a central source and transferred to cars as a liquid stored in a pressurised tank. Because of the energy required to liquefy the hydrogen gas, the supply chain for hydrogen has low efficiency compared to petroleum. The energy density is also small relative to petrol. The high production cost of both hydrogen itself and the fuel cells currently questions the viability of the process. These disadvantages may take decades to overcome, and the hydrogen truck may never become widely available.

Conclusion

The technology to produce second generation biofuels on a commercially viable scale is very much in its infancy. Not only is manufacturing prohibitively expensive, the damage to the Earth's atmosphere caused by cutting down forests to grow fuel crops is completely counter-productive. The investment in the infrastructure to distribute these fuels (especially gaseous ones) and make their availability as wide as today's fuels, is also massive and on a global scale.

Nevertheless, we must reduce our dependence on fossil fuels. Biodiesel offers the most potential at present but its large scale usage will only happen if its disadvantages – not least of which is its NO_X emissions – are overcome. Almost certainly, the best returns will come in the form of the hybrid, a vehicle powered by both a diesel and an electric engine. With the considerable resources being channelled by the global industry into this technology, progress will be rapid.

Part Four

How does road compare with rail?

The planet would obviously benefit most if mineral oil were left in the ground. If it is to be consumed, the environment benefits most if each litre of fuel is used with maximum efficiency – so that the greatest amount of work is realised.

On this criterion, it can be said that maximum weight trucks are efficient and have the potential for greater productivity. Can the same be said of cars?

First, we should look at the sheer numbers of vehicles on the road. While truck numbers have actually declined from their peak in the ‘fifties to today’s total of 433,000, cars have increased from 2.1 million to 26.2 million over the same period. In the 'fifties, one truck shared Britain's roads with four cars. 50 years later, that one truck shared the roads with no fewer than 55 cars. Is this car parc being used efficiently? Given that the percentage of car journeys involving the transport of one person – the driver – continues to grow, efficiency has to be questionable.

A shared people-carrier for example, operates at greater efficiency than one person in a small car. The efficiency with each litre of fuel is consumed is of greater significance than the carbon rating of an individual model.

Vehicle population (000s)

	1951	2007
Cars	2,095	26,208
Trucks	451	433

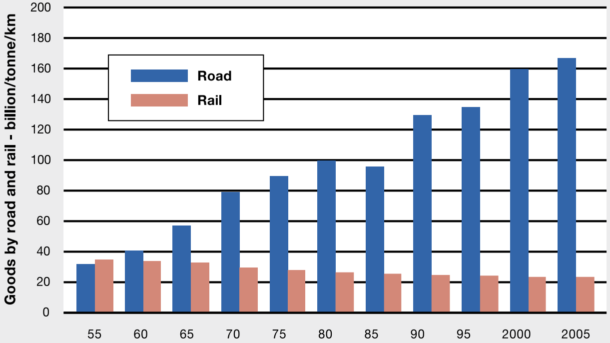
The role of public transport

It is clear that public transport – buses, coaches and trains – with the maximum number of passengers, is operating at far greater levels of efficiency than the sole occupant of a car. The environment would benefit most if public transport were more flexible, user-friendly and available - so tempting people out of cars. In London, the combined effect of bus lanes and ‘bendy buses’ has succeeded in attracting passengers who would otherwise have travelled by car.

Ironically, giving greater priority to buses and coaches could be matched by giving greater priority to fully-laden, maximum weight trucks. On some motorway routes, it’s not inconceivable that they could be given precedence over single-occupant cars. California could be the first place where bus lanes are shared by certain heavy trucks.

The promise that trains as freight carriers had in the ‘fifties has never really materialised. Then, 37 billion tonne kilometres of freight was delivered by rail – more, in fact, than was carried by road. 50 years later rail freight had declined by 40% to 22 billion. Over the same period, truck freight rose from 32 billion tonne kilometres to 163 billion – a five fold increase.

Road versus rail 1955 - 2005



Trains are efficient at carrying large, dense goods – like aggregate. Beyond this, road transport wins because it is convenient, efficient and flexible. Truck productivity improvements, as we have seen, have been dramatic through constant investment. If Brunel's far-sighted proposal for a 7ft gauge railway had proved a winner with his investors, we would not have inherited the 4ft 8in gauge and trains today would be bigger, faster and their low freight cost per tonne would be formidable competition for road transport. There is a growing trend, particularly present as Eastern Europe grows, for containerised goods to be moved by inland waterway and by sea - including the Baltic. As such it may take some pressure of Europe's overloaded road network.

Trains for people and roads for freight?

The railways are efficient carriers of people. But they could be more successful at attracting people out of cars and into carriages if trains were more user-friendly and if there were more of them. There are examples where these conditions are met – and everybody, including the environment, benefits.

If buses, coaches and trains fail to attract the motorist, the outcome is likely to be even greater road congestion and, potentially, even more harm to the environment. In the last 50 years, there has been an increase of over 700% in vehicles in use. Compare that with an increase in road length of only 29% and it's not really surprising that the roads are clogged. As there are fewer trucks on the road today than there were 50 years ago, it's clear that, in terms of vehicle numbers, it's the increase in cars that is primarily responsible for road congestion. To take just one statistic that illustrates the point, one truck load of goods delivered to a supermarket is driven away by 400 car drivers.

Trucks might just be the victims of road congestion rather than the cause.

In this booklet we have seen how trucks, and diesel engines, have succeeded in becoming more efficient, more productive and more eco-friendly. We have also seen that the foreseeable future almost certainly lies in the further technological development of trucks and their engines.

The imperative to burn each litre of fuel as efficiently as possible will become even greater over time. Sustainability may well depend on local sourcing while, at the same time, trying to maintain our lifestyle and retaining as much as possible of our natural resources.

Saving fuel not only saves CO_2, it also saves money. There are fuel savings to be achieved right now: greater emphasis on logistics planning, for example, will maximise the time that trucks spend running fully laden. Operating at the correct specification, fitting aerodynamic aids and adopting the most economical mode of driving can, as we have seen, save fuel.

Rising prices of fossil fuels will assist the adoption of these short-term measures and may well make alternative fuels a more economical long-term proposition. So the greater productivity which we need to achieve from the burning of every litre of fossil fuel may not only depend on the growing awareness of atmospheric CO_2 - economics may dictate the pace.

Data sources

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