Driving Sustainably

A guide to reducing your carbon footprint

Tigroney Press
Sustainable Planet Series

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1. Travel as part of our carbon footprint

Introduction

Mobility is an integral part of all our lives and our dependence on personal transport higher than at any other time; something which is rapidly increasing word-wide, especially in Asia. The problem is that 95% of global energy consumption for transportation is based on oil, predominately diesel and petrol (gasoline), with road transport responsible for 74% of these emissions which continues to grow faster than any other energy consuming sector.

A survey of carbon (CO_2e) emissions in Irish homes carried out by Kenny and Gray in 2009 showed that on average 42.2% of emissions were associated with household energy use, 35.1% with car and public transport, 20.6% with air travel and 2.1% with waste disposal. This means that on average over half of our household or personal GHG emissions arise from travel. The average household carbon footprint was 16.55 t CO_2e yr^{-1} which is equivalent to an average personal carbon footprint of 5.70 t CO_2e yr^{-1}. Therefore, 3.2 tonnes (56%) of CO_2e per year of our personal footprint arises from travel making this area an important starting point for trying to reduce our carbon footprint.

On average 3.2 tonnes of CO_2e per year of our personal footprint of 5.7 tonnes (56%) arises from travel

More information: Kenny, T. and Gray, N.F. (2009) A preliminary survey of household and personal carbon dioxide emissions in Ireland. *Environment International,* **35**, 259-272.

Saving the planet can often save you money as well as make you feel better and driving is a good example of how this can work. Reducing carbon emissions means that you use less fuel which in turn means cheaper driving. Fuel is a major cost to motorists, so it is something we should all be keen to reduce. So how can you reduce your carbon emissions by using less fuel. The key elements are how you drive, maintenance of the car, and essentially what you put in or on your vehicle. Of course, what you drive is also an important consideration, but I can guarantee you can save a lot of fuel and reduce your emissions regardless of the vehicle you drive. Modern cars are increasingly efficient but if driven badly and poorly maintained then these advantages are quickly lost. To get some ideal of the fuel emissions that you should be getting according to the manufacturers see the website car-emissions.com (https://car-emissions.com/).

Carbon emissions from driving is based on kilometres or miles driven multiplied by the manufacturers combined carbon emissions in grams per litres of fuel used. For the majority this significantly underestimates their emissions, while for a smaller percentage, it overestimates it. The CO_2e produced as well as other pollutants is more linked to the volume of fuel we used rather than the distanced travelled. Consequently, focussing on fuel economy in terms of litres used per 100 km travelled (L/100km) is especially important if you are going to reduce your carbon footprint and make a real contribution to tackling climate change.

In this short guide Section 2 explores emissions and car usage, while if you just want to know how to reduce your emissions and save money on your fuel bill, go straight to Section 3. Section 4 discusses buying a new car and the advantages of older cars, and explores the hidden emissions associated with the manufacture of your car which can be substantial; while Section 5 looks at the overall impact of driving sustainably could have on climate change.

2. The problem

Car ownership

The transport sector is responsible for around one-fifth of the EU's greenhouse gas emissions with 70% of these emissions from road transport. To combat this, **the IPCC requires developed countries to reduce GHG emissions by 25-40% by 2020 and by 80-95% by 2050 to avoid the worst impacts of climate change**. While car manufacturers have been forced to respond, it has taken a long time. A lot of this change has been due to the EU setting strict limits designed to dramatically cut greenhouse gas emissions from cars. In 2007 the average new car emitted approximately 160 g CO_2e per km. In 2009 the EU introduced new emission targets for manufacturers to bring this figure down to 120 CO_2e per km for at least 65% of their new cars by 2012. Due to unreliability of emission values from manufactures, new legally binding emission standards were introduced in 2014 for all new cars sold in Europe from 2015. This states that, on average, new cars and SUVs should not exceed 130 CO_2e per km falling to 95 g by 2021.

Average new car emissions have fallen by 33.6% since 2000, and this downward trend continues, with the average emissions for new cars sold in 2017 just below 119 g CO_2e per km. The difference between average CO_2 emissions of new diesel and new petrol vehicles is just 3.3 g CO_2e per km. This gap is considerably lower than a decade ago, when the difference was 17 g CO_2e per km, which combined with better fuel consumption figures is why those who drove long distances tended to favour diesel cars, which is still the perception today. However, regardless of the relative price of the two fuels which is an important incentive for those driving long distances annually, modern diesel engines are still amongst the lowest in terms of emissions per unit distance travelled.

How far do we drive? Well this depends on so many factors. People in rural areas drive more than those in cities and towns due to a lack of public transport and the larger distance to services. Ireland, for example, has quite a high rural population which can be quite isolated. In 2005 *Sustainable Energy Ireland* used National Car Testing (NCT) data (the NCT is equivalent to the UKs MoT test) to assess **average mileage of Irish car owners which was found to be 16,894 km per year** (10,498 miles per year). Petrol cars were driven on average only 15,969 km (9,923 miles) compared to diesel cars with an average annual mileage of 23,817 km (14,799 miles).

The number of passenger cars in EU Member States has risen from 345 per 1000 in 1990 to 505 per 1000 in 2016 which is similar to the USA. Ireland has seen a dramatic increase in car ownership but is still below the EU average at 439 per 1000, similar to the UK at 469, with

Luxembourg topping the list at 662 cars per 1000 of population. The number of passenger cars in the EU exceeds 242 million, and globally could be as high as 1.8 billion. In the period January to May 2018, 6.9 million new cars were registered within the EU, an increase of 2.4% over the same period the previous year. The percentage of cars powered by petrol in the EU is 55.6% compared to 41.2% for diesel (Table 1). Electric and hybrids make up just 0.1 and 0.4% of the cars on the road although 2.2% use biogas or LPG, with 14% of cars in Poland using this fuel type. Italy, The Netherlands and Germany are the only other countries to have a well-developed LPG network resulting in 5.0, 1.9 and 1.2% of all cars using this fuel.

Table 1. The percentage of cars using different fuel types.

Country	Petrol	Diesel	Electric	Hybrid	LPG	Other
EU	55.6	41.2	0.1	0.4	2.2	0.4
UK	61.7	37.2	0.4	0.7	0.00	0.04
Ireland	59.3	37.7	0.1	0.4	0.00	2.5

More Information at: The European Automobile Manufacturers Association: https://www.acea.be/ ***The International Council on Clean Transportation:*** *http://www.theicct.org/* ***SIMI European Vehicle Statistics:*** https://www.simi.ie/en/motorstats/european-vehicle-statistics

Manufacturers and fuel efficiency data

It has been known for many years that the fuel efficiency and emissions values supplied by manufactures are sometimes misleading, and that we are mistaken if we think that if we buy a heavy, large engined vehicle it is going to have low emissions…it is unlikely to be true. These values were based on the New European Driving Cycle(NEDC) which was last updated in 1997. However, the reality may even be more complex. A study conducted Emissions Analytics (*http://emissionsanalytics.com/*) of 500 vehicles in the UK, half petrol and half diesel, found that on average fuel efficiency was 18% less in terms of miles per gallon (mpg) achieved than suggested by the manufacturer. They found discrepancies for all vehicle types but especially with small cars. Cars with engine sizes up to 1 litre performed 36% worse than expected based on the figures supplied by the manufacturers. The study observed that smaller engines must work much harder when accelerating than cars with larger engines so that this group only averaged 16.4 km/L (38.6 mpg). Vehicle engines between 1 and 2 litres showed a smaller average difference between expected and observed efficiency at 21% (average 19.9 km/L or 46.7 mpg) and for 2 to 3 litre engine cars the discrepancy was just 15% less than the manufactures figures (average 19.1 km/L or 45 mpg). However, this depends on how these vehicles were driven and the study does not explore this. In the US the average fuel efficiency of cars is 9.8 km/L (23 mpg).

This has been acknowledged by the EU and in September 2017 the NEDC test was replaced with the far more accurate Worldwide Harmonized Light Vehicle Test Procedure (WLTP) which has forced manufacturers to release better fuel-efficient vehicles to replace their popular but less efficient designs. From September 2018 the WLTP became mandatory for all new cars. The new test is designed to give buyers more reliable 'real-world' measurements of fuel consumption and CO2 emissions. The previous test scenarios of ‘urban’, ‘extra-urban’ and ‘combined’ have been replaced by’ low’, ‘medium’, ‘high’, ‘extra-high’ and ‘combined’. More details from http://wltpfacts.eu/what-is-wltp-how-will-it-work/.

To approximate the actual emissions from cars, the Department for the Environment, Food and Rural Affairs (Defra) in the UK has added an extra 15% (an uplift factor) onto the NEDC assessment (Table 2). This equates to an average decrease in fuel economy of 13% for petrol vehicles and 9% for diesel vehicles compared to manufacturers’ claims. Of course, these figures do not include emissions associated with the manufacture of the vehicle, replacement tyres, servicing, parts, repairs or the final disposal of the vehicle.

Table 2. Defra generalized CO_2 emission factors for cars based on fuel type and engine size. Data from Defra (2008). Reproduced with permission the Department for Environment, Food and Rural Affairs, London.

Vehicle type	Engine size	Size	EU conversion factors		Revised DEFRA real world conversion factors	
			(g CO_2/km)	mpg	(g CO_2/km)	mpg
Petrol cars	>1.4L	Small	159.2	40.8	183.1	35.5
	1.4-2.0L	Medium	188.0	34.6	216.2	30.2
	>2.0L	Large	257.7	25.2	296.4	21.9
Diesel cars	<1.7L	Small	131.0	56.7	150.7	49.3
	1.7-2.0L	Medium	163.6	45.4	188.1	39.5
	>2.0L	Large	229.1	32.4	263.5	28.2
Hybrid petrol-electric cars	Toyota Prius	Medium	109.7	59.3	126.2	51.5
	Honda Civic	Large	194.7	33.4	224.0	29.0

1 mile per gallon (mpg) is equivalent to 0.4251 kilometre per litre (km/L)

Emissions are calculated most efficiently by simply measuring the amount of fuel used which automatically takes into account variability in both the vehicle and driving skill.

Car engines are also designed for specific driving conditions, so a car with a small engine is more efficient when driven relatively slowly and becomes increasingly inefficient at higher speeds. Conversely larger engine cars are far more efficient at higher speeds (Figure 1).

Compare your own car emissions at: http://www.car-emissions.com/
More information: *http://emissionsanalytics.com/*
Check measured emissions of your car: *http://www.whatcar.com/truempg/my-true-mpg#*

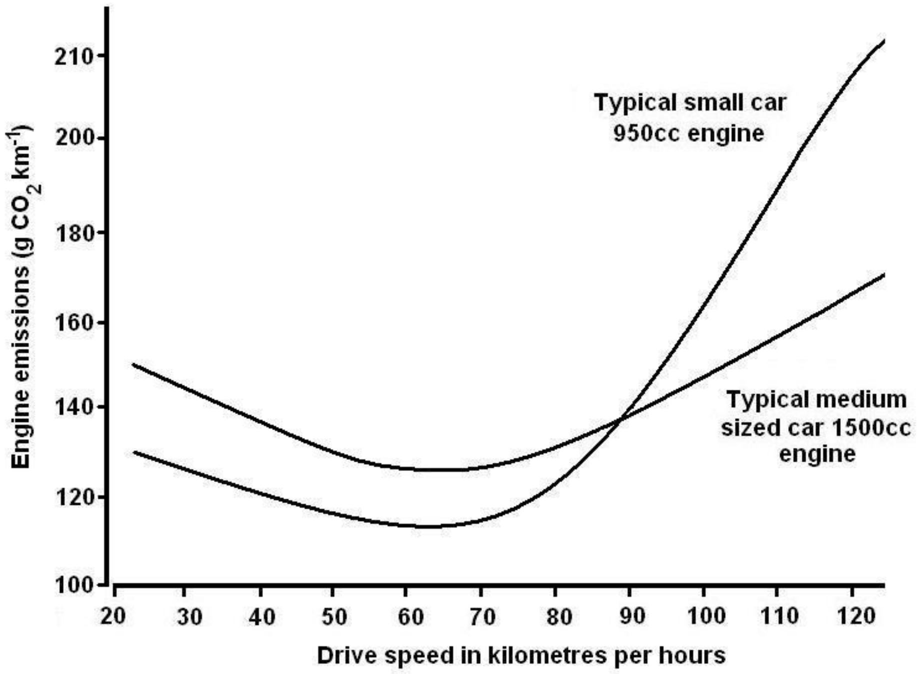

Figure 1. Emissions vary at different speeds depending on engine size. *Engines are often designed to give optimum performance at the speed at which emissions are tested.*

Of course, there are many different ways of travelling, and many opt to make their daily commute by public transport, but just like aviation and the car there is a carbon footprint attached. Emissions are normally expressed as grams of CO_2e per passenger kilometre travelled (g CO_2e per passenger km) and of course trains and buses also cause pollution just like cars and lorries. It is very difficult to calculate public transport emissions accurately as they depend on the actual number of passengers and the fuel used, rather than theoretical carrying capacity. The fact that a train or bus may be filled to capacity or even overcrowded during rush hour it is most likely to be only partially full for the rest of the day, so efficiency in terms of g CO_2e per passenger km varies by trip. So, an average value is required. Kenny and Gray (2009) at Trinity College Dublin determined Irish public transport emissions per passenger km and these are listed below. Commuter and intercity trains in Ireland are diesel, while the DART is an electrified suburban train service. The LUAS is an electrified light rail system similar to trams found in other European cities. Ireland being an Island is very dependent on both aviation and vehicle ferries to the UK and Europe (Table3).

What is the most effective way of commuting? Well walking and cycling are by far the most efficient methods although as we can see from Table 4 car sharing does reduce per passenger emissions significantly. Commuting is often complex. For example, it may require the person to drive to a train station, then travel by train maybe by a non-direct route and then take a bus to their destination. In suburban and city areas then the bus network usually feeds into the rail network as well as providing direct routes themselves. Therefore, it is always going to be preferable to use public transport where it is available and reasonably direct, and by supporting public transport you reduce the number of cars on the road, reduce congestion, reduce local pollution, reduce emissions and ensure that public transport services are maintained and are at their most efficient in terms of emissions. However, cost and time factors are also important issues for individuals, so if we are to reduce the number of cars on our roads public transport has to be frequent, reliable, affordable and safe.

Table 3. Irish travel emissions per passenger km for public transport and motorcycles.

Mode	**Emissions**
Train (Intercity)	54 g CO_2e/ passenger km
Train (Commuter)	49 g CO_2e/ passenger km
Bus	74 g CO_2e/passenger km
LUAS	55 g CO_2e/passenger km
DART	43 g CO_2e/passenger km
Ferry[a]	20.35 kg CO_2e/passenger
Taxis	Same as passenger vehicles
Motorcycles	
Small <125cc	73 g CO_2e/passenger km
Medium 125-500c	94 g CO_2e/passenger km
Large >500cc	129 g CO_2e/passenger km
Average for motorcycles	106.7 g CO_2e/passenger km

[a] One-way Dublin Holyhead High Speed Ferry

Table4. Comparison of commuting options by emissions per passenger kilometre travelled (data based on 2009 values).

Km travelled per passenger per kg CO_2 emitted	**Transport mode**
24.5	Small car (driver + two passengers)
23.3	DART (Suburban electric rail)
20.4	Train (Intercity diesel rail)
18.1	LUAS (Electric light rail)
16.5	Small car (driver + single passenger)
13.7	Scooter - Petrol
13.5	Bus - Diesel
12.3	Taxi – Medium car (two passengers)
8.3	Small car (driver only)
6.25	Taxi - medium car (160g/km) (single passenger)
3.69	2005 - E210 Mercedes-Benz petrol
3.46	Typical 3.0L diesel SUV

3. Making a difference by driving sustainably

Driving

Cars generally have two fuel efficiency indicators. The real-time indicator tells you how much fuel you are using per 100 km travelled and this changes every 15 seconds or so as it calculates the rate. So, if you suddenly accelerate or go up a hill it will soar up to 10 or more L per 100km or when you are going downhill it drops close to zero. This indicator is useful as it allows you to see when fuel is being used and saved, it also allows you to see the difference in driving style and the effect of driving in too high or too low a gear when driving on the flat along a motorway for example. This is really a training tool and is well worth using.

The second instrument is the integrated fuel efficiency gauge which gives you an average value (L per 100km) over the period since you last reset it. A problem is that the longer it has been left without being reset the longer it takes for any changes to register. My advice is to always reset your long-term gauge every time you refill the car with fuel and try and keep the value (L per 100km) as low as possible. Driving at or below 100 km per hour, or not exceeding a certain maximum rev count (2000 rpm in my own car) makes a dramatic difference in fuel efficiency. This depends on the size of your engine and the type of car you have, but with perseverance you can get much closer to the theoretical emissions level for your vehicle and you will also end up driving slightly slower, more smoothly and so more safely. I sometimes get into old habits and the long-term fuel efficiency indicator starts to climb and then have to start thinking about how improve fuel efficiency again.

So why are you not getting the expected fuel efficiency for your vehicle and if you are could you do even better? Here are some things to consider.

Smoothness of driving
Erratic driving is expensive especially rapid acceleration and sudden breaking. This is especially a problem with automatic cars. Try to increase your speed gradually rather than pushing the accelerator pedal to the floor, and similarly keeping a good distance between you and the car ahead can help you anticipate breaking and to slow down gently. Driving erratically, especially constantly accelerating and braking is a major cause of high fuel consumption as could be adding 10-20% to your fuel costs, although this type of driving is also associated with speeding.

Speed
It is a general rule that speed costs you money as the vehicle uses more fuel overall at higher speeds. Cars are designed to pass the emissions tests and so they tend to be most efficient at the speeds at which the car will be tested. If you drive at 50 mph (80 k/hr) instead of 70 mph (110 km/hr) you could be saving up to 35% in both fuel and emissions. In Ireland driving a cruising speed of 100 km/hr on motorways has been shown to reduce your emissions and fuel costs by 15-30% overall and has been widely adopted. But even keeping within the speed limit will save fuel, also will save any possible speeding fines.

The Rev Counter
This is probably the most useful piece of kit when trying to reduce emissions. Almost without exception car engines work most efficiently when driving between 1500-2000 rpm, so when the revs get to 2500 in a petrol car or just above 2000rpm in a diesel, then it is safe and desirable to change gear. Many modern cars have gear change indicators, and these help you get the best from the engine, although use your common sense.

Attention to these three points makes you a better and safer driver, makes the passengers have a smoother ride and above all is significantly reducing your emissions while saving cash.

Air conditioning
Many new cars now have air conditioning, but it does come at a price? Many cars seem to default to air conditioning mode whenever the heater is turned on or the window demister option is selected, so it's very easy to end up driving with it on all the time. The problem is that it can add a staggering 10% to your fuel overall bill, it can also stop the stop-go system working as it draws down too much power for the normal battery to supply. So, make sure it is switched off and only used sporadically to cool the interior when it is really hot, or for rapid windscreen demisting where the normal window setting on your fan isn't working fast enough. Air conditioning is unnecessary for heating the car with the ordinary car heater more than adequate, nor for just getting fresh air, when the lowest heat setting on your car fan or opening your window a few centimetres will give you plenty of cool fresh air. Air conditioning does not affect how your air filter or pollen trap works as they are part of the normal fan system. If you want to see the effect of the air conditioning system in your car just watch the rev counter when the engine is idling and then switch it on; you will notice an increase in the work being done by engine and hence more fuel being used and you are still stationary! It's not only the air conditioning that can increase fuel consumption, but the heater and even the lights all add a small amount to the fuel demand so turn off your fog lights when they are not required and only use the heater when required.

Loading the Car

Drag
Car manufacturers spend untold millions on enhancing the aerodynamics of their vehicles ensuring that the air flows over and past the vehicle as smoothly as possible minimizing drag. They need to optimize performance at the lowest possible fuel consumption in order to meet with EU emission standards, and this is one of the ways they can do it. So, when a roof or cycle rack is added this significantly reduces the aerodynamic efficiency of the vehicle, so much so, that a loaded roof rack or bicycles on the roof of your car can increase fuel consumption and emissions from between 8-25%, depending on whether the rack is empty or loaded. Boot racks are better but disturb the airflow to the rear of the car causing similar effects. Open windows can also affect the flow of air past the car, so the more open the window the greater the drag will become. Having both side windows doesn't cancel out the problem but makes the drag effect worse. So only open car windows a small amount or use the fan at the lowest setting so that only unheated air is coming into the car.

Towing is always going to be expensive in terms of fuel economy due to the extra weight and the drag effect. One way of reducing emissions is to remove extended wing mirrors, commonly used for towing caravans, when not being used for towing. Just this small action can save 5% or more on fuel

Weight matters

Weight certainly does matter in terms of overall fuel consumption which is why car manufacturers are constantly striving to make cars more efficient by reducing their overall weight. As the weight you add to the car increases so it takes more fuel to move the car overall. So, try to avoid driving with a boot full of unnecessary items, especially heavy DIY equipment. This also applies to fuel. The weight of vehicle fuel varies according to density and other factors. At 15^{o}C diesel can weigh between 832 to 959 grams per litre compared to petrol which is lighter at 710 to 775 grams per litre. To calculate the total weight of your vehicle's fuel tank when full multiply the size of the tank in litres by an average value of 0.850 kg per litre capacity for diesel and 0.749 kg per litre for petrol vehicles. Compact cars can carry between 45 to 65 litres in their fuel tank while larger cars and SUVs between 75 to 100 litres. This is equivalent to carrying on average 41.2 or 46.8 kilograms of fuel in a petrol or diesel compact car respectively when the tank is full. For larger cars and SUVs this equates to 65.5 or 74.4 kilograms for petrol and diesel respectively. This means that we are carrying a lot of weight as fuel. If you are using the car for short to medium trips then you can save fuel and money by refuelling more often rather than always refilling your tank to full when it is three-quarters or half empty, which is common practice. This way you are reducing the overall weight of your car in terms of fuel by 50%. Reducing the weight of your car by keeping it clean and the boot empty, plus not always driving with a full fuel tank will easily save you 5-10% of your fuel bill, plus reduce all those important emissions. But remember not to run out of fuel.

Extra passengers will of course slightly increase your emissions, but the good news is that car sharing means that you are reducing your personal emissions. For example, if two people drive to work in their own cars and each car is emitting 130 grams of CO_2e per km, a 40 km round trip is producing 10.4 kg of CO_2e each day. By car sharing, this almost halves the total emissions for two people to 5.5 kg even though 5% more fuel is used due to the extra passenger. From the perspective of a personal footprint that means sharing this journey has reduced to emissions going to work from 5.2 for each passenger to 2.25kg CO_2e per trip. That is a reduction from 1.24 tonnes per year to 0.54 tonnes per person per year, preventing an extra 0.7 tonnes of CO_2e entering the atmosphere each year (based on 239 working days a year). Car sharing equates to the lower emission values normally associated with using public transport. Carpooling does more than reduce our emissions, it significantly reduces all associated exhaust pollutants including hydrocarbons, volatile organic carbons, all particulates including PM_{10}, PM_{25}, and brake pad debris and of course NOx. However, check with your vehicle insurer to make sure you are covered. Most companies have a central carpooling scheme so that drivers and passengers can connect, or you can use an online site or an app such as http://www.carpooling.com

Tyres and maintenance.

These two items are no-brainers as they also ensure that you are driving a safer and more reliable vehicle. After speeding and erratic driving, tyres are the single largest factor affecting fuel consumption and emissions. This not only includes using inappropriate tyres for your vehicle or the type of driving you do, but also the wear and inflation pressure. Underinflated tyres are often recommended for extra grip and a smoother ride, but underinflation leads to a reduction in tyre life, perhaps by as much as 30%, plus a rapid increase in fuel consumption. **By ensuring the correct pressure of your tyres and that the tracking is okay, you could save you up to 15% in fuel costs and emissions**.

To ensure maximum performance from electric and some hybrid cars low rolling resistance tyres have been developed which reduce fuel consumption by about 2.5% compared to standard tyres. This is achieved by using silica in the manufacture of the tyre which increases the grip while achieving a lower resistance. The lower the rolling resistance of the tyres the less fuel consumed.

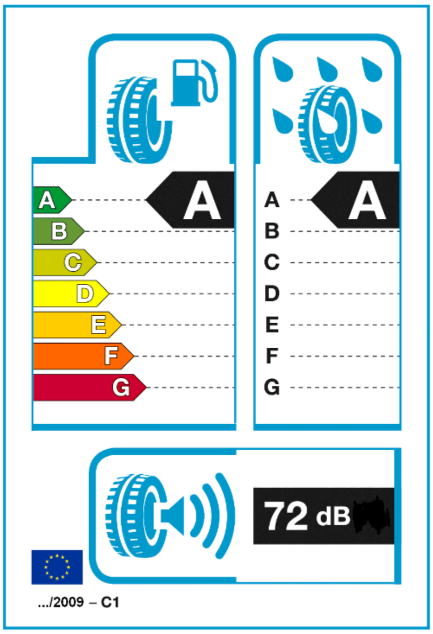

Figure 2. The new EU tyre label which gives details of the fuel economy, based on rolling resistance, noise and grip in wet weather.

Tyres manufactured after July 2012 must conform to EU regulations and display a EU tyre label (Fig. 2). The rolling resistance rating is expressed from A to G, with A to C the highest ratings and E to G the least efficient. Rating D is not currently used in this system. Tests done at 80 km/hr (50 mph) have shown that the difference between A to G rated tyres amounts to roughly a fuel efficiency difference of 7.5%. Most standard vehicles are limited to B or C rated tyres at present although electric cars can avail of several specially developed A rated tyres such as the Michelin Energy E-V tyre which boosts 20% less rolling resistance and 6% more kilometres compared to their Michelin Energy Saver + range of tyres. However, most energy efficient tyres are for summer use only, so the savings within the A-C ranks may be marginal in practice. But fitting an off-road tyre on your SUV which you are driving mainly on the road instead of one of the more efficient all-weather tyres available (B rated for fuel) could equate to just under half a tonne of extra CO_2e emissions a year based on 30,000 km per annum usage.

Can you do better than manufacturers emission values?

You may not believe that any of the above suggestions make a difference to your fuel consumption. Well, we can test this. The first question is: Are you getting your manufacturers estimated fuel economy? These have become more accurate since the various investigations into several manufactures, the notable being Volkswagen, with new regulations being brought into place in the EU in January 2018. These were done under very strict and controlled conditions. If you are achieving the combined efficiency estimates, then well done. However, you could do even better. The MPG Marathon is an annual competition set over a course of 300 miles over two days to test the maximum efficiency of production cars and commercial vehicles. It is open to anyone who wants to see if they can complete a set route using as little fuel as possible. The course has set stops and is designed to simulate real driving conditions. Remarkably these drivers using the skills described above, not driving erratically, judging road conditions and adapting driving technique accordingly, can improving fuel efficiency over the manufacture's claims by up to 60% with the compact diesel car achieving 122 mpg (that is 43.2 km/L or just 2.3 litres per 100 km) (Table5).

More information: https://thempgmarathon.co.uk/

Table 5. Winners of the 2017 MPG Marathon comparing the maximum fuel efficiency achieved compared to manufacturer's combined efficiency in miles per gallon (mpg) and kilometres per litre (km/L).

Award category	**Vehicle**	**Manufacturers Combined**		**Actual achieved**		**Percentage improvement**
		mpg	km/L	**mpg**	km/L	%
Most efficient vehicle	Ford Fiesta 1.5 TDCi (120PS) Titanium	**80.7**	28.6	**122.01**	43.19	**51.2**
Percentage increase cars	Honda Jazz 1.3 i-VTEC EX Navi Manual	**55.4**	19.6	**88.73**	31.41	**60.2**
Percentage increase Vans/pickup	Isuzu D-Max Utility 4x4 Double Cab Manual	**40.4**	14.3	**51.22**	18.13	**26.8**
Petrol Champion (Compact)	Ford Fiesta 1.0 (125PS) EcoBoost Titanium	**65.7**	23.3	**97.43**	34.49	**48.3**
Diesel Champion (Compact)	Ford Fiesta 1.5 TDCi (120PS) Titanium	**80.7**	28.6	**122.01**	43.19	**51.2**
Diesel Champion (Family)	Jaguar XE Portfolio 2.0 Turbocharged Diesel 180ps RWD	**67.3**	23.8	**71.05**	25.14	**5.6**
ULEV, Alternative or Hybrid Champion	Suzuki Swift SZ5 DualJet SHVS AllGrip	**62.8**	22.2	**81.05**	28.69	**29.1**
Medium Van	Volkswagen Transporter T32 ST-LN TDI BMT	**45.6**	16.1	**46.90**	16.60	**2.9**

Embedded footprint of car manufacture

One thing we do not take into account in calculating travel footprints are the embedded GHG emissions from the manufacture of the car and its components. This varies from vehicle to vehicle as we can see below. But how do we allocate these emissions in personal footprints? We can see the comparison between the typical small car which has embedded CO_2e emissions equivalent to 6 tonnes per vehicle to that of a typical SUV which has embedded emissions of 24 tonnes of CO_2e. One way of allocating these could be to set them against actual mileage over the expected lifetime of the vehicle, so for 80,000 km this would be equivalent to an extra 37.5 or 150 g of CO2e per km on top of the emissions for the fuel for a small car or luxury SUV respectively. Alternatively, this can be allocated on a yearly basis, so for the small car this would be equivalent to 0.6 tonnes CO_2e per year over a lifetime of 10 years (Table 6). This puts another layer of emissions onto our driving footprint which we have tended to ignore. Of course, the longer you keep the car in good working order then the lower this part of the footprint will be (Table 7), but we must accept that this is part of our overall driving footprint.

Table 6. Example of embedded CO2e emissions from the manufacture of vehicles and how they might add to travel per kilometre emissions or annual carbon footprints based on vehicle lifetime in a personal carbon budget.

	GHG emissions as grams per kilometre (g/km) or tonnes per year (t/yr)					
Vehicle	**Embedded GHG**	**20,000km (g/km)**	**80,000km (g/km)**	**160,000km (g/km)**	**5 years (t/yr)**	**10 years (t/yr)**
Small car	6 tonnes	300	75	37.5	1.2	0.6
Luxury SUV	24 tonnes	1200	300	150	4.8	2.4

Table 7. Average age of car in European countries

Country	**Average age of car (years)**	**Country**	**Average age of car (years)**	**Country**	**Average age of car (years)**
Austria	8.9	Greece	13.5	Portugal	12.6
Belgium	7.7	Hungary	14.5	Romania	15.3
Croatia	14.1	Ireland	9.0	Slovakia	13.4
Czech Republic	14.5	Italy	10.7	Slovenia	11.2
Denmark	8.5	Latvia	16.3	Spain	11.4
Estonia	15.1	Lithuania	16.7	Sweden	9.6
Finland	12.7	Luxembourg	6.2	United Kingdom	8.5
France	9.0	Netherlands	9.5	**EU (average)**	**10.7**
Germany	8.9	Poland	17.2		

4. Buying a car

Many people simply feel that the best way to minimize emissions is by buying a new car, especially a hybrid or an electric vehicle (EV). It is true that each year cars get more efficient in terms of fuel economy; however, it is not essential to buy a new car in order to save fuel and reduce your carbon emissions from driving. In fact, buying a hybrid model can sometimes be less efficient that a standard model. No matter how efficient your car may be poor driving and maintenance will eliminate the advantages of better fuel economy it offers.

To be sustainable with our driving we need to buy the car that will best serve our driving needs. To help us in making that decision several useful initiatives have been introduced. For example, LowCVP is a UK public-private partnership aimed at helping the transition to more sustainable transportation (https://www.lowcvp.org.uk/). They introduced Fuel Economy labels in the UK for private vehicles, including EVs, which are now legally required for new cars and are displayed on second-hand cars on a voluntary basis (Figure 3).

Car engines are often designed to have their lowest emissions at or around 60 – 80 km per hour (km/hr), so in theory this is the optimum speed to minimize your GHG emissions. Small cars and SUVs driven above 100 km/hr are usually very polluting in terms CO_2e emissions, so these vehicles need to be driven at or below 100 kmh. In urban areas the SUV will also be using a lot more fuel than the smaller car as well as releasing a lot of particulate pollutants known as particulate matter (PM) expressed as different particle sizes in micrograms (e.g. PM40, PM20 and PM10). Heavy duty SUVs are purpose-built vehicles which should only really be used in rural areas where their capabilities can be fully exploited for off road and towing needs, so they should have low annual mileage. If you drive a lot on motorways or long distances you need a larger, probably a modern diesel, car. If you drive in congested areas and have to brake a lot then you need a standard hybrid car which will ensure that the use of the self-charging battery is maximized, but these are less efficient than a standard car if you are simply plying up and down the motorway as they have relatively large, usually petrol engines, and carry a heavy battery. Plug-in hybrid electric vehicles (PHEV) are best for shorter trips and when they can be regularly charged thereby making the most of their electric-only capability. If you are driving in urban areas or making primarily short to medium distance trips, then you need a small car, preferably fully electric vehicle, petrol fuelled, or alternatively a car with a small engine with stop and go. The stop and go facility is extremely important for urban areas and makes a significant contribution to air quality as well as reducing fuel usage while stationary at traffic lights or in heavy traffic. Remember that both plug-in hybrids and electric vehicles require you to have somewhere to charge them. At the end of 2017 there were just 13,949 public vehicle charge connects in the UK, so the ability to charge your vehicle either at home or at work is essential.

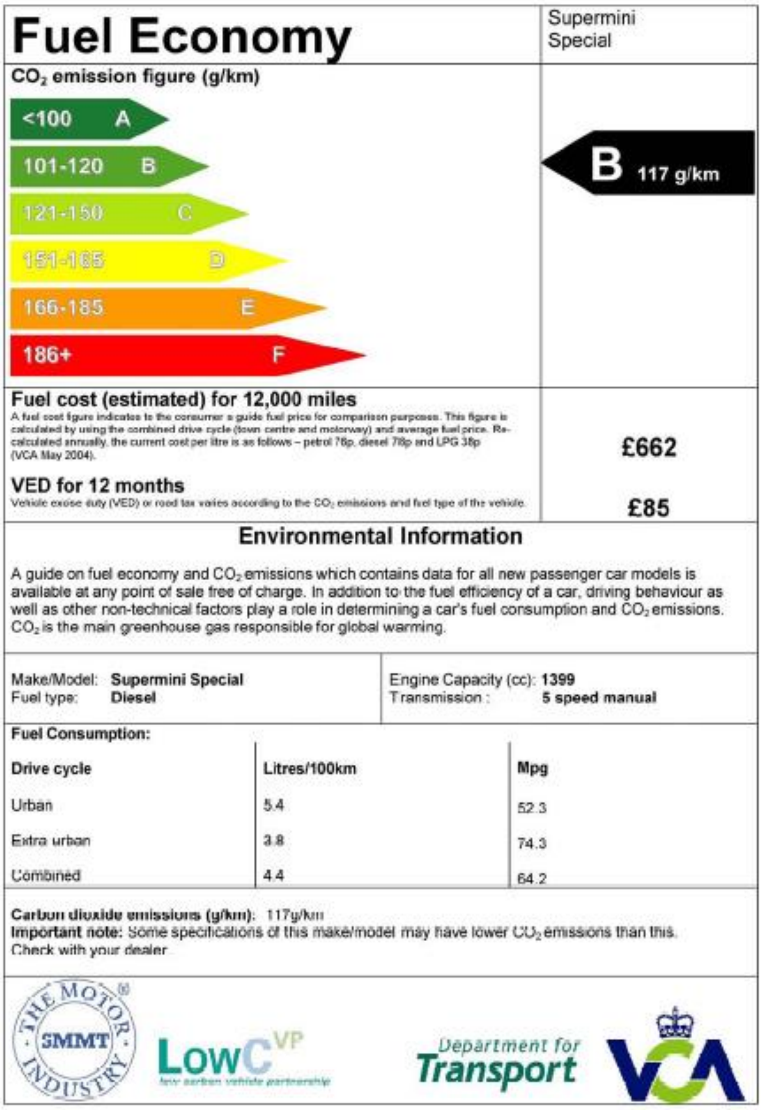

Figure 3. The new Fuel Economy label used in the UK gives clear rating from A – F for CO2 emissions of your new or second-hand car as well as fuel consumption rates for urban, extra urban and combined driving situations. It could be advantageous if it were more widely adopted. The Vehicle Certification Agency in the UK also provide a fuel consumption and CO2 emission data base for all new cars, 4x4s vans and pickups available for sale in the UK. Data is also available on exhaust pollution levels as well as noise, making it a unique resource (https://carfueldata.vehicle-certification-agency.gov.uk/).

Electric cars need fuel just like diesel, petrol or LPG vehicles, so their efficiency really depends on how the electricity used to recharge their battery is generated. In Iceland and Paraguay where hydroelectricity is in abundance then the carbon footprint of an EV is less than 1 g CO_2e/km. Other countries heavily into hydroelectricity generation are Sweden (11 g CO_2e/km), Brazil (19 g CO_2e/km) and Canada (45 g CO_2e/km). Squashed between these countries is France with just 23 g CO_2e/km but this low value is due to their high nuclear electricity generation capacity. **Countries which utilize a mixture of fuel types (i.e. nuclear, natural gas, coal, as well as renewables) such as Germany, Italy, Japan and the UK, result in EV emissions of between 100-119 g CO_2e/km (UK 119 g CO_2e/km).** However, as fuel mixes vary during the day and time of year then these are average values. For example, during the day coal may be used to meet the high electricity demand but not at night thereby affecting emissions depending on when you recharge your vehicle. The US figure of 132 g CO_2e/km is declining as coal is slowly being phased out for electricity generation, but the exact figure depends on the fuel mix of the area where the power is generated. There are some countries where electric cars are considered far more polluting in terms of greenhouse gas production than either their diesel or petrol equivalent due to the high dependence of coal for electricity generation. These include China (188 g CO_2e/km), Australia (222 g CO_2e/km), South Africa (248 g CO_2e/km) and India (300 g CO_2e/km). These figures exclude manufacturing of the vehicle which is explored in Section 3. A full examination of the EV carbon emissions has been prepared by the NGO Shrink-That-Footprint in their report *Shades of Green*. (http://shrinkthatfootprint.com/wp-content/uploads/2013/02/Shades-of-Green-Full-Report.pdf)

So there appears to be no difference in terms of carbon footprint in the UK or Ireland between an electric vehicle or a standard petrol hybrid, or even the most effective modern petrol or diesel small cars. The key thing about electric cars is that they are free from airborne pollutants and so are ideal for urban scenarios and especially short journeys such as the school run, shopping etc.

Diesel vehicles, while not suitable for short trips or for primarily urban driving, such as taxi use, do achieve better efficiency both in terms of miles to the gallon and in terms of emissions. The new Euro 6 engines are amongst the cleanest diesel engines made. They can also deliver excellent fuel efficiency with the best small to medium cars in 2018 achieving between 80-90 mpg for the combined cycle with the Peugeot 208 1.6 Blue HDi 100 Allure 5dr achieving a staggering 94.2mpg, that is just 79 g CO_2/km.

We all want to buy a second-hand car from that single careful owner who had the car regularly serviced didn't over rev the engine and didn't abuse it through reckless driving. So, a question to ask yourself is would you buy a car that you had previously owned? Before you buy that new or second-hand car do some basic homework on whether it is the right car for your needs and what the emissions are going to be. To get some idea of the fuel usage and associated emissions for that particular model and year see the website car-emissions.com (https://car-emissions.com/).

A useful comparison service which allows you to input details of your type of driving to calculate emissions from various cars is given by What Car (see link below):
Check measured emissions of your car: *http://www.whatcar.com/truempg/my-true-mpg#*

5. The bottom line

No matter what type or age of vehicle you drive, whether it's a car, SUV or van, you can make a significant difference in you carbon emissions as well as save yourself money by following the tips given in section 3. Newer cars do have lower emissions, but this advantage quickly disappears if you don't follow those simple rules. Some sources have suggested that for the average driver savings of 10-30% are easily achievable while for the worst driver scenarios they could reduce their fuel usage by 30-50%. That is a lot of money and a lot of emissions.

So how will driving sustainably help control climate change? Well if you think that there were 252 million passenger cars in Europe in 2015 alone, a rise of 4.5% since 2010, so there are a lot of drivers out there who could contribute to reducing emissions from driving sustainably. According to the European Automobile Manufacturers Association in 2015 there were 33,542,448 cars in the UK with an average age of 8.5 years and 1,985,130 cars in the Republic of Ireland with an average age of 8.0 years. Between January to March 2018 there were 6,879,885 new cars registered in the EU, an increase of 2.4% over the same period in 2017, so the total number of registered cars is constantly increasing. So, if each one of these drivers can reduce their emissions by just 10 or 20% then this would save a lot of CO_2 and other pollutants getting into the atmosphere. How much is a lot?

If the average age of a car in the EU is 10.7 years and the average EU emissions of new cars in 2007 was 159 g CO_2e per km, then for an annual distance of 10,000 km the average EU passenger car is emitting 1.59 tonnes of CO_2e per year. If 10% of this is 0.159 tonnes then just a small reduction of 10% could save 40 million tonnes of CO_2 or 80 million tonnes for a 20% reduction. This presents an enormous potential to save emissions without even reducing the amount or distance we drive.

In the UK this equates to 7.85 or 15.7 million tonnes of CO_2e for either a 10 or 20% reduction respectively (assuming an average driving distance of 16,000 km with average UK car emissions for 2010 at 146 g CO_2e per km). For Ireland, with its much lower number of passenger vehicles, this equates to 0.42 or 0.85 million tonnes of CO_2e for either a 10 or 20% reduction respectively (assuming an average driving distance of 16,000 km with average Irish car emissions for 2010 of 133 CO_2e per km).

That is an average saving per car of 0.234 and 0.213 tonnes of CO_2e for every 10% reduction in your fuel consumption for UK and Irish drivers respectively. So, for the worst drivers that could mean an individual saving of one tonne of CO_2e currently contributing to climate change saved every year with absolutely no change in the distance you drive and causing no real change to your life.

When I first started looking at my own emissions while driving I couldn't get below 4.8 L per 100km until I realized that my tyres were underinflated, and once at the correct pressure I was able to get to 4.5 L per 100km immediately, so the condition of your vehicle is important as is regular servicing. Of course, carrying extra passengers or weight in the car can increase this slightly again in my case by 0.2 or 0.3 L per 100km per passenger, but again if you think about how the weight is displaced within the car then this can be minimized. Other factors also have an effect, the smoothness of the road surface, time spent at traffic lights or in traffic jams, inclines, bends, all these things add to your fuel efficiency. For example, travelling on a flat motorway in Ireland compared to that in the UK in my car is the difference between 3.9 and 4.2 L per 100 km respectively, and that is due solely to the smoother surfaces found on UK motorways. So, by optimizing my driving skill I can easily save 10-15% on my fuel bills and my associated car GHG emissions. The savings are even greater in vans and SUVs. One friend of mine who drove his large van at high speed up and down the motorway found that he could easily save 25% on his fuel bill when he reduced the amount of equipment he carried and drove more slowly and less erratically. It is quite easy to do and it is actually fun to have targets to try and beat. Of course, extra features such as stop and go, which not only saves fuel but is so important in urban areas to reduce pollutant concentrations where traffic is stationary, and an optimum gear change indicator to ensure optimum use of the engine, all add to that efficiency.

The potential for each one of us to significantly reduce our carbon emissions and reduce air pollution, without changing the distance travelled requires very minimal effort. The advantages in safer driving as well as saving you money are also obvious. If practicable we should also try to reduce the distance we drive by carpooling, not using our vehicles for short journeys, and planning our journeys to reduce the number of trips and to avoid congestion. Supporting public transport is also important especially in rural areas and in the suburbs to sustain their use. Urban air pollution from cars is a major problem globally, so avoiding town and city centres where possible is desirable, especially if you are driving a diesel vehicle. Individually we can make a difference to climate change and driving sustainably should be just one of our goals in achieving a safer and more sustainable world.

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