

THE EVOLUTION OF THE CAR

The image shows five overlapping cards, each representing a different car model. The cards are tilted and scattered on a dark asphalt road. The cards are:

- Toyota RAV4 (2007)**: A silver SUV, with a CO₂ emission of 0.02 g/km.
- Ford Fiesta Mk I (1976)**: A red hatchback.
- Volkswagen Golf 1.6D MkII (1987)**: A red hatchback.
- Mercedes 190 E 2.0 (1991)**: A silver sedan, with a CO₂ emission of 0 g/km.
- MINI Cooper (2007)**: A red hatchback, with a CO₂ emission of 0.012 g/km, HC of 0.044 g/km, and a fuel consumption of 129 mpg.
- Vauxhall Astra (2007)**: A red hatchback, with a CO₂ emission of 0.198 g/km and a fuel consumption of 226 mpg.





Summary

Cars have come a long way in the last 30 years. Air quality pollutants have been cut by more than 98 per cent. Fuel economy has improved and CO₂ emissions reduced, despite increases in vehicle weight. As for safety, new cars are crammed with kit to prevent accidents, not just limit their effects on occupants and pedestrians.

The Evolution of the Car, shows these aren't just idle claims. They are facts supported by comparisons of real models as they have evolved across the generations.

And, of course, evolution is dynamic. The motor industry, Europe's largest investor in R&D, is committed to developing technologies that will go even further on safety and sustainability. That's despite the challenges that come from an over-complicated regulatory framework and the ever-present threat of heavy-handed policy making.

Introduction

There is an old adage in the car industry that goes something like this. Thirty years ago the first thing a designer reached for was his pencil and paper. Today, it's a book of rules and regulations the size of War and Peace.

Tongue in cheek this may be, but it hides a truth about the increasing pressures on car makers as they develop new models and evolve current variants.

On the one hand, the industry is the largest investor in R&D in Europe (€20 bn or four per cent of turnover) creating safer, cleaner cars that appeal to customers and meet market demand at the right price.

On the other, there is the rise of regulation. According to SMMT, in 1996 there were 62 bundles of rules which define the template for a new car coming to market. In 2007 the number of these so-called 'type approval' regulations had risen 37 per cent to 85 in total.

It is true that rules like limits for exhaust pollutants in Euro engine standards have helped focus investment in engine and exhaust technology to reduce harmful emissions. Equally, safety rules on occupant and pedestrian protection have complemented investment in active safety systems like ABS and ESP, helping halve road fatalities in the UK since the early eighties, and cut pedestrian deaths by a factor of three.

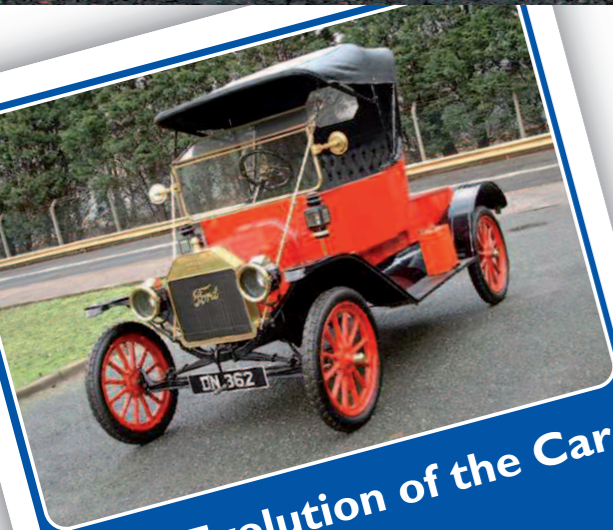
But as this report shows, these rules have consequences in other areas. More pollution abatement technology and safety systems have played a large part in creating larger, heavier (and less aerodynamic) cars.

For car makers it is proving increasingly difficult to balance these objectives - the need to reduce emissions, improve safety, give customers the comfort features they demand, keep prices down and all within the constraints of a competitive auto sector.

For example, experts have engineered more than 98 per cent of air quality pollutants like NO_x (oxides of nitrogen), CO (carbon monoxide) and HC (hydrocarbons) from tailpipe emissions in the last 30 years. Is it reasonable for regulators to impose ever tighter limits in a spiral of diminishing returns, at ever greater cost to manufacturers?

Can the European industry absorb the cost of meeting proposed CO₂ reduction targets, that some independent sources suggest could add an average of €3650 to the price of a new car? Would consumers be willing to pay?

This report does not suggest that we are at the end of the line, or that the industry is unwilling to make further progress. Far from it. Investment will continue to bring



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TOP JUMPS

A progress report
from car makers

air quality, fuel economy and safety benefits to new cars of the future. However, it is important that we place a stick in the sand and emphasise the following points:

- The industry has come a long way on safety, emissions and fuel economy in the last 30 years, as the evolution of models in this report demonstrates.
- We must not allow policy makers to lose sight of the delicate balance between different aims in areas like safety and emissions – and the consequences that over-regulation in one area can bring in another (weight v fuel consumption and CO₂).
- The industry is not a soft target. The heavy hand of regulation could drive more car makers towards the brink of extinction, rather than to a bright and more sustainable future.

Methodology

Manufacturers were asked to select a pair of cars to compare in the *Evolution of the Car*. SMMT suggested that models should have a degree of lineage over the generations. For example, comparing a 1976 Ford Fiesta with a 2007 model of similar engine size and type, brings comparative figures that span five generations of the 'same' car.

Not all the model pairs offer exact like-for-like comparisons. For example, the 2007 VW Golf in this report has a slightly larger engine (1.9-litre diesel) compared to its Mk II equivalent (1.6-litre diesel). In name at least the Mercedes appears to be different, albeit the C 200 KOMPRESSOR is a direct descendent of the 190 E 2.0, to which it is compared here.

The Astra extends the principle of evolution slightly further - to the market place - where equivalent power output comes from a 2.0 litre petrol Astra GTE from 1990 and a current 1.9 turbo-diesel model.

Seven manufacturers responded with model pairs for inclusion in the report. They were asked to complete standard specification sheets supplied by SMMT. These included sections relating to emissions – both air quality pollutants and carbon dioxide – and to standard safety equipment, active and passive.

Ford and Vauxhall offered to supply data for early Mk II Astra and Mk I Fiesta variants, but emission figures were not available. However, the manufacturers kindly agreed to have these models tested separately at Millbrook Proving Ground in Bedfordshire.

In the week beginning 27 August 2007, tests were undertaken in accordance with procedures set out in 2007 type approval rules. This allowed an accurate like-for-like comparison between older models and the latest Ford and Vauxhall variants which would also have been tested to this schedule.

For other older models in the report, for example those supplied by BMW and Toyota, official figures were taken from type approval tests applied at the time of Euro I and II emission standards (see notes at end of this report for Euro timeline).

The data was subsequently collated by the SMMT communications team.

Key findings

The evolution of the car over successive generations has been characterised by greener, safer products.

On emissions, the data reveals air quality exhaust gases are now a fraction of what they once were. For example the modern Fiesta emits less than two per cent of the air quality emissions of its 30 year-old counterpart. The 2007 VW Golf 1.9 TDI produces nearly 73 per cent fewer particulates from the tailpipe than its 20 year old cousin. The 2007 RAV4 has cut NOx from 0.14 g/km to just 0.02 across one generation.

Fuel consumption has improved in every pair compared, despite some very clear weight penalties. For example, the Mercedes is 26 per cent heavier, yet uses 17 per cent less fuel; the RAV4 is 20 per cent heavier using 12 per cent less fuel and the Astra 29 per cent weightier, using 34 per cent less fuel on the urban cycle. From first to second-generation, the new MINI had improved mpg by 24 per cent.

As you'd expect latest variants are crammed with passive and active safety systems too. Passive safety systems include examples like side impact beams, crumple zones, seat belt pre-tensioners and airbags - technologies to mitigate the severity of an impact on occupants and pedestrians. Active safety technologies

are designed to prevent an accident taking place, like ABS (anti-lock brakes) and ESC (electronic stability control).

Almost all new cars sold in the UK (not just those in this report) are now fitted with ABS as standard, a voluntary move taken by the industry in 2004. Each example in this report also features at least two air bags and seat-belt pre-tensioners as standard, while ESP is standard on five of the cars and available as an option on the other two.

That's just the start. Latest models boast a host of additional safety features. Among those featured here are energy-absorbing steering columns, curtain air-bags, ISOFIX mountings, active head restraints, parking sensors, lane-departure warnings and adaptive headlamps.

And this is by no means an exhaustive list.

So let's take a look at some of these changes in emissions and safety, as cars have evolved over the last three decades, using real models and real data.

Ford Fiesta 1.0 (1976) v Ford Fiesta 1.25 Sigma (2007)

The Ford Fiesta is one of the most popular and enduring small cars on the market. It is one of only five cars that have topped the best-sellers list in the UK since 1965, hitting the top spot in 1990 and 1991 and from 1996 to 1998. Last year it took the number three slot, selling more than 100,000 units.

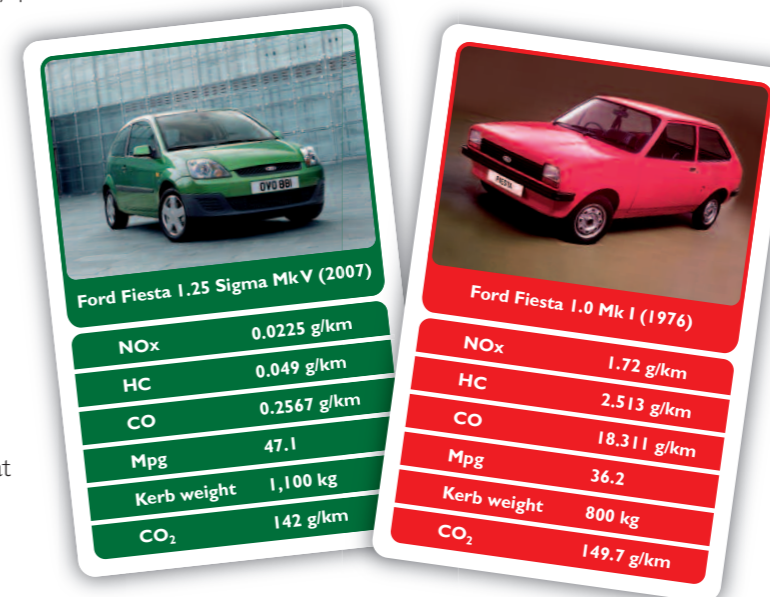
Ford Fiestas were manufactured at the Dagenham plant in Essex, from 1976 (the year of its introduction) to 2002. More than 2.7 million Fiestas, and 10.9 million cars in total, were made at the plant from 1931 to 2002. Dagenham is now Ford's global centre of diesel engine development and production. One of Dagenham's two assembly plants is entirely self sufficient, thanks to two on-site wind turbines.

For the purpose of this report a 1.25 litre 2007 petrol variant was compared to a 1-litre 1976 petrol Fiesta, since the 1.25 is the smallest petrol engine now fitted to the car. Emissions for the 1976 variant were ascertained during tests at Millbrook.

Key indicators:

The 2007 Fiesta emits less than two per cent of the NOx, HC and CO emissions of its 1976 predecessor. In fact, SMMT has calculated that it would take the following number of 1.25 petrol-engined Fiestas to generate the same level of emissions as one 1976 Fiesta model:

- On nitrogen dioxide – 76 cars**
- On carbon monoxide – 71 cars**
- On hydrocarbons – 51 cars**



VW Golf 1.6 D (1987) v VW Golf 1.9 D (2007)

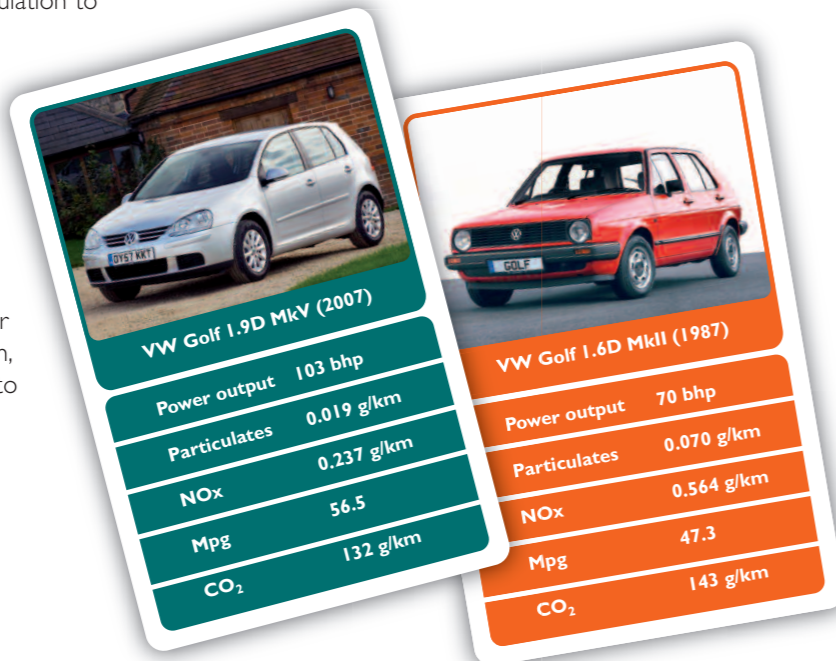
Since 1974, VW has produced more than 25 million examples of the Golf at its Wolfsburg factory in Germany. Last year alone 716,000 models were sold worldwide.

The 2007 model featured in this report has a slightly larger diesel engine than the 1987 predecessor to which it is compared. It is also fitted with DPF (diesel particulate filter) and benefits from exhaust gas recirculation to improve efficiency and cut tailpipe emissions.

Yet even greater efficiencies are promised in 2008 when a BlueMotion diesel variant of the Golf comes to market. Following the introduction of a sub-100 g/km BlueMotion Polo model, this new Golf will take CO₂ of the current car featured here down to just 119 g/km, NO_x to just 0.237 and particulates to 0.017 g/km.

Key indicators:

Power output - up 47%
 Fuel efficiency - improved 19.4%
 Particulates - down 72.8%
 NO_x emissions - down 58%



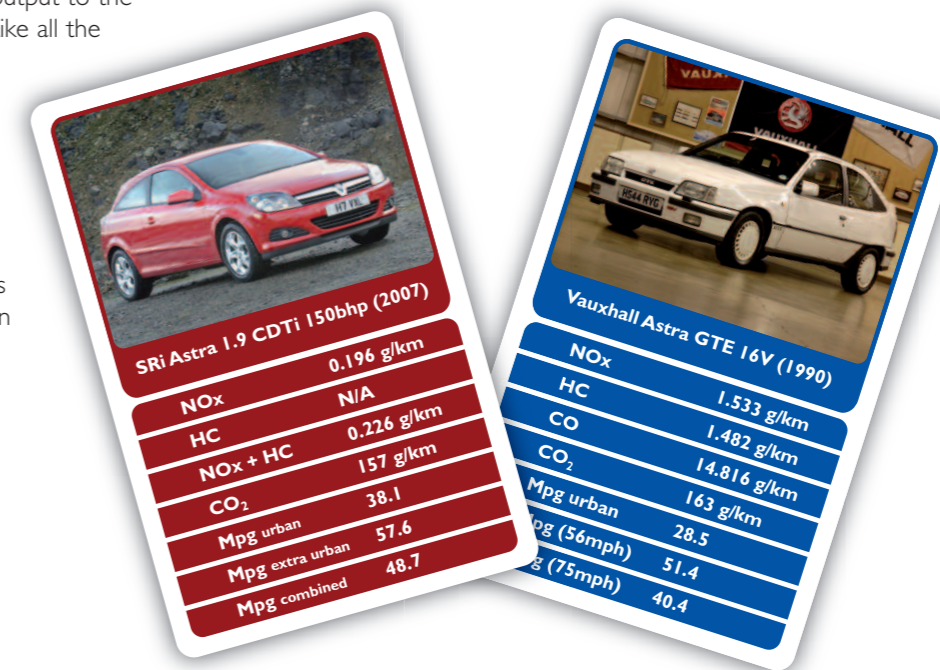
Vauxhall Astra GTE (1990) v SRi Astra 1.9 CDTi 150bhp (2007)

Is it reasonable to compare models with different engine types in a report that compares the evolution of the car over generations? Most definitely, if you look at market trends, particularly over the last seven years where sales of diesel cars have trebled in the UK. Modern diesel cars have become the vehicles of choice for many customers, boasting sophisticated, quiet engines, capable of strong on-road performance.

The original Astra GTE has a 2.0-litre petrol engine, with equivalent power output to the current 1.9-litre diesel. Like all the models in this report, the 2007 Astra is significantly heavier at 1,343 kg compared to 1,042 kg, thanks to a host of safety and comfort features as standard, yet still delivers stronger performance on fuel consumption and emissions.

Key indicators:

NO_x emissions – down 87.2%
 Combined NO_x and HC – down 92.5%
 Weight – up 28.9%
 Fuel consumption in urban use – down 33.7%
 ABS, ESP, Brake force distribution, six airbags and ISOFIX as standard



BMW 318i (1998) v (2007)

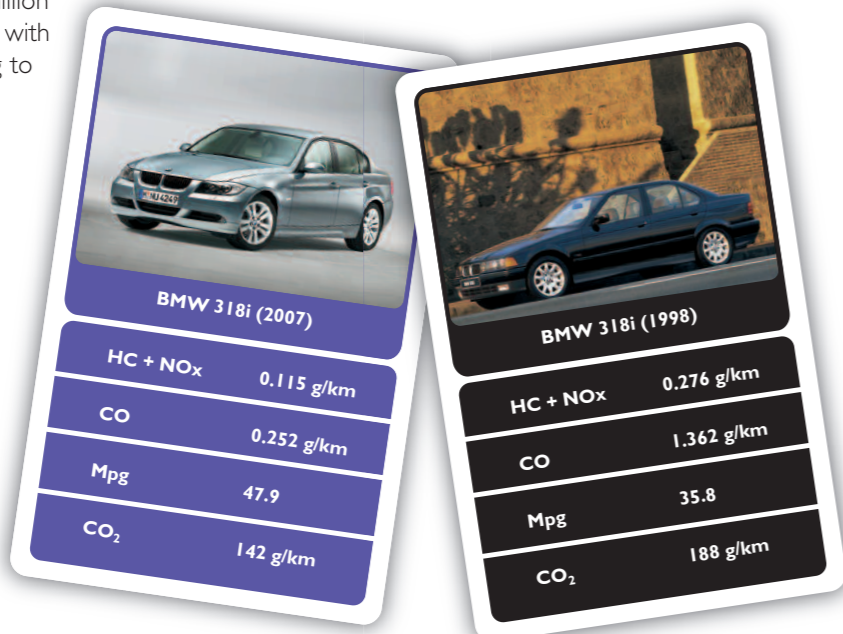
Strong DNA underpins the success of the BMW brand across the generations – in particular models like the best-selling 3 Series. Characteristics like rear-wheel-drive, double-kidney grille and C-pillar Hofmeister kink are just three examples of features that distinguish a BMW from other brands - and make the cars an aspiration for millions of driving enthusiasts.

BMW has been making the 3 Series since 1975. Over five generations, more than 10 million models have been produced with the latest E90 variant coming to market in 2005. The models compared here are a 1998 variant and current models, spanning the third and fifth generations of the car.

Key indicators:

CO₂ emissions – down 24.5%
 Mpg – improved 33.8%
 CO – down 81.5%

Among standard features in new model: seat belt pre-tensioners, DSC (Dynamic Stability Control), parking sensors, climate control and six air bags as standard



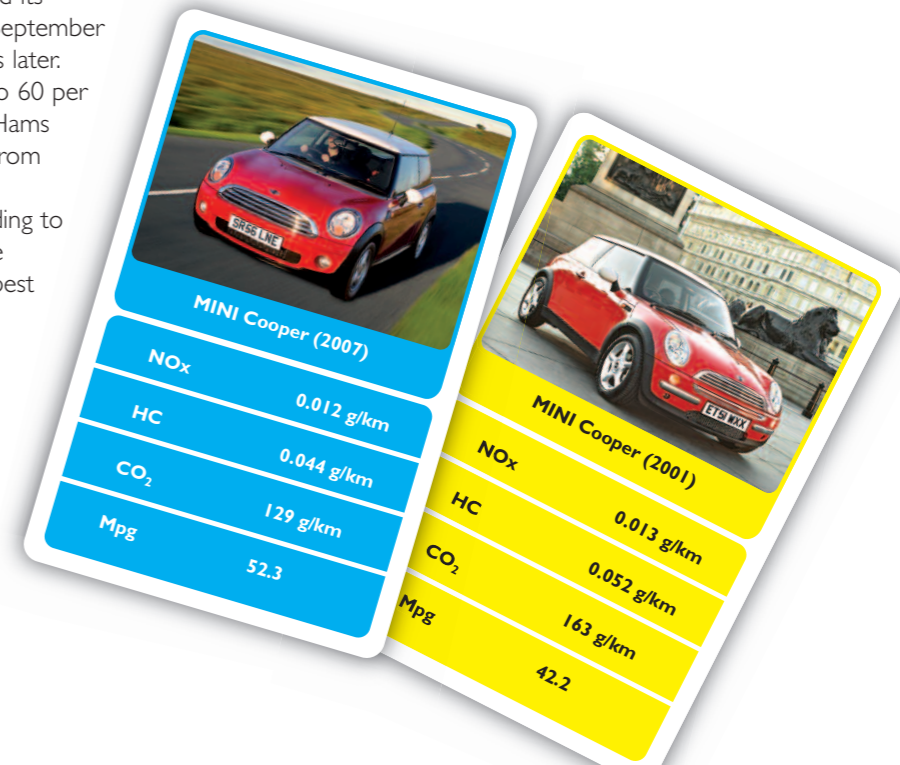
MINI Cooper (2001) v (2007)

Success stories don't come much bigger than the new MINI. Launched in 2001 to critical acclaim, the car quickly built a following among drivers of all types and ages. Built at Plant Oxford, more than a million models have been produced for world-wide distribution.

The second generation MINI started its journey down the Oxford lines in September 2006 and went on sale two months later. British-built content rose from 40 to 60 per cent, with engines supplied by the Hams Hall engine plant and body panels from Plant Swindon in what has become known as the MINI-triangle. According to a recent Lex report, MINI is still the volume model that holds its value best on the used market.

Key indicators:

Fuel efficiency – improved 24%
 CO₂ emissions – cut by 20.8%
 HC emissions – down 15.4%



Toyota RAV4 (1996 v 2007)

The Toyota RAV4 is the third best-selling SUV in the UK. The original model entered service in 1994 in petrol variant only. Despite the new model being 255 kg heavier than its replacement, its fuel efficiency has improved 11.6 per cent and CO₂ emissions have been cut by 13.7 per cent.

In this report, petrol has been compared with petrol for consistency. However, the vast majority of new RAV4 sales are of its diesel cousin. Over the first six months of 2007, 62 per cent of RAV4s registered as new were diesel, and 38 per cent in petrol variant.

This reflects the 4x4 / SUV segment overall, where the diesel market makes up 75 per cent of total volumes. The 2.2-litre RAV4 diesel has CO₂ emissions of 173 g/km, just 6 g/km above the average of all new cars currently on the market. For more facts and figures on CO₂, download SMMT's New Car CO₂ Report – 2006 Market from the web site – www.smmt.co.uk

Key indicators:

- NO_x – down 86%
- CO – cut by 64%
- Weight – up 18%
- CO₂ – down 13.7%
- Mpg – improved 11.6%

Toyota RAV4 (2007)	Toyota RAV4 (1996)
NO _x 0.02 g/km	NO _x 0.14 g/km
CO 0.27 g/km	CO 0.75 g/km
CO ₂ 202 g/km	CO ₂ 234 g/km
Mpg 32.8	Mpg 29.4

Mercedes 190 E 2.0 (1991) v C 200 KOMPRESSOR (2007)

Longer, taller, wider and heavier, but the 2007 model is 17 per cent more fuel efficient than its direct predecessor, thanks in no small part to investment in technology and the skill of Stuttgart's engineers.

But why are the car's dimensions so much larger? Well, its increased length (133mm) accommodates more advanced crumple zones and improved deformation to lessen injuries to pedestrians in a collision. It's wider (80mm) to house side impact protection and taller (72mm) because people are physically larger than they used to be!

That's before you come to the additional safety technologies like ABS, ESP and the award-winning PRE-SAFE® active safety systems, as well as seven airbags fitted to the latest model as standard. All of which add weight to a vehicle.

Key indicators:

The new model has 54 per cent more power, 43 per cent greater torque, is 133mm longer, 80 mm wider and 72 mm taller than its predecessor. It is also 26 per cent heavier.

Mercedes C 200 KOMPRESSOR (2007)	Mercedes 190 E 2.0 (1991)
Airbags 7	Airbags 0
Crumple zones yes	Crumple zones yes
Active head restraints front	Active head restraints no
Belt pre-tensioners four	Belt pre-tensioners no
ABS yes	ABS yes
Skid control yes	Skid control no
Brake assist yes	Brake assist no
PRE-SAFE® yes	

Regulated tailpipe emissions – a timeline

Since the introduction of mandatory air quality standards in 1992, car makers have faced ever-tighter limits on air quality emissions for hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NOx) and diesel particulates (PM). These are known as Euro standards and the industry is currently working to Euro IV limits.

Only models capable of meeting targets, based on a series of emission tests, can be marketed in Europe. While this has of course helped drive down harmful

emissions, it has also meant significant changes to engine technologies and the fitting of exhaust gas abatement systems.

In the past this meant fitting catalytic converters and reconfiguring engine design to include variable valve timing and exhaust gas recirculation. To meet PM limits in the forthcoming Euro V standard, particulate traps will now need to be fitted to new diesel cars, adding further weight and cost.

Euro standard timeline (cars not exceeding 2.5 tonnes laden)

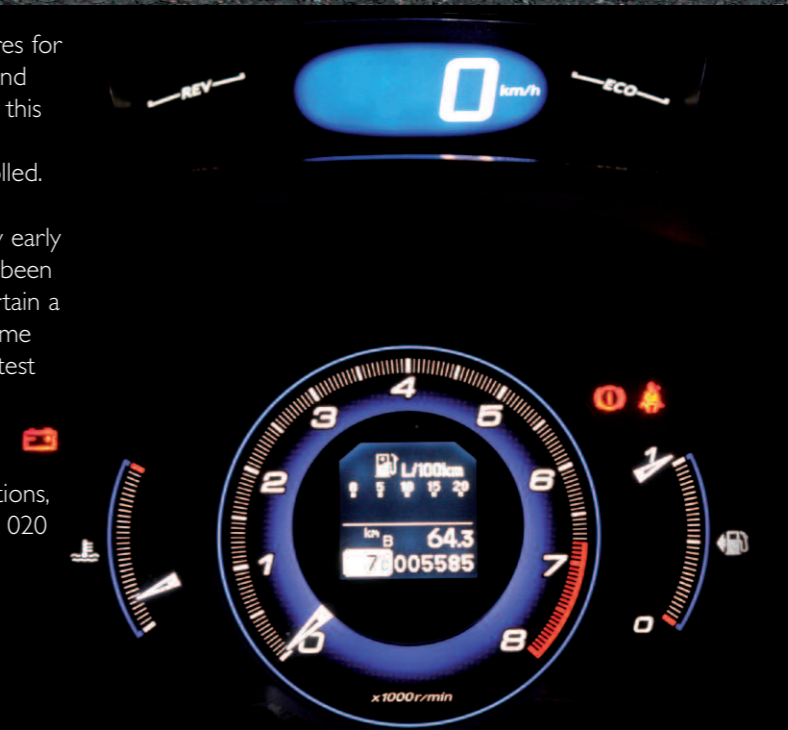
Standard		Petrol(P)	Diesel(D)	P	D	P	D	P	D	P	D
		HC+NOx	HC+NOx	HC	HC	NOx	NOx	PM	PM	CO	CO
Euro I	1992	1.13	1.13	-	-	-	-	-	0.18	3.16	3.16
Euro II	1996	0.5	0.7	-	-	-	-	-	0.08	2.2	1.0
Euro III	2000	-	0.56	0.2	-	0.15	0.5	-	0.05	2.3	0.64
Euro IV	2005	-	0.3	0.1	-	0.08	0.25	-	0.025	1.0	0.5
Euro V	2009	-	0.23	0.1	-	0.06	0.18	-	0.005	1.0	0.5

HC – Hydrocarbon NOx – Oxides of nitrogen PM – Particulates CO – Carbon monoxide P – Petrol variants D – Diesel variants

It is also worth noting that emission test procedures for Euro III and Euro IV were not identical to Euro I and Euro II type-approved cars. According to the VCA this results in some emission levels having an apparent increase when in fact they are more tightly controlled.

We should also be clear that while latest and very early model variants (Fiesta / Astra) in this report have been tested according to the latest test criteria to ascertain a true like-for-like comparison, figures quoted for some variants have been taken from data derived from test cycles applicable to Euro I and Euro II standards.

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