



FIA Foundation
for the Automobile and Society



EcoTest: superminis and small family cars



Testing and Assessment Protocol
including Results and Findings

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Testing and Assessment Protocol including Results and Findings

1. Introduction

This protocol has been developed by ADAC, with funding from the FIA Foundation.

The aim of the research is to provide consumer information on aspects of the environmental performance of popular car models in Europe. It is hoped that the publication of the EcoTest programme may help to raise awareness of the environmental choices available to motorists.

2. Testing Protocol

During all driving cycles the emissions of carbon monoxide (CO), carbon dioxide (CO₂), total hydrocarbons (HC), nitrogen oxides (NO_x) and particles (PM) are measured integrally. The fuel consumption is determined by the carbon containing emission components.

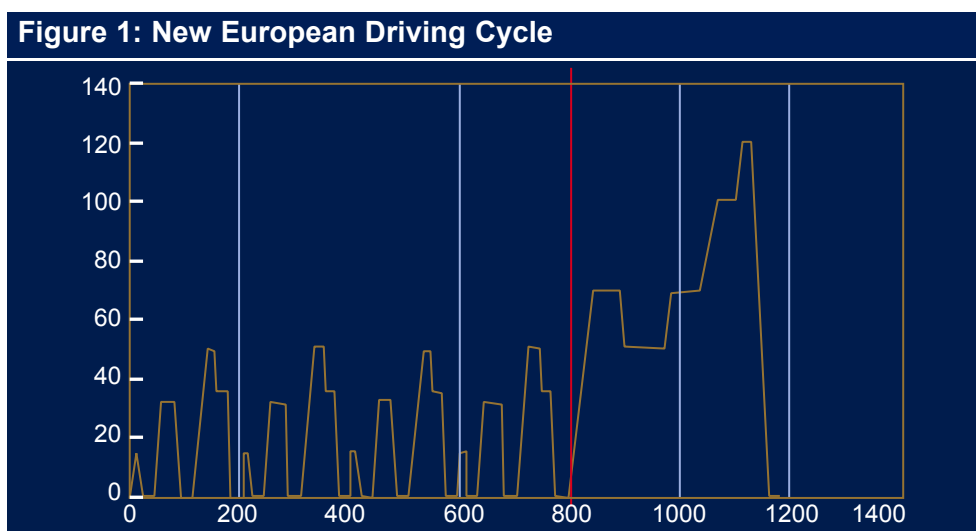
The road load (homologation values) is provided by the vehicle manufacturers.

2.1 New European Driving Cycle (NEDC)

The exhaust emissions are measured during the “New European Driving Cycle” (NEDC) according to directive 98/69/EC. The NEDC is shown in Figure 1.

The first part represents urban driving, in which a vehicle is started in the morning (after being parked all night - only in cold test) and driven in stop-and-go rush hour traffic. The second part represents extra-urban driving with a maximum speed of 120 km/h.

For all tests the adjustments are in accordance with directive 70/220/EWG.



2.1.1 NEDC Cold Test

This test is used to evaluate:

- pollutants
- CO₂
- fuel consumption

The vehicle's engine temperature is 22°C ± 2°C before starting the NEDC cold test. The soak time is at least 6 hours and maximum 30 hours.

This test cycle is to control the condition of the vehicles. Therefore the measured data will be compared with the manufacturer's specifications.

2.1.2 NEDC Hot Test

This test is used to evaluate:

- CO₂
- fuel consumption
- efficiency of air condition

For the NEDC hot test the vehicle oil temperature is approx. 90°C before starting the test procedure.

The temperature of the testing room is set to 22°C ± 2°C.

This test is carried out twice: first time with air conditioning on (air condition temperature set to 20°C), second time with air conditioning off. Normally for emission tests made after EU regulation all energy consuming aggregates such as air conditioning have to be switched off, but our hot test is intended to more closely replicate consumer behaviour.

To determine the EcoTest rating only one NEDC hot test is used.

Adjustment of Manually Controlled Air Condition

- A/C Button: on
- Temperature selector: about 20°C;
checked by temperature measurement
- Fan speed selector: 1/4
- Air flow selector: Floor/ Windshield; (alt.: Bi-level; the air flows both from the floor vents and the instrument panel vents.)

Adjustment of Automatically Controlled Air Condition

- A/C Button: on
- Temperature selector: 20°C
- Fan speed selector: AUTO
- Air flow selector: Floor/Windshield; (alt.: Bi-level; the air flows both from the floor vents and the instrument panel vents.)

2.2 Highway Driving Cycle

This test is used to evaluate:

- pollutants
- CO₂
- fuel consumption

This additional test is used to detect if the exhaust emission control system also performs well outside the EU homologation cycle NEDC.

For the highway test the vehicle oil temperature should be approx. 90°C before starting the test procedure.

Due to the fact that 130 km/h is the speed limit on highways in many European countries, the maximum speed in the highway driving cycle is limited to 130 km/h. In addition the highway cycle includes full-load acceleration.

The adjustment of the air conditioning for highway tests is similar to NEDC hot test with air conditioning on.

The highway driving cycle is shown in Figure 2. The ratings are based on Phase 1 and Phase 2 performance of the cycle.

3. Assessment Protocol

The EcoTest rating is calculated by the contributions of pollutants and CO₂ ratings. Each partial result is kept with one decimal for further calculation. Fuel consumption is also provided, as shown in Figure 3.

The EcoTest rating is calculated according to formula (1):

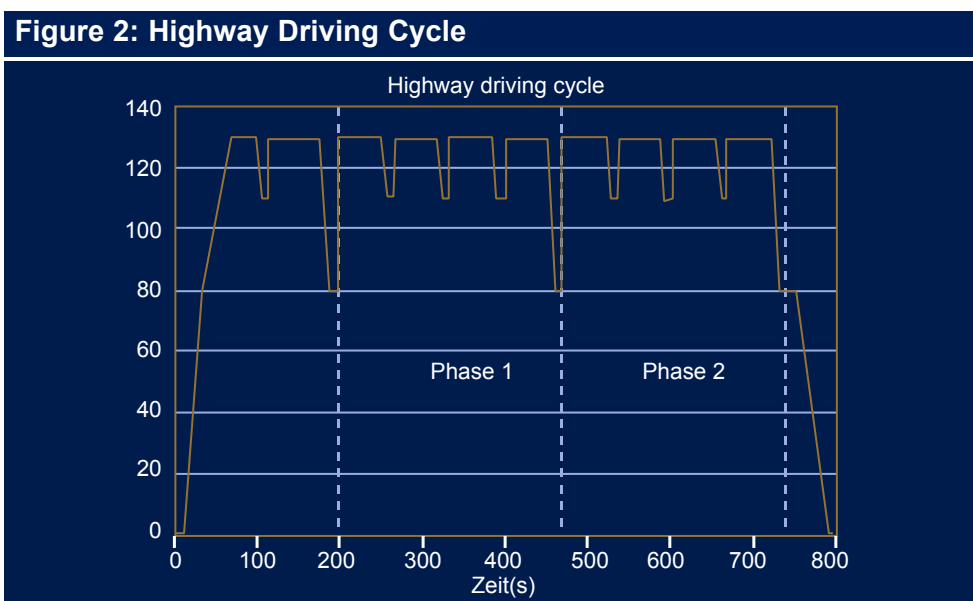
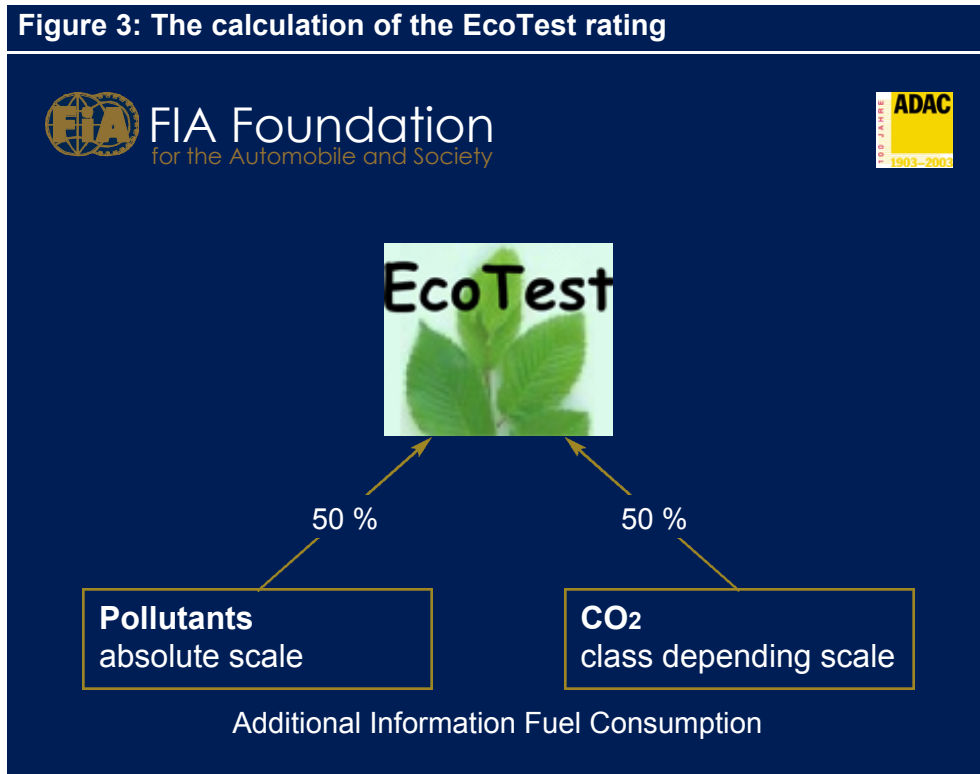


Figure 3: The calculation of the EcoTest rating



$$\text{Rating}_{\text{EcoTest}} = 0.5 \cdot \text{Rating}_{\text{pollutants}} + 0.5 \cdot \text{Rating}_{\text{CO}_2} \quad (1)$$

The EcoTest rating assesses the environmental impact of each tested car according to Figure 4. ★

Figure 4: EcoTest star rating

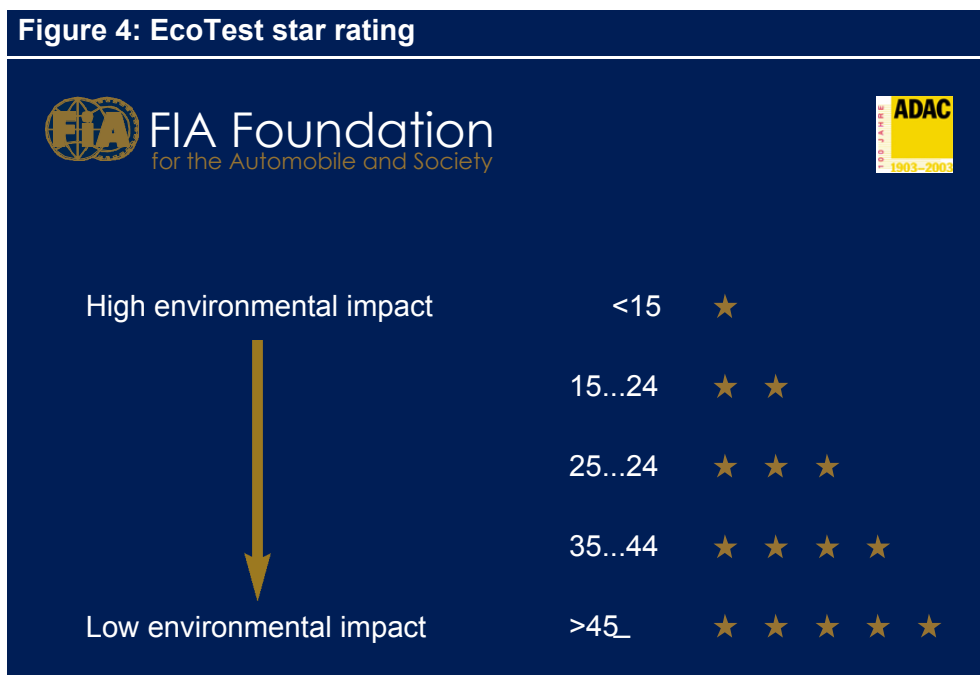


Table 1: Vehicle classes

ID	Vehicle class	Example
1	City (two seats)	Smart
2	City	Fiat Seicento, Peugeot 106, VW Lupo
3	Supermini	Fiat Punto, Peugeot 206, VW Polo
4	Small Family	Toyota Corolla, VW Golf
5	Family	BMW 3-series, Mazda 6, Opel Vectra, Toyota Avensis
6	Executive	Audi A6, BMW 5-series, Mercedes E-class, Peugeot 60
7	Luxury	Audi A8, BMW 7-series, Jaguar XJ, Mercedes S-class

The ratings for pollutants and CO₂ are calculated with the corresponding measured values on the base of dedicated scales.

For the rating of pollutants absolute scales are used, which are independent of the vehicle classes.

For the CO₂ rating relative scales based on the vehicle classes are used.

Table 1 shows the vehicle classes that are being used, together with examples of the type of vehicle in each class.

3.1 Pollution

The ratings are based on a linear scale system. The range is between two limits for each parameter, which represent the minimum and maximum rating, respectively.

The rating of the pollutants is calculated by contributions of the ratings of NEDC cold and highway. Although conventional Petrol engines, except direct injection systems, do not have particle emissions, the same rating formula (2) for Petrol and Diesel vehicles is used. The consequence is that Petrol vehicles (except direct injection engines) have the maximum rating for particles which influences the emission-result positively. This scheme is shown in Figure 5.

$$\begin{aligned}
 \text{Rating}_{\text{pollutants}} = & \quad (2) \\
 & 0.7 \cdot (0.6 \cdot \text{Rating}_{\text{NEDC cold PM}} + 0.4 \cdot \text{Rating}_{\text{NEDC cold worst case}}) \\
 & + 0.3 \cdot (0.4 \cdot \text{Rating}_{\text{Highway PM}} + 0.6 \cdot \text{Rating}_{\text{Highway worst case}})
 \end{aligned}$$

The weighting factors represent the driving frequencies in the different areas:
 70% := urban + extra urban
 30% := highway

For the emission value of each pollutant (CO, HC, NOx, PM) the ratings are calculated according to the thresholds given in Table 2.

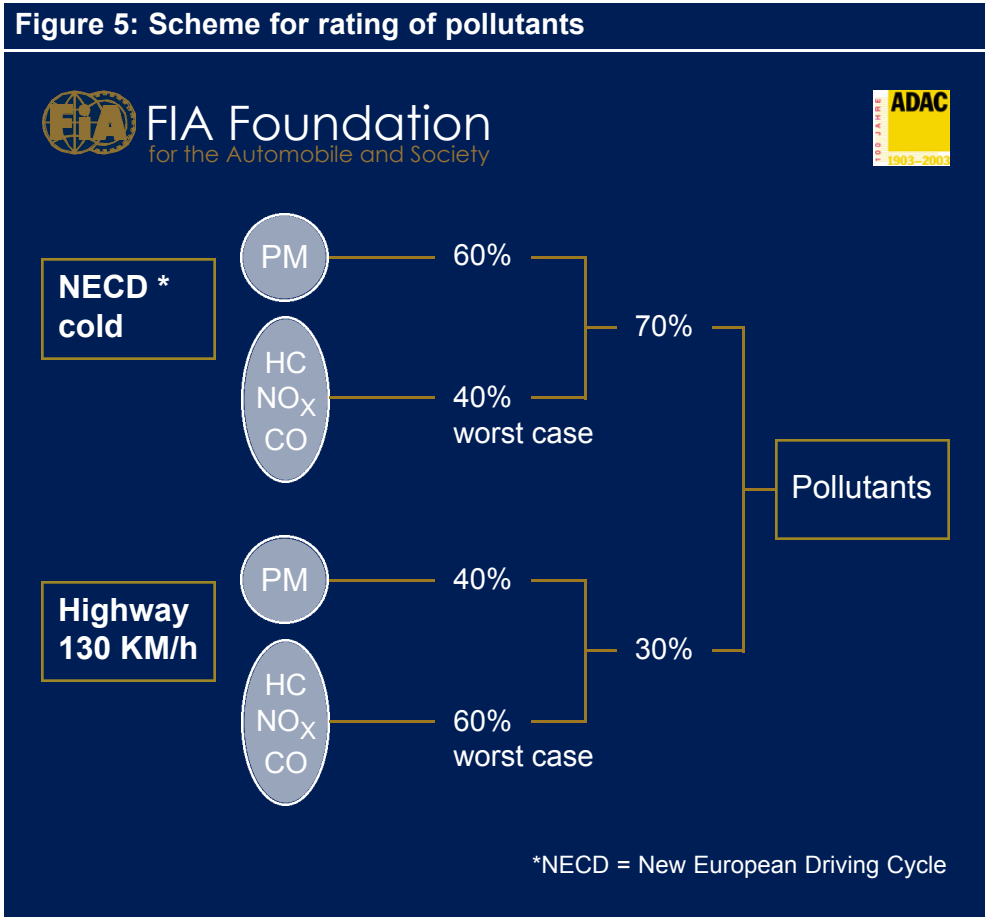


Table 2: Thresholds for pollutants during NEDC and highway cycle

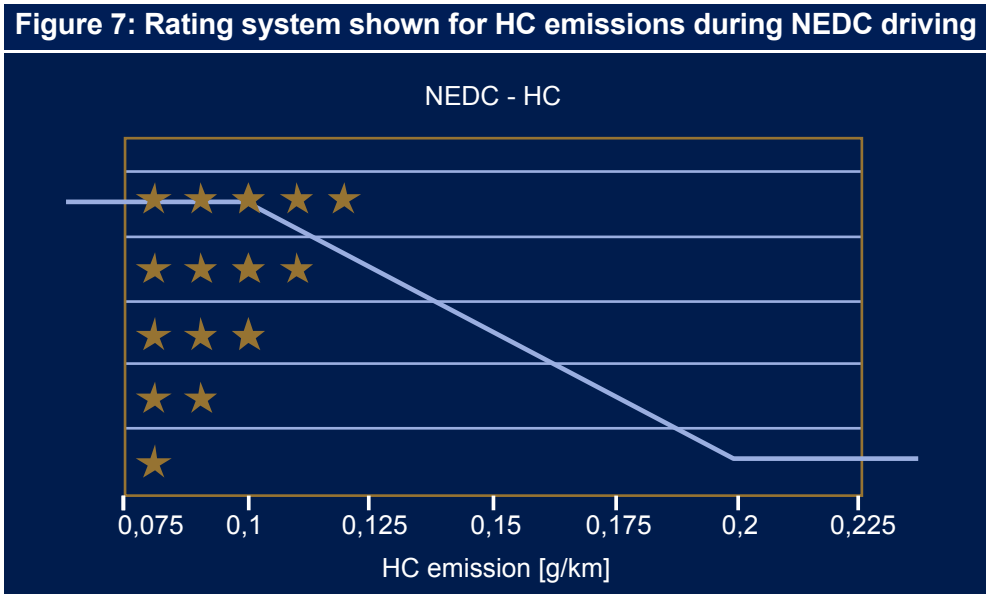
	NEDC		Highway	
	maximum at [g/km]	minimum at [g/km]	maximum at [g/km]	minimum at [g/km]
HC	0.10 ^a	0.20 ^c	0.10 ^a	0.20 ^d
CO	1.00 ^a	2.30 ^c	1.00 ^a	14.00 ^d
NO _x	0.08 ^a	0.50 ^b	0.08 ^a	1.00 ^d
PM	0.005	0.05 ^b	0.005	0.05 ^d

- ^a value according to directive 98/69/EC: Euro 4 Petrol NEDC
- ^b value according to directive 98/69/EC: Euro 3 Diesel NEDC
- ^c value according to directive 98/69/EC: Euro 3 Petrol NEDC
- ^d value according to state of the art

As an example the rating system for NEDC emissions of HC is given in Figure 7.

3.2 Carbon Dioxide CO2

The rating of CO2 is calculated by contributions of the NEDC cold, NEDC hot and highway results. The scheme is shown in Figure 6.



The rating of the CO2 emission is calculated according to a formula (3) using the thresholds given in Table 3.

$$\text{Rating}_{CO_2} = 0.7 \cdot (0.5 \cdot \text{Rating}_{\text{NEDC cold}} + 0.5 \cdot \text{Rating}_{\text{NEDC hot}}) + 0.3 \cdot \text{Rating}_{\text{Highway}} \quad (3)$$

$$0.7 \cdot (0.5 \cdot \text{Rating}_{\text{NEDC cold}} + 0.5 \cdot \text{Rating}_{\text{NEDC hot}}) + 0.3 \cdot \text{Rating}_{\text{Highway}}$$

The thresholds for the maximum rating include the potential of future engines. As a result the system will remain relevant for a long time period, enabling the test pro-gramme to show any technical progress.

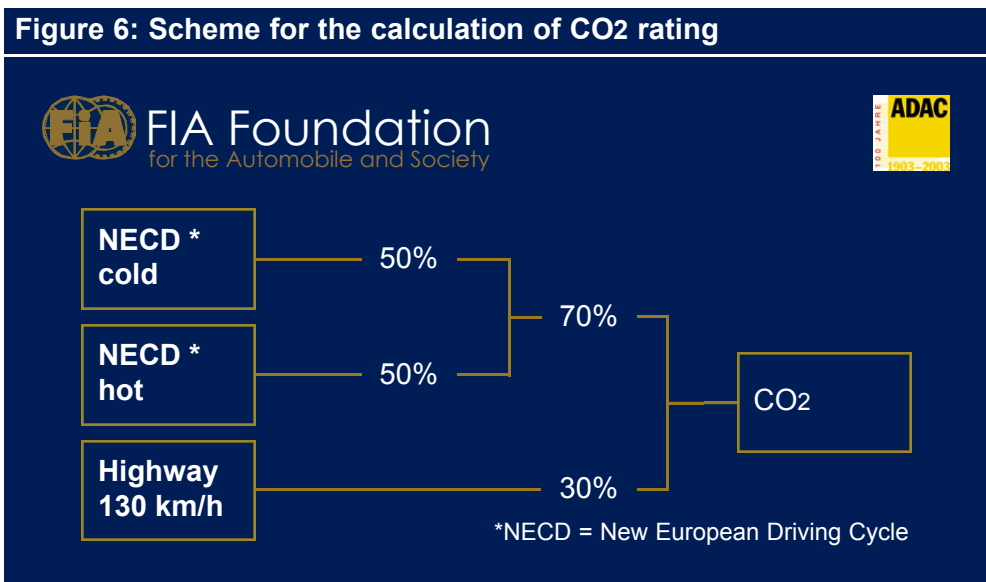


Table 3: Thresholds for CO2 emission rating

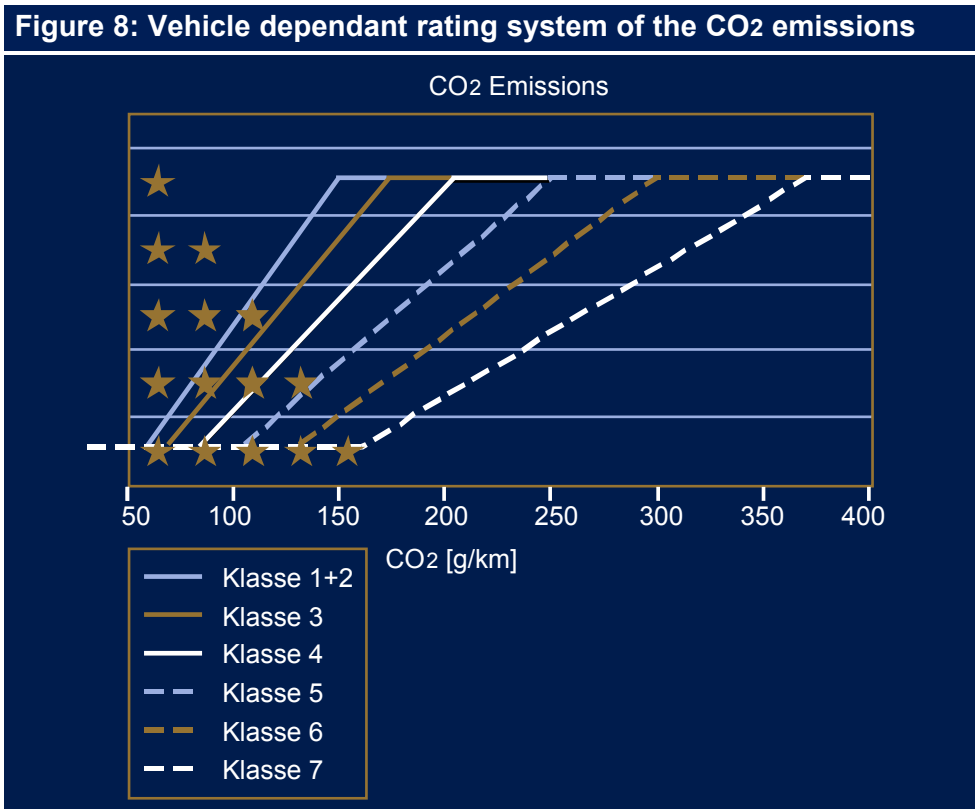
Vehicle class	Maximum at [g/km]	Minimum at [g/km]
1	60	150
2	60	150
3	70	175
4	85	205
5	105	250
6	130	300
7	160	370

Figure 8 shows the rating system for the given thresholds of CO2 emissions.

3.3 Fuel Consumption

The fuel consumption is calculated for the measured cycles. The NEDC is split up into urban and extra urban part. For each part the fuel consumption is determined separately. Furthermore for the highway cycle the fuel consumption is also measured.

The overall value is calculated including 30% highway driving and 70% NEDC driving. The separate values are given as usual in the ADAC Auto Test.



4. Results and Findings

To calculate the EcoTest rating, 22 cars with Petrol and 11 cars with Diesel engines have been measured to date. Seven Petrol cars and four of the Diesel cars belong to class 3 (supermini), the rest represents class 4 (small family cars) according to Table 1. The results are shown in Table 4 for class 3 and in Table 5 for class 4. The tables are sorted by the EcoTest Rating, starting with the best.

The selection of the tested cars is based on the European market share of the car model. For each particular model different engines were chosen: the version with biggest market share and the version with the lowest fuel consumption according to the recommendation of the manufacturer. This system was carried out – if available – for each Petrol and Diesel engine.

As an example the Ford Focus was tested with four different engines: Ford Focus 1.6 Turnier and Ford Focus 1,8 TDDI (66 kW) have the biggest market share as the particular Petrol and Diesel version. Ford Focus 1.4 and Ford Focus 1,8 TDDI (55 kW) are the announced versions with the lowest fuel consumption.

For some cars the model with the biggest market share and the lowest fuel consumption are identical (e.g. Golf 1.9 TDI, Mercedes A 140 Classic, Mazda 323 F 1.4). Some cars are not offered with Diesel engine (Nissan Almera 1.5, Honda Civic).

4.1 Rating Pollutants

The threshold for the rating of pollutants are the same for Diesel and Petrol engines. The maximum rating is achieved with Euro 4 Petrol values. This follows the point of view that emissions according to Euro 4 Petrol reduce air pollution to a standard which does not need a further improvement.

As most of the tested cars with Petrol engines fulfil Euro 4 regulations during NEDC cycle, these cars achieve high ratings for pollution (four and five pollution stars). The average values of Petrol engines in class 3 (47) and class 4 (46), means that 17 of the 22 tested Petrol cars gain five pollution stars.

The best rated Petrol cars (class 3: Opel Corsa 1.0 Eco, class 4: Toyota Prius 1.5 Hybrid) gain the maximum value of 50 points, which shows that not only during NEDC (homologation) cycle but also during the highway cycle Euro 4 thresholds are reached. For those Petrol cars with Euro 4 but less than 50 points problems with CO emissions higher than Euro 4 level (which had been set up for NEDC) during highway cycle lead to worse ratings. Particle emissions are no problem for Petrol engines, even for the direct injection engine of the VW Golf IV 1.6 FSI, according to current measuring procedure.

The worst performing Petrol engine on pollutants (class 4: Toyota Corolla Verso 1.6 with automated transmission) gains a pollution rating of 42, the best Diesel reaches 36 (VW Golf 1.9 TDI, class 4, four Pollution stars). This car is the only tested Diesel which achieves Euro 3 D4 regulations.

The only car which provides a Diesel filter is the Peugeot 307 HDI FAP. Although it does not fulfil Euro 4 regulations (NOx pollution is too high) it achieves with 35 points (four stars) the second best result of all Diesel cars.

The difference in class 3 is even higher: The worst Petrol car concerning pollution (Peugeot 206 1.1 Filou 60, 43 points, four Pollution stars) gains 15 points more than the best Diesel within this class (Audi A2 1.4 TDI, 28 points, three Pollution stars). The average rating for pollution of the tested cars with an Petrol engine (46) is almost twice as good as the pollution rating of the Diesel cars (24). This shows the present problem, but also the potential of the development of Diesel engines for reducing pollution. Ratings are low mainly as a result of high NOx emissions, but also because of PM emissions. The lowest pollution rating of all Diesel cars is only 20 points (Mercedes A170 CDI Classic, class 4, two Pollution stars).

The introduction of particle filters and NOx catalytic converters should equalise Diesel and Petrol emissions.

Table 4: EcoTest results of the tested class 3 cars – superminis

Vehicle petrol	Emissions class	Power [kW]	Fuel[l /100 km]	Rating Pollution	Rating CO2	EcoTest Rating
Opel Corsa 1,0 Eco (o. Klima)	Euro4	43	4,96 S	49,8 ★★★★★	39,3 ★★★★★	45 ★★★★★
Audi A2 1,6 FSI	Euro4	81	6,64 SP	49,2 ★★★★★	26,2 ★★★	38 ★★★★★
Nissan Micra 1,2 visia	Euro4	48	6,53 S	47,0 ★★★★★	27,8 ★★★	37 ★★★★★
Peugeot 206 1,1 Filou 60	Euro3	44	6,34 S	42,8 ★★★★★	29,0 ★★★	36 ★★★★★
Seat Ibiza 1,2 Signo	Euro4	47	6,87 S	44,6 ★★★★★	25,8 ★★★	35 ★★★★★
Mini 1,6 One	Euro4	66	7,52 S	47,8 ★★★★★	19,5 ★★	34 ★★★★★
Kia Rio 1,5 LS	Euro3	71	7,69 N	46,0 ★★★★★	18,7 ★★	32 ★★★★★
Audi A2 1,4 TDI	Euro3	55	4,70 D	27,5 ★★★	36,7 ★★★★★	32 ★★★★★
Opel Corsa 1,7 dTi	Euro3	55	5,04 D	28,5 ★★★	33,7 ★★★	31 ★★★★★
Peugeot 206 HDI eco 70	Euro3	50	4,95 D	25,5 ★★★	34,5 ★★★	30 ★★★★★
Fortd Fiesta 1,4 TDCi Ghia	Euro3	50	5,38 D	21,0 ★★	30,3 ★★★	26 ★★★★★

- D: Diesel
- S: Super
- SP: SuperPlus
- N: Normal

Table 5: EcoTest results of the tested class 4 cars: small family cars

Vehicle petrol	Emissions class	Power [kW]	Fuel[l /100 km]	Rating Pollution	Rating CO2	EcoTest Rating
Toyota Prius 1,5 Hybrid	Euro4	53	5,70 S	50,0 ★★★★★	33,2 ★★★	42 ★★★★★
VW Golf IV 1,6 FSI	Euro4	81	6,46 SP	48,6 ★★★★★	27,6 ★★★	38 ★★★★★
Opel Astra 1,2	Euro4	55	6,95 S	48,8 ★★★★★	23,8 ★★	36 ★★★★★
Ford Focus 1,4	Euro4	55	6,86 S	47,1 ★★★★★	25,0 ★★★	36 ★★★★★
Mercedes A140 Classic	Euro4	60	7,23 S	48,5 ★★★★★	21,7 ★★	35 ★★★★★
Audi A3 1,6	Euro4	75	7,37 S	48,5 ★★★★★	20,5 ★★	34 ★★★
Honda Civic 1,6	Euro4	81	7,24 S	46,8 ★★★★★	21,9 ★★	34 ★★★
Renault Megane 1,6	Euro3	83	7,32 S	47,3 ★★★★★	21,3 ★★	34 ★★★
VW Golf IV 1,4	Euro4	55	7,25 S	46,4 ★★★★★	22,1 ★★	34 ★★★
Honda Civic 1,4	Euro4	66	7,24 S	45,7 ★★★★★	22,4 ★★	34 ★★★
Ford Focus 1,6 Turnier	Euro4	74	7,29 S	44,5 ★★★★★	22,3 ★★	33 ★★★
VW Golf 1,9 TDI	Euro3	74	5,64 D	36,4 ★★★★★	28,4 ★★★	32 ★★★
Opel Astra 1,6	Euro3	62	7,43 S	42,8 ★★★★★	21,7 ★★	32 ★★★
Nissan Almera 1,5	Euro4	72	7,71 S	43,6 ★★★★★	19,4 ★★	31 ★★★
Mazda 323F 1,6	Euro3	72	7,71 S	42,6 ★★★★★	19,5 ★★	31 ★★★
Peugeot 307 HDI FAP	Euro3	79	5,87 D	34,6 ★★★★★	26,4 ★★★	30 ★★★
Opel Astra ECO4 1,7DTI	Euro3	55	4,95 D	22,4 ★★	34,5 ★★★★★	28 ★★★
Mercedes A160 CDI Classic	Euro3	55	4,83 D	21,2 ★★	35,6 ★★★★★	28 ★★★
Toyota Corolla Verso 1,6 Autom	Euro3	81	8,39 S	41,6 ★★★★★	14,6 ★★	28 ★★★
Mercedes A170 CDI classic	Euro3	70	5,13 D	20,0 ★★	32,9 ★★★	26 ★★★
Ford Focus 1,8 TDDI 66kW	Euro3	66	5,63 D	20,8 ★★	31,7 ★★★	26 ★★★
Ford Focus 1,8 TDDI 55kW	Euro3	55	5,70 D	20,8 ★★	27,9 ★★★	24 ★★

D: Diesel
S: Super
SP: SuperPlus
N: Normal

4.2 Rating Carbon Dioxide CO2

The CO2 ratings of the Petrol cars show a wider range (15...39, two to four CO2 stars) than the pollutants. It has to be stated that the best rated car (Opel Corsa 1.0 Eco, CO2 rating 39, four stars) was tested without air conditioning, while all other cars were tested with air conditioning.

The second best (Toyota Prius 1.5 Hybrid, CO₂ rating 33) represents a different drive line concept. The Prius 1.5 Hybrid combines a Petrol engine with an electrical engine. The electronic control of the drive line decides whether to drive the car by Petrol engine, electrically or in combination of both, depending on the demand of the situation. During the test cycles the car's strategy decided the driving mode (Petrol, electrically or both).

Due to its automatic transmission the Toyota Corolla Verso 1.6 was awarded the worst CO₂ rating (15, just two stars).

The Diesel cars clearly have advantages in terms of CO₂ emissions. Their ratings are generally better than those of Petrol cars as indicated by the average values (Petrol: 24, Diesel: 32 points). Three cars (Audi A2 1.4 TDI in class 3, Opel Astra Eco 1,7 DTI, Mercedes A160 CDI Classic in class 4) achieve a four stars result. The worst Diesels for CO₂ emissions (Ford Focus 1,8 TDDI 55kW with 28 points, three stars) are still in the region of the best Petrol cars. Although Diesel fuel causes 15.4% more CO₂ emission than the same volume of Petrol the advantages in terms of fuel consumption (litre per 100 km) are obvious.

In the CO₂ rating of class 3 the best car is the Opel Corsa 1,0 Eco which achieves 39 points (four stars). The worst performing car is the Kia Rio 1,5 LS with only two stars (19 points). The Diesel cars are close together (Audi A2 1,4 TDI with 37 points, Ford Fiesta 1,4 TDCi Ghia with 30 points).

Within class 4 the Diesel cars are ahead of those with Petrol engine (except for the Toyota Prius which has already been described). The VW Golf 1.6 FSI (28 points) and the Ford Focus 1.4 (25 points) achieve a good scoring.

The best Diesel (Audi A2 1,4 TDI, 37 points, four stars) gains 2.5 times as much as the worst Petrol (Toyota Corolla Verso 1,6 wit automated transmission, 15 points, two stars).

4.3 EcoTest Star Rating

The range of the EcoTest rating goes from 28 to 45 (Petrol) and 24 to 32 (Diesel), respectively. This means a range from two EcoTest stars for the Ford Focus 1.8 TDDI (55 kW) up to five EcoTest stars for the Opel Corsa 1.0 Eco (no air condition-ing).

The mean values of the Petrol cars are higher (35 points) compared to Diesel (29) on the basis of the same weight for pollutants and CO₂. Class 3 cars achieve 34 points in average, a result which is only a little better than class 4 cars (32 points average).

Comparing the pairs of cars according to the guidelines for choosing the tested cars explained above (biggest market share compared to lowest fuel consumption) which are available at the moment a certain trend can be seen. For the Petrol engines four pairs can be compared: Ford Focus, Honda Civic, Opel Astra and VW Golf. Each of these cars provides a

similar or better EcoTest result for the “lower fuel consumption” version compared with the version with the biggest market share. The biggest difference is shown by the Golf models 1.4 and 1.6 FSI. The new direct injection technology provides higher power and less fuel consumption at the same time. This could be a trend for further development of Petrol engines.

Comparing two pairs of Diesel vehicles the result is not clear cut: Although the differences between “low fuel consumption” and “big market share” are small (two points) the situation is the same for the Mercedes A 160 CDI and A 170 CDI as for the Petrol versions: a better rating for the “low fuel consumption” model. The result is the other way around for the Ford Focus 1.8 TDDI comparing the 55 kW and the 66 kW version.

5. Summary

The EcoTest is intended to enable the assessment of the environmental impact of new cars based on measurements of pollutants and CO₂ emissions. A highway cycle and the influence of air conditioning have been introduced to the test protocol, in addition to the homologation cycle NEDC.

The results show a big advantage for Petrol engines concerning pollution, including particles. The Diesel engines show their potential with the CO₂ rating. The potential of Diesel following the introduction of new exhaust cleaning techniques is clear.

It can be expected that these positive developments would be reflected in improving EcoTest results over time.