Dieselgate: Who? What? How?

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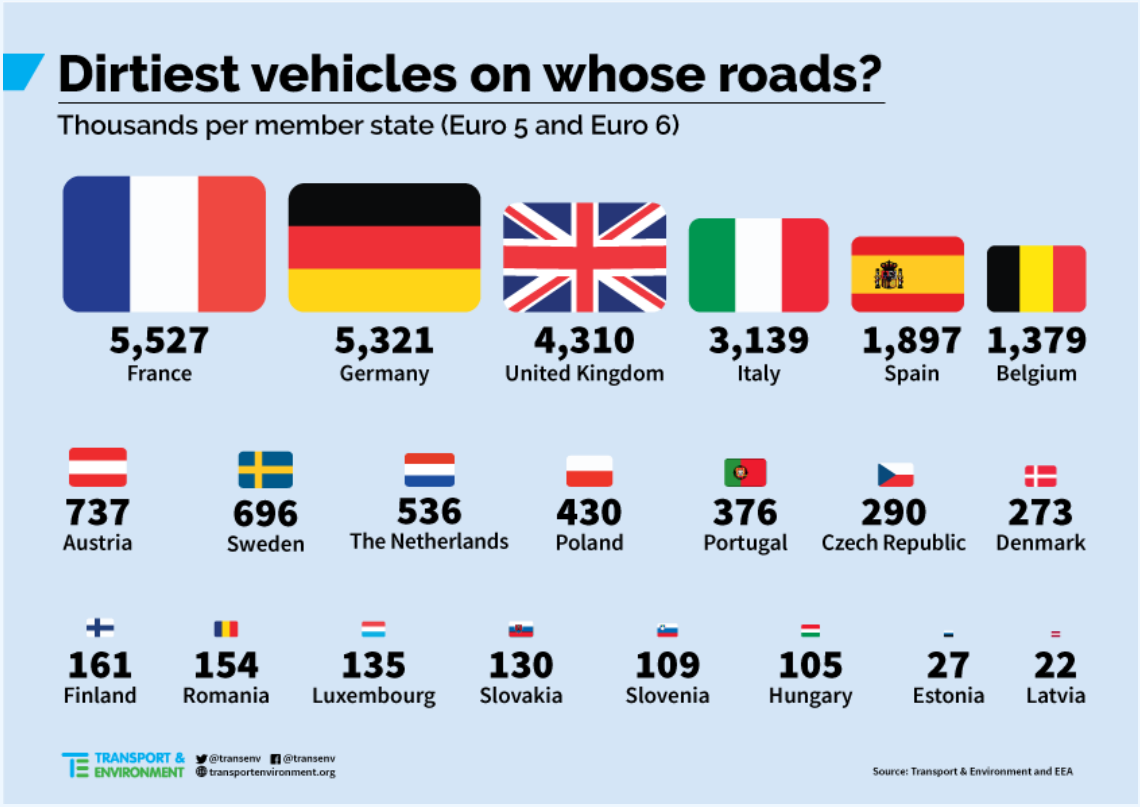
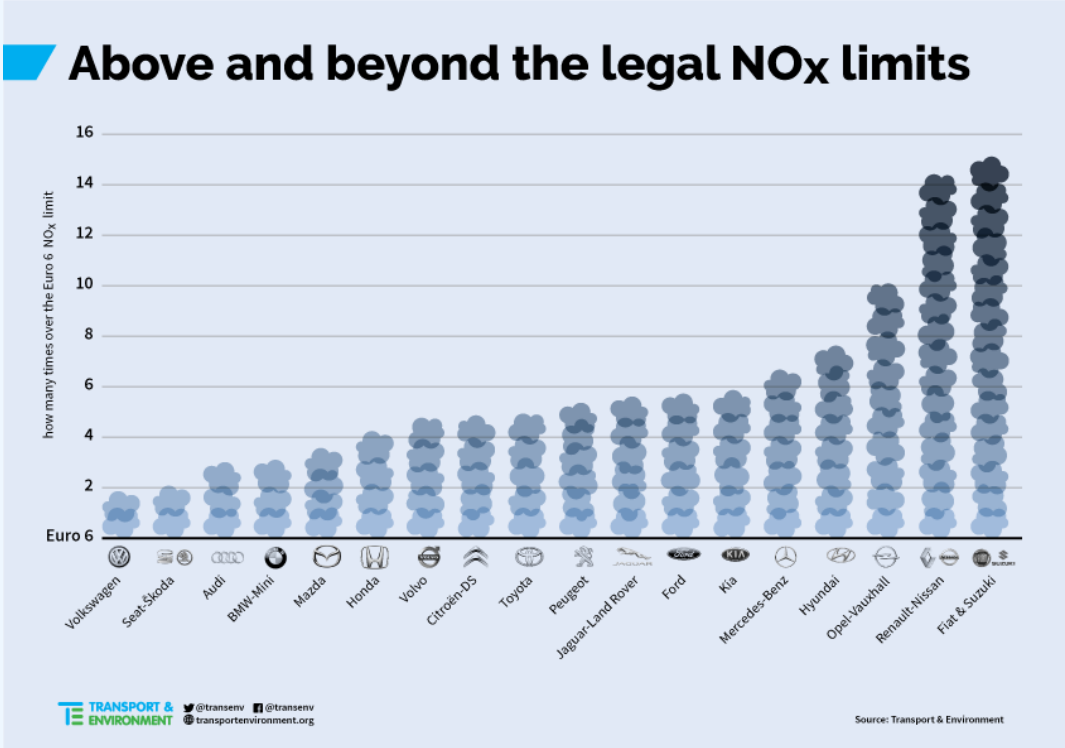
Executive Summary

This report, released on the first anniversary of the Dieselgate scandal, exposes the shocking number of dirty diesel cars on the EU's roads and the feeble regulation of cars by national authorities that have focused on protecting their own commercial interests or those of domestic carmakers. In the US, following the disclosure that VW had cheated emissions tests, justice has been swiftly and effectively delivered. This is in stark contrast to Europe where VW claims it has not acted illegally, no penalties have been levied and no compensation has been provided to customers. But the failure to penalize VW in Europe is the tip of the Dieselgate iceberg with an estimated 29 million grossly polluting modern diesel cars now in use, a number that is still growing. Over four in five cars that meet the Euro 5 standard for NOx in the laboratory (180g/1000km), and were sold between 2010-14, actually produce more than three times this level when driven on the road. Two-thirds of Euro 6 cars (most on sale since 2015) still produce more than three times the 80g/1000km limit when driven on the road. 69% of the dirty diesel cars were sold in France, Germany, Italy and the UK. These member states also approved most of the polluting diesel cars for sale.

	Estimated number of dirty diesel vehicles		Proportion of dirty vehicles of the total registered	
	Euro 5	*Euro 6*	*Euro 5*	*Euro 6*
Passenger Cars	21.4 million	4.7 million	82%	66%
Light Commercial Vehicles	2.2 million	0.7 million	62%	53%
Total	23.6 million	5.4 million	79%	64%



The manufacturers responsible for these vehicles include over: 4 million VWs; 3 million Renaults; 2 million Peugeot, Citroën, Mercedes and Audi cars.



In addition to estimating the absolute numbers of dirty diesels manufactured, the report identifies which are the worst companies in terms of the level of emissions. For Euro 5 vehicles, the five worst performing companies were (in order of the highest emissions): Renault (including Dacia); Land Rover, Hyundai, Opel/Vauxhall (including Chevrolet) and Nissan. The best performing Euro 5 cars were made by (in order of lowest emissions first): Seat, Honda, BMW (including Mini), Ford and Peugeot. For current Euro 6 cars a different pattern emerges. The worst performers are: Fiat (including Alfa Romeo + Suzuki (to whom Fiat supply engines); Renault (including Nissan, Dacia and Infiniti); Opel/Vauxhall; Hyundai; and Mercedes. Somewhat counter intuitively the company producing the cleanest Euro 6 cars is VW Group with VW cars the cleanest followed by Seat, Skoda and Audi; BMW (including Mini) and Mazda. However, this cannot be claimed as evidence of VW Group 'learning its lesson'; the group brought its Euro 6 cars to market ahead of the Dieselgate scandal being exposed. VW Group's Dieselgate engines were mostly of the previous Euro 5 generation.

Dirty diesel cars are failing to operate their exhaust after-treatment systems for most of the time the car is driving, almost certainly illegally misusing a loophole in the rules governing the use of Defeat Devices. This is done partially to improve official fuel economy figures but also due to doubts about the durability of the emissions treatment systems carmakers have chosen to use. The excessive nitrogen oxides emissions that result are the principal cause of the high levels of nitrogen dioxide in cities that lead to the premature death of 72,000 EU citizens annually.

The claim by carmakers that they are allowed to turn down the exhaust controls when the car is driven on the road and operate them fully during a test is a gross misrepresentation of the regulations and such a practice is almost certainly illegal. The regulations are clear that the emission control systems should work fully during vehicles' normal use. Carmakers are required to provide type approval authorities with information on the operating strategy of the exhaust treatment system. National type approval authorities have turned a blind eye to the use of defeat devices leading to such widespread health and environmental impacts. They have done this because there is regulatory capture. Carmakers "shop around" for the best offer from the regulators that compete among themselves for type approving business. Some, for example,

approval authorities KBA in Germany, CNRV in France and MIT in Italy, protect their national carmakers and shy away from scrutinising them too strictly. Others, like the VCA in the UK, RDW in the Netherlands or SNCH in Luxembourg see type approval as a lucrative business.

The figure shows which authority approved the 50 most polluting Euro 6 cars. It highlights that approvals are often done to support domestic manufacturers or as a business for the approval authority. This feeble system of approvals is exacerbated by technical services that are supposed to undertake tests but routinely only witness these in carmakers' own labs and are paid for their assistance. Sometimes the testing and approval organisations are even the same. Once the vehicle has been approved there is virtually no independent on-road checks to verify its performance in use due to a lack of will or resources.

Fixing the EU's failed system of vehicle approval and the resulting lethal air quality will involve a series of steps. Firstly there must be enforcement of defeat device legislation, including recall of cars. Cleaning up cars with illegal defeat devices will significantly improve air pollution in cities. If the member states will not act, the European Commission must bring infringement proceedings against countries that fail to enforce the law and coordinate an EU-wide recall programme. Secondly, there must be better tests and more of these. The new real-world driving emissions test is a step forward but details are still to be finalised and must be done quickly. Type approval tests must be complemented by far more in-service tests of cars on the road. Thirdly we need better regulators and independent oversight of their work. Regulators and testing organisations that fail to act in the public interest must be prevented from approving cars and distorting the single market. To assist with this, clearer and stronger regulations are required on both how to approve vehicles and detect defeat devices.

Ultimately Europe must end its diesel addiction. To do this diesel and petrol vehicle emissions limits should be equivalent, and member states should equalise taxes on diesel vehicles and fuel – the biases in favour of diesel must end. Electromobilty will ultimately solve the air pollution crisis in our cities; but the measures outlined in this report will make an important contribution to remediating the current problems in the short-term and also put the automotive industry on a more sustainable long-term path.

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1. The problem with diesel cars

Published on the first anniversary of the Dieselgate scandal, this report details the causes and effects of, and the solutions to, the high levels of nitrogen oxides emissions from diesel cars. On 18 September 2015 the US Environmental Protection Agency (US EPA) announced that Volkswagen Group (VWG) was breaching its federal emissions legislation by fitting illegal software (defeat device) to cheat emissions tests. The device recognised that a vehicle was undergoing a laboratory test and lowered the emissions of nitrogen oxides (NOx) so that the vehicle achieved the strict US regulatory limit. On the road, the same vehicle produced up to 40 times more NOx emissions. VW has since admitted that the company fitted the illegal software to 11 million vehicles worldwide; 8.5 million of which are in Europe (and 500,000 in the US).

In the US justice has been swift, and meaningful penalties have been applied to compensate for the harm done and to discourage similar practices by other carmakers in future. Customers are being compensated, cars are being fixed or bought back. In the US wrongdoing by the car industry is penalised and emissions legislation met. This is not a persecution of a European company by the US Government, this is the way that things are done. US companies have been sanctioned similarly by the US EPA for other breaches of regulations.[1]

The progress in the US is in stark contrast to the EU. The German regulator Kraftfahrt-Bundesamt (KBA) has required the voluntary recall of affected cars and has agreed a programme to remediate the emissions. But there is no transparency as to exactly how the recalls will be conducted, or what the effect of the changes will be on the emissions of NOx or CO2 or the drivability of the car. No penalties have been levied on the company; VW obstinately refuses to compensate its customers and opposes a suite of cases being bought against it.[2] The European regulatory system, based on a system of 28 national type approval authorities implementing EU vehicle emissions regulations, is failing and this report shows how and explains why regulators refuse to act and how the interests of the carmaker are prioritised above those of citizens and the law. Chapter 3 explains the steps needed to fix the problems and end the regulatory capture that pervades the system.

Over the last 12 months investigations in Europe (notably the testing programmes in Germany, France and the UK) have shown that the scandal engulfing VW represents the tip of an iceberg. Most carmakers systematically manipulate cars to pass emissions tests through highly questionable and probably illegal means. This results in performance that achieves regulatory limits in a lab but exceeds these by 10 times and more when the emissions are measured on the road. Such behaviour that has been going on for at least six years and probably longer. Regulatory limits for NOx emissions are also breached by a significant margin when tested in conditions even slightly divergent from those prescribed in the EU test protocol (NEDC).[3] The principal reason for such gross exceedances is that carmakers routinely switch-off technologies that clean up the exhaust when the car is driven on the road, and only operate these fully during the narrow conditions of the tests. This is partially to improve official fuel economy figures but is also due to questions about the durability of the emissions treatment systems carmakers have used – specifically exhaust gas recirculation systems that pump hot exhaust gases with a lower oxygen content back into the cylinders to lower production of NOx. Investigations have revealed that national testing authorities have failed to scrutinise the way in which these exhaust after-treatment systems operate (despite a legal requirement for them to do so) and for a decade have turned a blind eye on this unprecedented maltreatment of emissions regulations.

[1] US EPA database of infractions, https://www.epa.gov/enforcement/clean-air-act-vehicle-and-engine-enforcement-case-resolutions

[2] http://www.hausfeld.com/news/us/michael-hausfeld-appointed-to-plaintiffs-steering-committee-for-vw-emission

[3] Transport & Environment, https://www.transportenvironment.org/publications/dieselgate-continues-new-cheating-techniques

Coinciding with the first anniversary of the Dieselgate scandal, this report exposes – largely using the data from national investigations – the shocking non-compliance by light-duty vehicles (LDVs) with the EU NOx emissions regulations on the road. Chapter 2 analyses the latest data on the number of highly polluting vehicles in use and sheds light on the defeat strategies employed by carmakers.

1.1. Risks of NOx exposure

Air pollution in Europe is persistently above the levels that the World Health Organisation (WHO) considers to be harmful to human health. The health risks of nitrogen dioxide (NO_2) have been extensively studied in recent years. NO_2 is a dangerous toxic gas which, when breathed in high levels for a short period, causes a range of adverse respiratory effects including airway inflammation in healthy people and increased respiratory problems in people with asthma or other pre-existing respiratory conditions. Long-term exposure is linked to contributing to lung cancer. It is also linked with a range of other abnormalities in children.

The 2015 EEA figures[4] have for the first time put the number of premature deaths caused by NO2 exceedances across Europe at 72,000 annually. The US EPA has estimated[5] that the pollutant exceedances caused solely by VW on its 500,000 vehicles with illegal software in the US caused 59 premature deaths. It is difficult to extrapolate to the EU but this would suggest that the defeat devices employed just by VW Group vehicles in the EU would lead to more than 1,000 deaths. NO2 is also a major precursor of ozone and particulate matter (in the form of nitrate aerosol).

NO_2 is both emitted by vehicles and formed from the natural conversion of other nitrogen oxides (NOx) that are also produced during combustion. NOx emissions limits are regulated for vehicles through Euro Standards, and the overall amount permitted in the air is regulated through EU ambient air pollution standards. However, it is estimated that 8 to 27% of Europe's urban population lives in areas of harmful exceedance.[6] While background concentrations and industrial emissions of NOx have decreased by an estimated 30% since 2003, the measured NO_2 annual mean concentrations in the air of cities have not followed the same downward trend. The European Environmental Agency (EEA) attributes this primarily to increased NO2 emissions from diesel vehicles, which in real-world driving conditions fail to correspond to the regulatory reductions agreed in legislation.[7] In urban areas these vehicles are responsible for the majority of NOx emissions, for example, around half of all NOx emissions in London.[8] As a result, the European Commission has opened infringement procedures for NO2 limit exceedances against 12 EU member states: Austria, Belgium, Czech Republic, Denmark, Germany, France, Hungary, Italy, Poland, Portugal, Spain, and the UK.[9]

[4] European Environment Agency, http://www.eea.europa.eu/media/newsreleases/many-europeans-still-exposed-to-air-pollution-2015/premature-deaths-attributable-to-air-pollution

[5] *Science for Environment Policy*, http://ec.europa.eu/environment/integration/research/newsalert/pdf/emissions_from_2008_2015_vw_diesel_vehicles_fitted_with_defeat_devices_linked_to_59_premature%20deaths_444na1_en.pdf

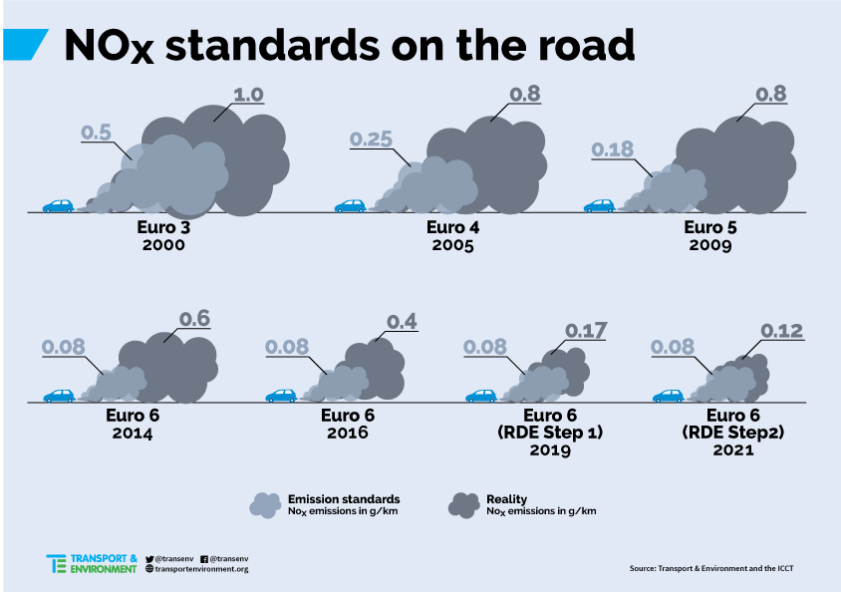
[6] European Environment Agency, http://www.eea.europa.eu/data-and-maps/indicators/exceedance-of-air-quality-limit-3/assessment-1

[7] European Environment Agency, http://www.eea.europa.eu/themes/air/national-emission-ceilings/nec-directive-reporting-status-2015

[8] Mayor of London, 2010, *Clearing the air: The Mayor's Air Quality Strategy*

[9] Commissioner Karmenu Vella, hearing with the European Parliament's enquiry committee into the Emission Measurements in the Automotive Sector (EMIS), 12 September 2016

1.2. Reasons for high levels of NO_2



NOx emissions from vehicles' exhaust have been regulated across Europe since the early 1990s when the first set of Euro emission standards was introduced. The latest Euro 6 limits that allow no more than 80 mg of NOx per km on the road were agreed back in 2007 and entered force in September 2014 for new types and in September 2015 for all new vehicles. But manufacturers have consistently failed to produce diesel cars that meet these limits on the road. The gap between test and real-world performance was a factor of 2 for Euro 3 vehicles; more than 3 times for Euro 4; more than 4 times for Euro 5. When Euro 6 vehicles first entered the market in 2014 they typically produced around 600mg/km of NOx or 7.5 times the 80mg/km limit. More recent models are better, typically 5.5 times the limit (440mg/km). However, some models' exceedances are over 10 times.

There are two principal causes for the failure to meet limits on the road. First, the laboratory test procedure used to measure the pollutant and CO2 emissions in Europe today is totally unrealistic and undemanding and in no way representative of real-world driving conditions. There are too many flexibilities and loopholes in the testing protocols that allow carmakers to game the system. Secondly, the Dieselgate scandal has exposed the widespread practice of disabling emission control technologies in many conditions when the car is driven on the road. Manufacturers claim that they are utilising a legitimate loophole in the legislation. Chapter 2 of this report explains why their behaviour is not only immoral but how carmakers are incorrectly claiming use of the legal loophole – meaning that their emissions management almost certainly does not comply with Euro 5 and 6 regulations. Millions of diesel cars and vans in the EU not only produce huge levels of harmful emissions but, critically, also fail to comply with emissions regulations.

Many, but not all of the problems with the obsolete testing procedure will be resolved with the introduction of the a new real-world driving emissions (RDE) test which will be used to verify compliance with NOx emission limits from September 2017 for new types and September 2019 for all new vehicles. But some details of the RDE test are not yet complete. Notably the test has to account for the high emissions when the engine and exhaust treatment system are cold and during regeneration of the diesel particulate filter. Further work is necessary to make the new test truly representative to effectively control emissions. Furthermore in 2019 new vehicles will be permitted to emit 168mg/km during the test, falling to 120mg/km by 2021. In practice the Euro 6 limit of 80mg/km passed in 2007 will still not fully apply 14 years later as a result of watering down by EU member states under pressure from carmakers.[10]

The RDE test is much better, but will only be effective if it is properly conducted and the results independently scrutinised. The current system fails to do this with tests conducted in manufacturers' own laboratories overseen by testing services contracted by the carmaker. The results are approved by one of 28 national type approval authorities (TAAs) that are paid by the carmakers, so they lack independence and there is no oversight of their work. The regulatory capture of the system of type approval is at the

[10] https://www.transportenvironment.org/press/governments-double-and-delay-air-pollution-limits-diesel-cars

heart of Dieselgate. Once a vehicle is approved the car can be sold EU-wide and only the authorising authority can remove the type approval or require the vehicle to be recalled. Carmakers "shop around" for the best offer from the regulators while the authorities compete among themselves for type approving business. Some, approval authorites like KBA in Germany, CNRV in France and MIT in Italy, protect their national carmakers and shy away from scrutinising them too strictly. Others, like the VCA in the UK, RDW in the Netherlands or SNCH in Luxembourg see type approval as a lucrative business that create a revenue stream and they again fail to be strict in order to maintain a flow of business and avoid upsetting their carmaker customers. All this results in a race to the bottom where carmakers choose authorities that let them pass the tests easily and where no one is overseeing the 28 TAAs to make sure they enforce the rules correctly.

The feeble system of approvals is exacerbated by the virtual absence of any clear separation of functions within the type approval system. In theory, national regulators (TAAs) should assign technical services (private companies like Dekra and TUeV Group) to carry out testing in their specialised labs to which carmakers should deliver representative vehicles. In practice, TAAs often act as both regulators and private testing services (and sometimes also as consultants to carmakers). Carmakers do most tests in their own laboratories with testing specialists "witnessing" the tests without executing them directly. Once the vehicle has been approved there is virtually no independent on-road checks to verify its performance in use due to a lack of will and resources.

In response to the Dieselgate scandal the European Commission has proposed the long-awaited reforms to vehicle approval in its Type Approval Framework Regulation (TAFR) proposed in January 2016. The reform is currently being negotiated and is expected to be finalised by the end of 2017. A tough negotiation is expected as the car industry seeks to protect its privileged relationship with national type approval authorities, and governments seek to protect either their car industries or approval agencies from effective scrutiny.

2. NO_x emissions from diesel cars

Transport & Environment has reanalysed NO_x emissions data from the national investigation reports prepared in France, Germany and the UK, and complemented this with additional information from Emissions Analytics (EA) EQUA Air Quality index[11] that grades the NO_x emissions from road tests EA has performed. In total, T&E has assembled a database of 541 tests of vehicle NO_x emissions and has extracted the evidence presented in this section to answer the following questions:

1. What are the dirtiest Diesel cars on the market today (Euro 6, sold since 2014)?
2. What are the dirtiest Diesels on the road today (Euro 5 cars sold between 2010 and 2015)?
3. How many dirty Diesel cars are on the road today?
4. How do manufacturers compare in their production of dirty Diesel cars?

2.1. What are the dirtiest new (Euro 6) diesel cars on the market today?

Previously[12], T&E identified 30 of the most polluting current (Euro 6) Diesel cars presently on sale in the EU highlighting this "Dirty 30". For this report, T&E has extended this analysis using the EQUA Air Quality Index results and has identified 52 (22 more) grossly polluting Euro 6 cars. Our analysis assesses the

[11] http://equaindex.com/equa-air-quality-index/
[12] https://www.transportenvironment.org/press/%E2%80%98dirty-30%E2%80%99-diesel-cars-mostly-approved-carmakers%E2%80%99-home-countries-%E2%80%93-report

suspect test results for each model and explains what these show about the use of potential illegal defeat devices on these vehicles, which cause much higher emissions when the car is on the road than when it is being tested. National investigations were screening exercises designed to identify models with anomalous emissions. The EQUA Air Quality Index results are road tests conducted using Portable Emissions Measurement Systems (PEMS). The tests were not capable of determining conclusively the presence of defeat devices. For suspect vehicles, more detailed follow up is required – but none is underway. To identify the most polluting Euro 6 diesel cars, T&E filtered the results in the database we have assembled to select the worst tests by using the following criteria:

- RDE NO_x emissions over 400 mg/km (meaning 5 times the Euro 6 limit);
- On track/road NO_x emissions over 160 mg/km (2 times the Euro 6 limit);
- Widest possible selection of vehicle brands and market segments to illustrate the fullest possible spectrum of emissions problems.

The list includes: five Mercedes-Benz; four BMWs, Fords, Hyundais and Renaults; three Opel/Vauxhalls and Volvos but most major manufacturers have at least one highly polluting model. The data is notable for the low number of Volkswagen Group Euro 6 vehicles. Of the 25 tests on 8 Volkswagen models conducted in national investigations, only the Golf 2.0 TDI failed 1 test according to our thresholds (x2.4 on an on road NEDC). EA tested 7 Volkswagen models and only 1 Polo 1.4 TDI failed to meet our criteria.

Full 'Dirty 50' list of Euro 6

Brand	Model	Engine	Country of approval	Most suspicious test(s)[13]	Possible defeat strategy to examine
Audi	A8	3.0 TDI	**DE**	7	**Thermal window (TW) + Test recognition (TR)**
BMW	2 Series GT	216d	**DE**	2 + 7	**TW + Hot restart (HR)**
	5 Series VI	530d		2	
	4 Series	420d		7	**TW**
	X3	xDrive20d			
Citroën	C4 Picasso II	1.6 BlueHDi	**FR**	4	**TW**
Dacia	Sandero II	1.5 dCi 66 kW	**FR**	1 + 2 + 3 + 7	**TW + HR**
Fiat	500X	1.6 MultiJet	**IT**	7	**TW**
		2.0 MultiJet		6	**Switch-off after 22 min**
Ford	C-Max II	1.5 TDCi 88 kW 2.0 TDCi 110 kW	**LU**	1 + 3 + 7	**TW + HR**
	Focus III	1.5 TDCi	**UK**	5 + 7	**TW + HR**
	Kuga II	2.0 TDCi	**LU**	4	**TW**
	Mondeo IV		**UK**	5 + 7	**TW + HR**
Honda	CR-V IV	1.6 i-DTEC 4WD	**UK**	4 + 5 + 7	**TW + HR**
	HR-V II		**BE**	3	**TW**
Hyundai	i20 II	1.1 CRDi	**UK**	1 + 3 + 7	**TW + HR**
	i30 II	1.6 CRDi		5	**TW + HR**
	i40	1.7 CRDi	**NL**	7	**TW**

[13] The tests are the following: Hot NEDC on road (1), hot NEDC in lab (2), hot NEDC in a lab at 10°C (3), NEDC on track (4), hot NEDC on track (5), independent tests done by DUH (6) and RDE (7).

	Santa Fe	2.2 CRDi	UK		
Infiniti	Q30	1.5d	UK	7	TW
Jaguar	XE	2.0d 120 kW	UK	1 + 5 + 7	TW + HR
Kia	Sportage III	1.7 CRDi	UK	5 + 7	TW + HR
Land Rover	Range Rover Evoque	2.0 TD4 132 kW	UK	1	TW + HR
Mazda	3 III	1.5d	DE	7	TW
	6 III	2.2d	UK	5	TW + HR
Mercedes-Benz	A Class III	A180d	DE	5 + 7	TW + HR
		A200d		4	TW
	C Class IV	C220d		1	TW + HR
	CLA Class	CLA200d		7	TW
	S Class VI	S350 Bluetec		1 + 2 + 3	TW + HR
	V Class III	V250d		1 + 2	TW + HR
Nissan	Qashqai II	1.6 dCi	FR	4	TW
Opel/Vauxhall	Mokka	1.6 CDTi	NL	4 + 5 + 7	TW + HR
	Zafira III	1.6 CDTi		1 + 3 + 4 + 7	TW + HR
	Insignia	2.0 CDTi	DE	1 + 3 + 5 + 7	TW + HR
Peugeot	3008	1.6 BlueHDi	FR	4 + 5 + 7	TW + HR
	5008	1.6 BlueHDi		4	TW
	508	2.0 BlueHDi			
Porsche	Macan	S Diesel	LU	1 + 3 + 7	TR + TW + HR
	Panamera	3.0 TD	LU	7	TW + TR
Renault	Captur	1.5 dCi 66 & 81 kW	FR	4	TW
	Mégane IV	1.5 dCi		7	TW + HR
	Kadjar	1.5 & 1.6 dCi		1 + 3 + 4 + 7	TW + HR
	Espace V	1.6 dCi		4 + 7	TW
Škoda	Octavia III	1.6 TDI	DE	5	TR + TW + HR
Ssangyong	Korando	220 e-XDi	ES	7	TW
	Rodius Turismo		NL		
Subaru	Forester	2.0D	LU	7	TW
Suzuki	Vitara IV	1.6 DDiS	NL	1 + 3 + 7	TW + HR
Toyota	Avensis III	2.0 D-4D	UK	5	TW + HR
Volkswagen	Polo	1.4 TDI	DE	7	TW + TR
Volvo	S60	D4	ES	7	TW
	V60	D3		1	TW + HR
	XC60	D5		7	TW

It is clear from the results that the 8.5 million Volkswagen vehicles affected by the Dieselgate scandal represent the tip of an iceberg of grossly polluting vehicles THAT IS STILL GROWING. Euro 6 cars are new models sold since this year and should represent the state of the art technology. Instead it is clear that many carmakers continue to use outdated and ineffective exhaust after-treatment systems on the cars in showrooms today. This includes premium manufacturers, e.g. Mercedes that uses a Renault engine in some smaller models. This is not a question of technology availability or unrealistic standards – there are models on the road today that achieve the emissions standards in normal use conditions:

- BMW 3 Series VI (318d), X5 III xDrive30d, X1 II xDrive20d, 2 Series (218d & 220d), 1 Series II (118d);
- Peugeot 208 1.6 BlueHDi, 308 II 2.0 BlueHDi;
- Citroën C4 Cactus 1.6 BlueHDi, DS5 1.6 BlueHDi;
- Ford Fiesta VI 1.5 TDCi, Ecosport 1.5 TDCi;
- Mercedes-Benz C Class IV (C200d);
- Mazda 2 IV 1.5d, CX-3 1.5d, CX-5 2.2d;
- Audi Q7 II 3.0 TDI;
- Volkswagen Golf Sportsvan (2.0 TDI).

Manufacturers also successfully sell diesel cars in the US where the emissions limits are about half the levels in the EU. There is no excuse for polluting dirty Euro 6 cars and vans.

2.2. What are the dirtiest (Euro 5) diesels on the road today?

T&E has performed a similar analysis to identify the most polluting diesel cars on the road today. To compile the list T&E filtered the results of 235 RDE test results and 65 on track/road NEDC test results and identified Euro 5 tests that met the following criteria:

- RDE NO_x emissions over 540 mg/km (meaning 3 times the Euro 5 limit);
- On track/road NO_x emissions over 360 mg/km (2 times the Euro 5 limit when repeated on NEDC test);
- Widest possible selection of vehicle brands and market segments to illustrate the fullest possible spectrum of emissions problems.

It is likely that Euro 4 and older vehicles still on the road are more polluting but very few emission test results of those are available. The evidence also suggests that the introduction of Euro 5 vehicles in 2009 did not lead to any material reduction in NO_x emissions on the road. Euro 5 vehicles are typically between 2 and 6 years old. The average lifetime of a car in the EU is around 17 years – these cars will therefore be in use producing excessive NO_x emissions for more than another decade – until after 2025. This will particularly affect countries in Central and Eastern Europe where older cars are usually driven for longer.

'Dirty 40' list of Euro 5

Brand	Model	Engine	Country of approval	Most suspicious tests[14]	Possible defeat strategy to examine
Alfa Romeo	Giulietta III	2.0 JTDm 110 kW	**IT**	1 + 2 + 3	**Hot Restart (HR) + Thermal Window (TW)**
Audi	A1	1.6 TDI 66 kW	**LU**	4	**TW + Test Recognition (TR)**
	A6 IV	2.0 TDI 150 kW	**DE**	1 + 3	**HR + TW + TR**
Citroën	C3 II	1.4 HDi 51 kW	**FR**	4	**TW**
	C4 II	1.6 HDi 85 kW		5	**HR + TW**
	C4 Picasso II	1.6 HDi 85 kW		4	**TW**

[14] The tests examined are: **Test 1** - hot NEDC on road, **Test 2** - hot NEDC in lab, **Test 3** - hot NEDC in lab at 10°C, **Test 4** - NEDC on track, **Test 5** - hot NEDC on track (NEDC is New European Driving Cycle that is used to check compliance with EU emissions (CO2 + air quality) legislation in Europe).

	C5 II	2.0 HDi 103 kW		4	**TW**
Dacia	Duster	1.5 dCi 81 kW	**FR**	4	**TW**
Fiat	Panda III	1.3 MultiJet	**IT**	1 + 2	**HR + TW**
Ford	Focus III	1.6 TDCi 85 kW	**UK**	4	**TW**
		2.0 TDCi 103 kW		1	**HR + TW**
	Mondeo	2.0 TDCi		5	**HR + TW**
Honda	CR-V IV	2.2 i-DTEC 4WD	**UK**	5	**HR + TW**
Hyundai	i30 II	1.6 CRDi 81 kW	**UK**	4 + 5	**HR + TW**
	ix35	1.7 CRDi 85 kW		5	**HR + TW**
		2.0 CRDi 100 kW		1 + 3	**HR + TW**
	Santa Fe III	2.2 CRDi 145 kW 4WD		5	**HR + TW**
Jeep	Cherokee IV	2.0 MultiJet 125 kW	**NL**	1 + 2 + 3 + 4	**HR + TW**
Kia	Sportage III	1.7 CRDi 88 kW	**UK**	4	**TW**
		2.0 CRDi 4WD		5	**HR + TW**
Land Rover	Freelander II	TD4 or SD4 4WD	**UK**	5	**HR + TW**
	Range Rover IV	TDV6		1 + 5	**HR + TW**
Mercedes-Benz	E-Class IV	E250 CDI	**DE**	5	**HR + TW**
Nissan	Qashqai I	1.6 dCi	**FR**	5	**HR + TW**
	Qashqai II	1.5 dCi	**ES**	5	**HR + TW**
Opel/Vauxhall	Corsa IV	1.3 CDTi	**DE**	5	**HR + TW**
	Astra IV	1.7 CDTi		5	**HR + TW**
	Insignia	2.0 CDTi		5	**HR + TW**
Peugeot	208	1.4 HDi 51 kW	**FR**	5	**HR + TW**
	807	2.0 HDi 103 kW		4	**TW**
Porsche	Cayenne II	Diesel	**DE**	4	**TW + TR**
Renault	Clio IV	1.5 dCi 66 kW	**FR**	4	**TW**
	Scenic III	1.5 dCi 81 kW		4	**TW**
		1.6 dCi		4	**TW**
	Laguna III	2.0 dCi 129 kW		4	**TW**
	Espace IV	2.0 dCi 96 kW		4	**TW**
Škoda	Octavia II	1.6 TDI	**UK**	5	**HR + TW + TR**
Toyota	Yaris III	1.4 D-4D	**UK**	4	**TW**
Volkswagen	Polo V	1.2 TDI	**DE**	1	**HR + TW + TR**
	Beetle III	2.0 TDI 103 kW		1 + 2	**HR + TW + TR**
	Passat VII	2.0 TDI 103 kW		1 + 2	**HR + TW + TR**
	Tiguan I	2.0 TDI 103 kW		4	**TW + TR**
	Sharan II	2.0 TDI 103 kW		4	**TW + TR**
Volvo	V40 II	D2	**NL**	5	**HR + TW**

There are models on the road that achieve the Euro 5 air pollution standards in normal use conditions including the BMW 1 Series I (116d); the Citroën C5 II (1.6 HDi) and the Toyota Auris II (2.0 D-4D). If these manufacturers were able to produce acceptable NO_x emissions on these models it begs the question why the performance of other manufacturers and models was so much worse and why approval authorities allowed such grossly polluting cars on the road.

2.3. How many grossly polluting diesel cars are on the road today?

A typical Euro 5 car manufactured between 2009 and 2015 emits around 800 kg of toxic NO_x every 1000 km driven. In contrast more modern Euro 6 cars are typically producing around 350 kg/1000 km. There are also significantly more Euro 5 Diesel cars on the road today compared to Euro 6, although the numbers of the latter are growing. If we are to tackle the NO_2 pollution afflicting European cities it is important to make new cars cleaner but also clean up the grossly polluting older ones.

T&E has estimated the number of grossly polluting cars on the EU's roads and the country in which these were first registered. The analysis uses the database of vehicle sales compiled by the European Environment Agency to monitor CO_2 emissions. Information on NO_x emissions, as previously mentioned, was obtained from the three national emission investigation plus the EQUA Air Quality Index by EA. The test used by EA is similar to the RDE test procedure that will be mandatory in the EU from September 2017 and uses Portable Emissions Measurement System (PEMS) technology to measure emissions on public roads. All of these tests give a reliable overview of the emissions performance of most engines used by carmakers in Europe. For the purposes of this research, the grossly polluting vehicle is defined as meeting the following criteria:

- RDE NO_x emissions above 3 times the limit (540 mg/km for Euro 5 and 240 mg/km for Euro 6);
- On track/road NEDC NO_x emissions above twice the limit (360 mg/km for Euro 5 and 160 mg/km for Euro 6);

We separated 'dirty' vehicles into engine families that use the same engine. For instance, the 1.6-litre diesel engine developed by Fiat is used by the whole Fiat-Chrysler Group (including Alfa Romeo, Chrysler, Fiat, Jeep and Lancia in Europe); also by Suzuki and by Opel/Vauxhall, whose Combo is a clone of the Fiat Doblò. This approach enabled T&E to construct estimates of the "dirty" models and brands, while the EEA registrations database shows where these models were first registered and most probably still driven. As the registration figures in EEA databases are on an annual basis, we focused our counting process from 2011 to 2015 inclusive. The split of the vehicles between the two main categories (passenger cars and light commercial vehicles, or LCVs) respects the method used by the EEA as cars and vans have separate databases (which for vans starts in 2012 only). To understand the proportion of "dirty" vehicles, we compared the estimated number of dirty Euro 5 and Euro 6 diesel vehicles with the total number of diesel vehicles registered in the same period. It should be noted that the difference between the total number of registered vehicles and the number of identified "dirty" vehicles is not the total number of "clean" vehicles since T&E does not have a comprehensive database of all engine families' sales or NO_x emissions, especially for LCVs. Our estimates are therefore conservative. In total around 400,000 registered vehicles could not be included in the analysis because of the lack of data.

The estimates of the number of "dirty" Euro 5 and Euro 6 vehicles are summarised below:

Category	Number of suspected dirty Diesel vehicles		Total number of Diesel vehicles registered		Dirtiness ratio	
	Euro 5	*Euro 6*	*Euro 5*	*Euro 6*	*Euro 5*	*Euro 6*
Passenger Cars	21.4 million	4.7 million	26.2 million	7.1 million	82%	66%
Light Commercial Vehicles	2.2 million	0.7 million	3.5 million	1.4 million	62%	53%
Total	23.6 million	5.4 million	29.7 million	8.5 million	79%	64%

T&E estimates there are around 29 million "dirty" Euro 5 and 6 diesel vehicles (cars and vans) on the European roads, which corresponds to about 76% of all diesel vehicles registered over the 5 years

assessed. These cars will typically be on the road for 10 – 15 years. To address the hazardous NO_2 pollution in cities and reduce the 72,000 premature deaths they cause these cars need to be cleaned up and there are strong legal arguments why carmakers should be required to do this. Included within this figure is 5.4 million "dirty" Euro 6 cars and vans. This is significantly less because the vehicles have only been marketed since 2014 and our figures only include sales in 2015 and are therefore conservative. However, each year the number of Euro 6 vehicles is increasing and the problem growing. New RDE tests introduced in 2017 will reduce emissions from these cars and vans but there is a legacy problem affecting these early Euro 6 vehicles with high emissions. Type Approval Authorities should be re-examining test results for these vehicles and recall them where they are misuse the defeat device exemption.

The table below gives an indication on how these vehicles are distributed per each EU Member State. The biggest European car markets (France, Germany, Italy and the UK) encompass about two thirds of the 'dirty' fleet. These Member States also approved most of these polluting vehicles.

Member State	Number of dirty Diesel cars on the roads for the EU27[15] (rounded figures)		
	Euro 5	*Euro 6*	*Euro 5 and Euro 6*
Austria	628,000	109,000	737,000
Belgium	1,180,000	200,000	1,380,000
Czech Republic	229,000	61,000	290,000
Denmark	229,000	44,000	273,000
Estonia	21,000	5,000	27,000
Finland	139,000	22,000	161,000
France	4,620,000	904,000	5,530,000
Germany	4,450,000	873,000	5,320,000
Hungary	84,000	21,000	105,000
Italy	2,630,000	513,000	3,140,000
Latvia	18,000	4,000	22,000
Luxembourg	114,000	21,000	135,000
Netherlands	440,000	96,000	536,000
Poland	352,000	77,000	430,000
Portugal	295,000	80,000	376,000
Romania	123,000	31,000	154,000
Slovenia	91,000	18,000	109,000
Slovakia	107,000	23,000	130,000
Spain[16]	1,420,000	475,000	1,900,000
Sweden	561,000	135,000	696,000
United Kingdom	3,460,000	849,000	4,310,000

France has the biggest number of the 'dirty' Euro 5 and 6 cars on its roads, closely followed by Germany. Indeed, the German diesel market was larger but national manufacturers sell disproportionately well in their home countries and the test results show that there are more dirty French diesels than German

[15] Bulgaria, Cyprus, Greece, Ireland, Lithuania and Malta do not appear in this table because the data quality is variable from a year to another.

[16] The estimation of dirty Euro 5 vehicles driven in Spain is underestimated because of the lack of data for 2013.

ones[17]. This is opposite to the claims of the French Transport and Environment Minister when she launched the Commission Royal to investigate in France.

The table below lists a top down ranking of 20 biggest manufacturers with the most 'dirty' sales. It is notable that half of the 'dirty' Euro 5 fleet are manufactured by five carmakers: the two main brands of Volkswagen Group (Volkswagen and Audi) and the three French makers (Citroën, Peugeot and Renault). On average, French carmakers[18] produce a higher share of 'dirty' Euro 5 Diesel vehicles (92%) than their German competitors[19] (80%). However, this 'dirty' phenomenon concerns almost all brands sold in Europe, from domestic groups to Asian and American companies, from cost-effective models (Chevrolet, Suzuki, etc.) to premium/luxury ones (Porsche, Jaguar, etc.).

Manufacturer	Origin of the brand/parent company	Number of dirty Euro 5 Diesel vehicles sold (rounded figures)
Volkswagen	Germany	3,610,000
Renault	France	2,407,000
Peugeot	France	1,870,000
Citroën	France	1,806,000
Audi	Germany	1,799,000
Mercedes-Benz	Germany	1,605,000
Opel/Vauxhall	Germany/United States	1,498,000
Ford	United States	1,212,000
BMW-Mini	Germany	1,008,000
Nissan	Japan	865,000
Fiat-Lancia	Italy	844,000
Škoda	Czech Republic/Germany	733,000
Volvo	Sweden/China	666,000
Dacia	Romania/France	661,000
Hyundai	South Korea	584,000
Kia	South Korea	548,000
Jaguar-Land Rover	UK/India	444,000
Toyota	Japan	349,000
Seat	Spain/Germany	348,000
Alfa Romeo	Italy	192,000

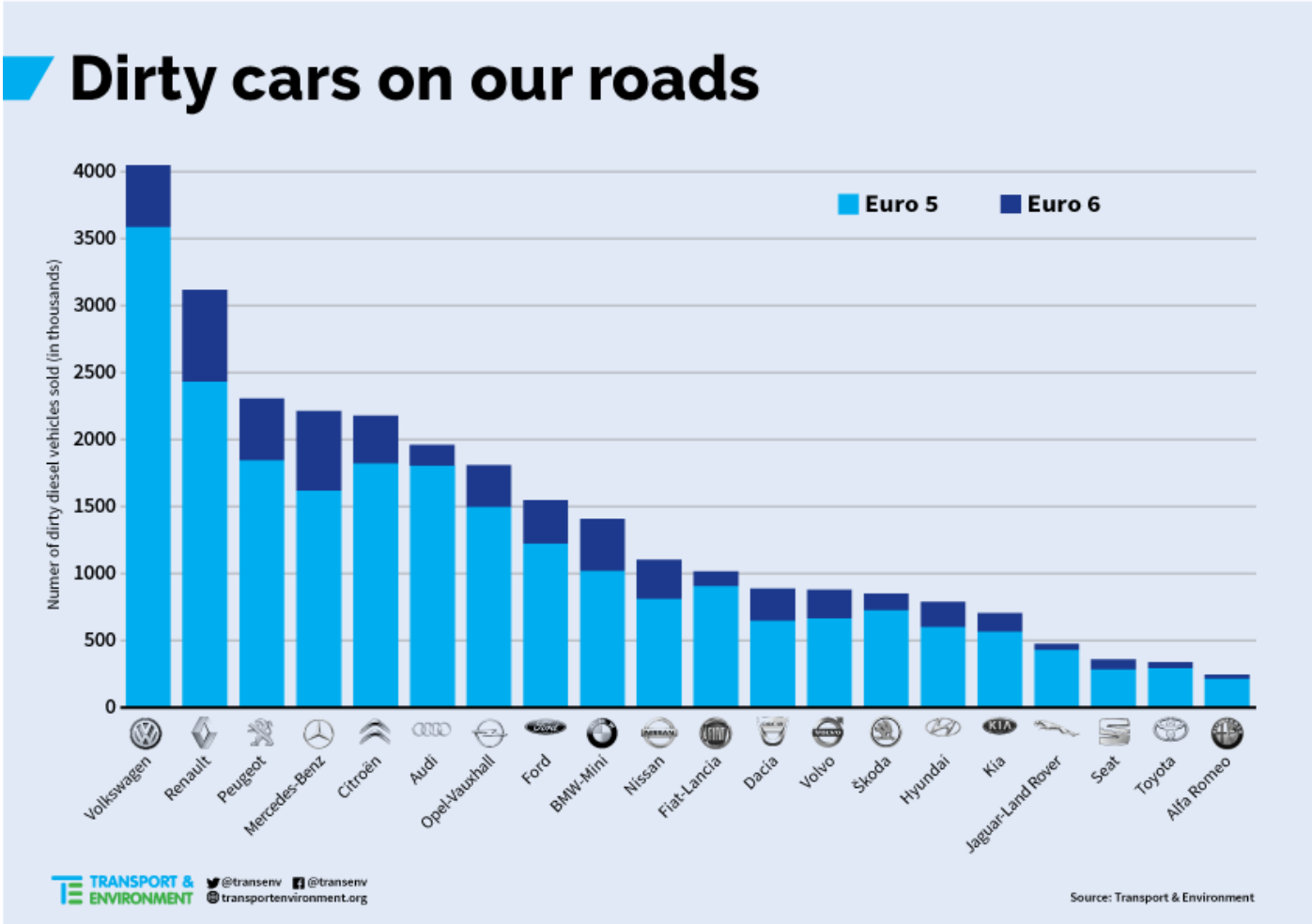
For Euro 6 a different picture emerges.

Manufacturer	Origin of the brand/parent company	Number of dirty Euro 6 Diesel vehicles sold (rounded figures)
Renault	France	699,000
Mercedes-Benz	Germany	620,000
Peugeot	France	464,000
Volkswagen	Germany	446,000
BMW-Mini	Germany	410,000

[17] The distribution per manufacturer concern passenger cars and light commercial vehicles.
[18] It includes Peugeot, Citroën from PSA Group and Dacia, Nissan and Renault, as these brands use Renault's Diesel engines and are members of the same Alliance.
[19] It includes BMW and Mini, Mercedes-Benz, Opel/Vauxhall and Volkswagen Group without counting Porsche.

Citroën	France	379,000
Ford	United States	341,000
Opel/Vauxhall	Germany/United States	311,000
Nissan	Japan	277,000
Dacia	Romania/France	200,000
Volvo	Sweden/China	183,000
Hyundai	South Korea	165,000
Audi	Germany	163,000
Kia	South Korea	156,000
Škoda	Czech Republic/Germany	123,000
Fiat-Lancia	Italy	116,000
Seat	Spain/Germany	71,000
Jeep	United States/Italy	52,000
Honda	Japan	48,000
Jaguar-Land Rover	UK/India	40,000

Dirty Euro 5 & 6 combined



2.4. Which manufacturers produce the dirtiest Euro 5 cars?

The previous section calculated the amount of grossly polluting cars and vans in use. But how 'dirty' are different carmakers' vehicles? To get a better understanding of this aspect, T&E has developed a ranking system based on all the test results available in our NO_x database (235 RDEs and 65 on track/road NEDCs). For Euro 5 vehicles T&E's ranking uses the Emissions Analytics methodology and classifies the NO_x test results from the national investigations into the categories listed below.

Ratings by Emission Analytics[20]	NO_x emission range (mg/km)	Exceedance factor range (-)	Average exceedance factor (-)
C	120-180	0.7-1.0	0.8
D	180-250	1.0-1.4	1.2
E	250-500	1.4-2.8	2.1
F	500-750	2.8-4.2	3.5
G	750-1000	4.2-5.6	4.9
H	> 1,000	> 5.6	7.8 (RDEs) 10 (NEDCs)

For on track/road NEDC tests, T&E applied a tolerance threshold of 2 times over the Euro 5 limit; and for the RDE tests - 3. In order to use these NEDC data in combination with those for RDE a weighting factor of 1.5 has been assigned to every NEDC NO_x result to have all exceedance factors on the same scale. For the H category with NO_x emissions higher than 1,000 mg/km, the average exceedance factors used are the following:

- 7.8 for RDE tests, which corresponds to the average exceedance factor for RDE tests done by national commissions with an individual exceedance factor equal or higher than 5.6;
- 10 for NEDC tests, which corresponds to the average exceedance factor for NEDC tests done by national commissions with an individual weighted exceedance factor equal or higher than 5.6.

Once every test of each category gets its average exceedance factor, an average result per manufacturer can be calculated. Manufacturers with a test sample lower than five results are not considered in this ranking or, where possible, have been counted with their parent company to obtain a sufficient sample.

	Manufacturer[21]	Average result	Size of test sample
1	Seat	3.2	8
2	Honda	3.3	8
3	BMW + Mini*	3.4	23
4	Ford	3.8	16
5	Peugeot	3.8	17

[20] The ratings A and B are not taken into account for T&E's Euro 5 ranking as no Diesel nor Diesel-hybrid vehicles got one of these ratings in Emission Analytics' index.

[21] The brands with an asterisk have been counted with their parent company to get a big enough sample. This comment concerns Alfa Romeo, Chevrolet, Dacia, Jeep and Mini.

6	Citroën	3.9	13
7	Toyota	4.0	8
8	Audi	4.4	16
9	Škoda	4.4	12
10	Mercedes-Benz	4.6	15
11	Volkswagen	4.8	33
12	Volvo	5.6	15
13	Jaguar	5.9	6
14	Kia	6.0	11
15	Alfa Romeo* + Fiat + Jeep*	6.3	11
16	Nissan	6.6	13
17	Chevrolet* + Opel/Vauxhall	7.0	18
18	Hyundai	7.2	17
19	Land Rover	7.6	17
20	Dacia* + Renault	7.9	12

In our analysis Mazda and Smart achieved an average exceedance of less than 3 times the Euro 5 limit (2.8 both), but the size of the test sample is too small to make these brands appear in our Euro 5 ranking. In contrast Porsche and Jeep are the two brands that get the worst average (8.5 and 9.3 respectively) but are not ranked separately due to a similarly low sample size.

What the above results show is that there is widespread non-compliance with the Euro 5 NO_x emission limits across industry with none of the carmakers meeting the standard on the road. The exceedances, on average per fleet, range from 3 times the limit to almost 8 times, with the latter resulting in 1.5 g of NO_x per km on the road. European as well as Asian and American manufacturers have excessively high emissions on the road, with the Volkswagen Group vehicles fitted with the illegal defeat not performing any worse than the vehicles by other manufacturers; and even considerably better than the Euro 5 cars manufactured by Renault, Opel and Fiat.

2.5. Which manufacturers produce the dirtiest Euro 6 cars?

T&E also used the same database to identify the dirtiest Euro 6 manufacturers using the data from the national investigations and Emissions Analytics (around 150 RDE tests and 90 NEDC on track test results).

Ratings by Emission Analytics	NO_x emission range (mg/km)	Exceedance factor range[22] (-)	Average exceedance factor (-)
A	< 80	< 1.0	0.5
B	80-120	1.0-1.5	1.3
C	120-180	1.5-2.3	1.9
D	180-250	2.3-3.1	2.7
E	250-500	3.1-6.3	4.7
F	500-750	6.3-9.4	7.8
G	750-1000	9.4-12.5	10.9
H	> 1,000	> 12.5	13.5 (RDEs) 16.1 (NEDCs)

[22] The exceedance factors used in this table are related to the Euro 6 NO_x limit (80 mg/km).

The method was identical to the one used for the Euro 5 ranking:

- NEDC test results are weighted with a 1.5 factor to have all the exceedance factors on the same scale;
- RDE results and weighted NEDC results are classified by categories (A to G), following the table above;
- for the H category, RDEs with an individual exceedance factor equal or above to 12.5 times the Euro 6 NO_x limit are assigned with the average exceedance factor of 13.5. NEDCs with an individual weighted exceedance factor equal or above to 12.5 times the Euro 6 NO_x limit are assigned with the average exceedance factor of 16.1.
- the average result is calculated for each manufacturer and potentially with its parent company if the size of the test sample is too small (below five tests).

The results, from better to worse performing, are as follows:

Manufacturer[23]	Average result	Size of test sample
1 Volkswagen	1.8	23
2 Seat* + Škoda	2.1	8
3 Audi	2.7	15
4 BMW + Mini*	3.0	26
5 Mazda	3.6	15
6 Honda	4.3	5
7 Volvo	4.5	13
8 Citroën + DS*	4.6	8
9 Toyota	4.7	5
10 Peugeot	5.3	10
11 Jaguar + Land Rover*	5.7	13
12 Ford	5.8	15
13 Kia	5.9	6
14 Mercedes-Benz	6.4	23
15 Hyundai	7.7	8
16 Opel/Vauxhall	10.0	14
17 Dacia* + Infiniti* + Nissan* + Renault	14.4	19
18 Alfa Romeo* + Fiat* + Suzuki*	15.1	5

The dirtiest manufacturer of Euro 6 vehicles is the Fiat Chrysler Group (including Alfa Romeo). The Renault Group also performed poorly (including Nissan, Infiniti and Dacia), as does Opel/Vauxhall. Porsche also performed badly (average of 13.5) but the sample of tests is too small to include in the ranking. Surprisingly some premium manufacturers perform poorly including Mercedes (that uses some Renault engines), Infiniti and Jaguar-Land Rover. The Euro 5 models from these brands performed poorly too. The current shift to Euro 6 has been poorly delivered by Ford, Mercedes-Benz and Peugeot as their respective average results are significantly worse than for Euro 5 models. If Mercedes' models powered by Renault's diesel powertrains are not included, the average for the German premium brand would be 5.2, at the same level as Peugeot, instead of 6.4.

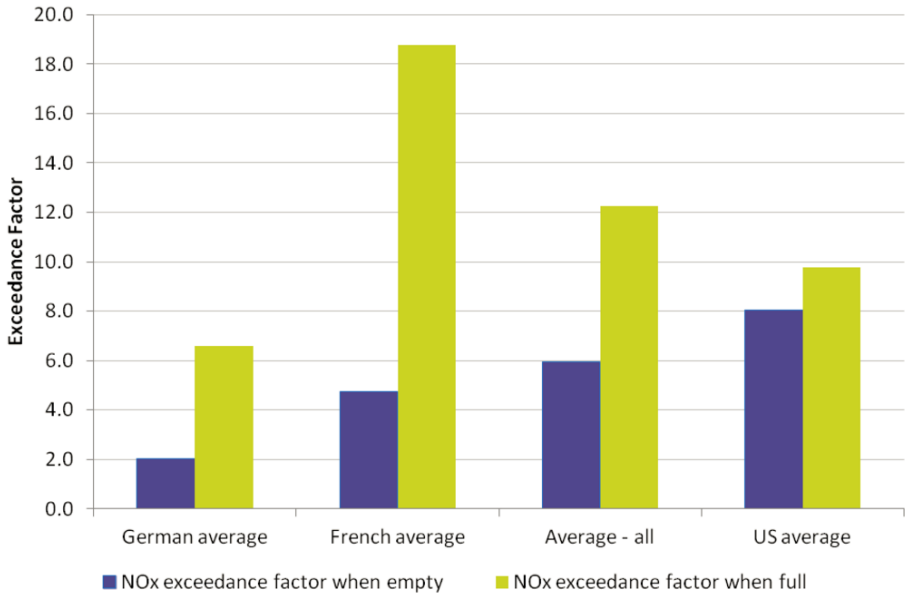
[23] The brands with an asterisk have been counted with their parent company to get a big enough sample. This comment concerns Alfa Romeo, Dacia, DS, Fiat, Infiniti, Land Rover, Mini, Nissan and Seat. Suzuki is counted with Alfa Romeo and Fiat because the Japanese car maker uses Fiat's Diesel engines for its models. The tested Infiniti model uses Renault's Diesel engine and not one from Mercedes-Benz, hence Infiniti is counted with its parent company, Nissan.

Several carmakers' Euro 6 vehicles are notably better than their Euro 5 performance. This includes Volvo and Volkswagen Group (except Porsche) that achieve typically a performance below 3 times the Euro 6 NO_x limit. There has been a considerable improvement from Volkswagen for its main brands in the transition from Euro 5 to Euro 6.

The analysis shows it is possible to get cleaner diesel vehicles on the road today with the current level of technology – it is the carmaker that chooses whether to deploy the technology and utilise it to its potential. Seat and Škoda are positioned as affordable brands of Volkswagen Group, showing that, with economies of scale, it is possible to make effective after-treatment systems and affordable cars with low emissions, if the manufacturers also have the will to calibrate their engines properly.

2.6. Dirty vans

Little data has been published to date about NO_x emissions from vans but some results are available from Emissions Analytics that has examined the effect of payload on NO_x emissions for Euro 5 LCVs[24]. For this EA has tested a small sample of Euro 5 vans on two tests: one test with an empty vehicle and one with 100% payload. The results show that the average exceedance factor is 5.9 times when empty; which raises to 12.2 times when tested with a full payload. The impact of load varied from vehicle to vehicle. For example, Volkswagen produces the cleanest van for NO_x when empty but the emissions rise to 225% of the limit when full. In contrast the Ford vans, while having high unladen emissions of 7.1 times the limit; barely increased when full (7.6 times).



A small number of vans tests were undertaken by the national investigations in Germany, France and the UK (9 tests on Euro 5 vans). On average, NO_x emissions were 9.9 times the Euro 5 limit on the road (results from 5.2 to 14 times included 3 big vans and 2 pick-up trucks). NEDC tests conducted on the road also showed very high emissions averaging 6.8 times the Euro 5 limit (results from 2.8 to 12.5 times included 4 small vans, 3 big vans and 2 pick-up trucks). These results are alarming and indicate much more investigation of van emissions is required.

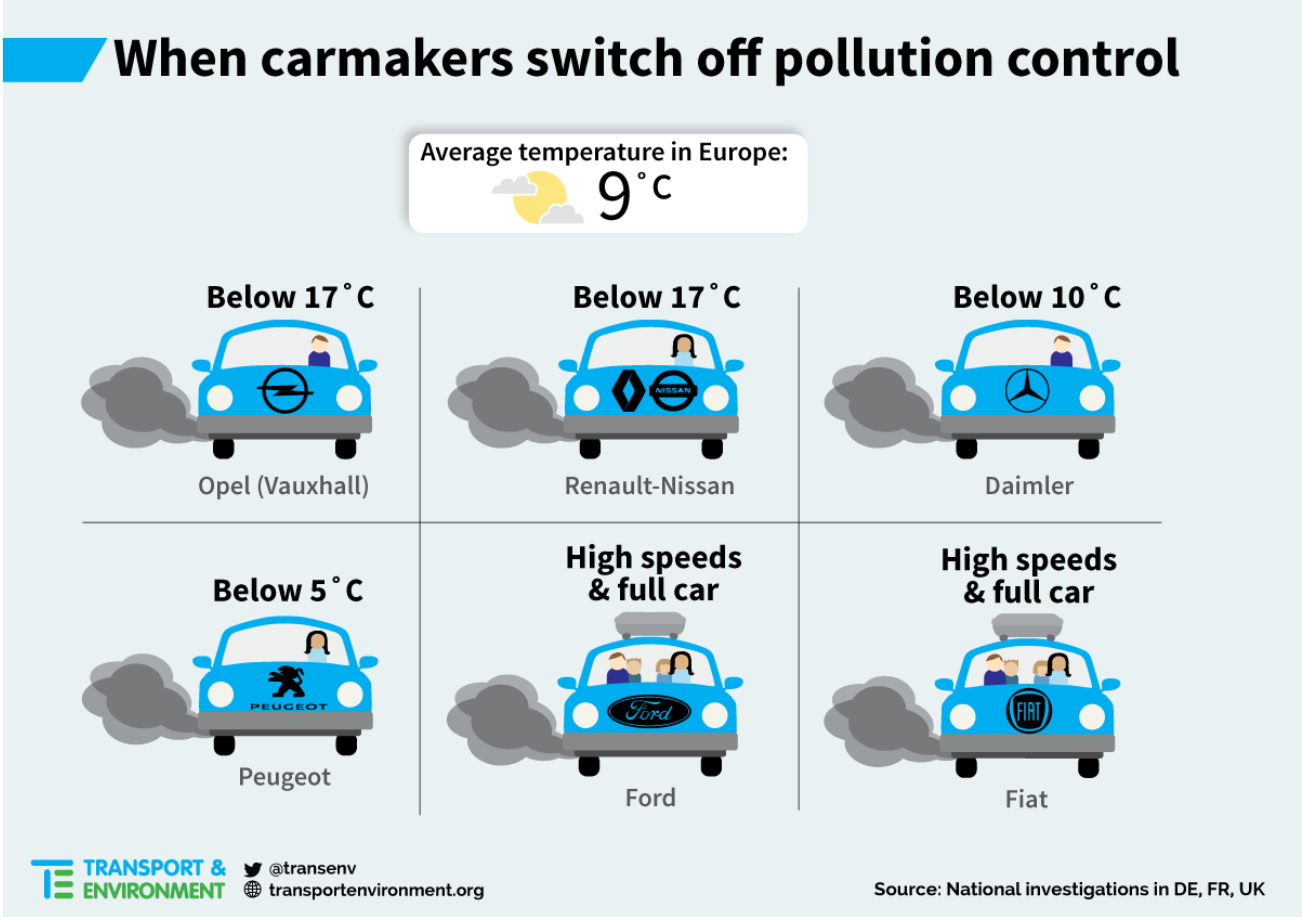
[24] http://emissionsanalytics.com/cargo-weighs-heavily-for-some-lcvs/

2.7. Defeat strategies and their illegality

The emissions tests reanalysed by T&E clearly point to a number of different cheating techniques used by carmakers that result cause high NO_x emissions. While these tests are not detailed enough to definitely determine the presence of illegal defeat devices, they clearly illustrate where further investigations and/or enforcement activity are needed. Techniques which significantly raise emissions on the road include the use of:

1. Thermal window defeat device
2. Hot restart defeat device
3. Cycle detection defeat device.

Almost all of the dirty models identified show the presence of a **"thermal window" defeat device**. These switch off or lower the effectiveness of the exhaust treatment systems at temperatures below those typically used during laboratory tests (23 - 29°C). Because the national testing investigations were mostly undertaken in winter and early spring, tests conducted on track or road produced high emissions highlighting that the cars were turning down or switching off the emission control systems during these tests. Manufacturers claim such behaviour is needed to protect the engine but the temperatures at which the exhaust treatment effectiveness is lowered is much higher than necessary in many models. This is demonstrated by Renault which has voluntarily agreed to extend the operating range for full functioning of its exhaust treatment system to between 5°C and 40°C from below 17°C and above 35°C for some models. Such wide thermal windows should *not* have been allowed by approval authorities and almost certainly constitute illegal defeat devices. At a minimum, further investigations are needed to determine whether the original approval was granted incorrectly; and whether the manufacturer provided incorrect or misleading information. If so, penalties should be applied and the recalls made mandatory.



The second type of defeat device relates to **"hot restarts".** Again a high number of the dirty models on the road show much higher emissions after a hot engine restart than when the engine is cold. Manufacturers' explanation – that high emissions are generated by hotter engine temperatures and pressures experienced at warm restarts – is "bogus"[25] as the emissions generated are both a function of the combustion and effectiveness of the after-treatment that should be much better when hot, as found in data obtained by the ICCT from the EPA[26]. High warm start emissions are highly suspicious and possibly suggest that during a cold start a different and more effective engine and exhaust calibration is being used (as the EU test mandates cold starts). If so this would constitute an illegal defeat device.

In May 2016 allegations of a **third defeat device** came to light. It was reported that several tests by the German type approval authority (KBA) had found evidence that the exhaust treatment system in some Fiat models would switch itself off after 22 minutes[27]. Emissions tests normally run for around 20 minutes. Despite the Italian Transport Ministry (that approved these cars) denying the accusation, KBA are currently asking the European Commission to investigate Fiat 500X models for the presence of this defeat device. If such a device is proven it is undoubtedly illegal.

Whether or not the various defeat devices are legal in Europe has been the subject of a lengthy debate with manufacturers claiming they are using a legal loophole. Under EU law, defeat devices (defined as any sensor or equipment that senses different parameters to alter the operation of emission control systems) are banned apart from a few exemptions, including to protect the engine against damage and ensure safe operation. The Euro 5/6 Regulation 715/2007 (EC), in its article 5, stipulates the following:

1. The manufacturer shall equip vehicles so that the components likely to affect emissions are designed, constructed and assembled so as to enable the vehicle, in normal use, to comply with this Regulation and its implementing measures.
2. The use of defeat devices that reduce the effectiveness of emission control systems shall be prohibited. The prohibition shall not apply where:
    a) the need for the device is justified in terms of protecting the engine against damage or accident and for safe operation of the vehicle;
    b) the device does not function beyond the requirements of engine starting;
    c) the conditions are substantially included in the test procedures for verifying evaporative emissions and average tailpipe emissions.

It is the above derogation, notably the need to protect the engine that the majority of carmakers are using to justify the deployment of the defeat strategies described above. However, carmakers are misusing the derogation and therefore the defeat strategy is probably illegal for a number of reasons:

1. Such a defeat device must be **necessary**. In the case of a thermal window for example, ambient temperature is not the key parameter for EGR operation; the exhaust temperature is much more important and is affected by many factors in addition to the ambient temperature. In the US manufacturers are only allowed to switch off exhaust clean-up technologies when the outside temperature drops below -3°C;
2. The law clearly stipulates that the defeat device is justified if it is used to protect the **engine**, not separate components. Exhaust systems such as EGR are components and the need to protect their durability cannot be used as an argument;

[25] http://www.theicct.org/blogs/staff/emissions-test-defeat-device-problem-europe-not-about-vw
[26] Ibid.
[27] http://www.bild.de/bild-plus/geld/wirtschaft/abgas-skandal/auch-fiat-betruegt-mit-illegaler-software-45905214,var=x,view=conversionToLogin.bild.html

3. The exemptions must be used to guarantee **safe operation of the vehicle**. A loss of durability of the EGR or another exhaust after-treatment system does not make the vehicle unsafe as this will not lead to any dangerous incident such as fire;
4. The Euro 5/6 law requires the vehicles to comply with emission standards in **normal use**, which means that the permanent durability of the technologies used to reduce emissions must be checked over a total driving distance of 160,000 km;
5. Finally, disabling emission control technologies in many real-world driving conditions goes against the very aim of the law (detailed in recitals) to **achieve air quality goals**, such as improve air quality and help comply with EU ambient air pollution limits.

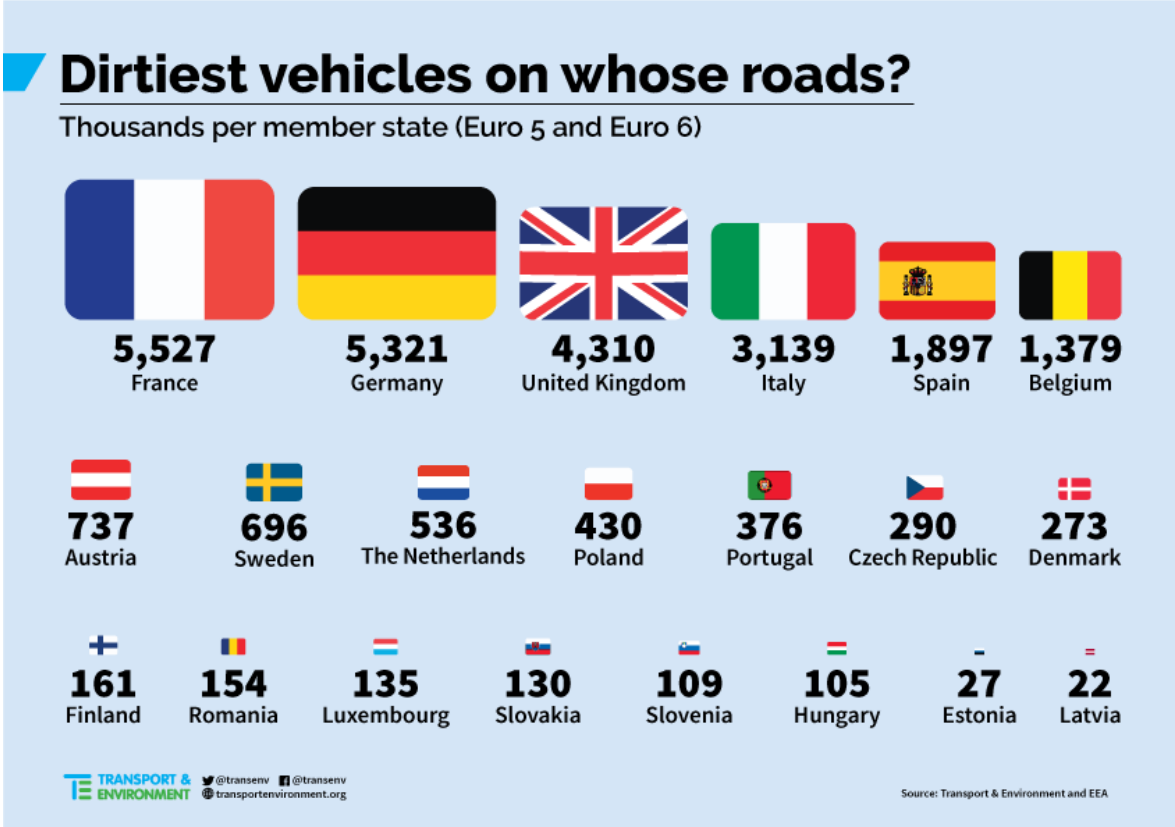
To summarise, the current industry interpretation of the regulations is inappropriate and their use of defeat devices – almost certainly illegal. Emission control systems should work fully during vehicles' normal use. The above derogations are only justified if absolute necessity to protect the engine from damage/accident, not for mere component protection and durability concerns, which is currently the case because car manufacturers chose to use cheaper and less reliable materials and designs. When it comes to safety, no-one would allow a switch-off device that reduces braking effectiveness or changes the door locking system under low outdoor temperatures – same applies to emissions legislation.

In addition, the Euro 5/6 implementing measure 692/2008 further requires that: "In addition, the manufacturer shall provide the approval authority with information on the operating strategy of the exhaust gas recirculation system (EGR), including its functioning at low temperatures." It is the responsibility of the national type approval agencies to enforce the above ban and verify the legitimacy of the exemptions used. It is also their job to check the working of pollution control systems in different ambient temperatures. The defeat device ban is enforced in a much more comprehensive manner in the US. First, it is the burden of manufacturers to prove why they need to use the exemptions, who need to disclose upfront (together with technical justifications) what "legal" defeat devices they use. Second, the authorities (US EPA) have clear powers to approve or reject the use of exemptions and penalise manufacturers for false claims. Third, there is extensive technical guidelines on which to base the decisions – taking into account best available techniques, effect on emissions and various weather and engine conditions. The current legislation is clear but the Dieselgate scandal clearly shows a need to strengthen the current clauses on defeat devices to ensure the requirements are enforced by reluctant Type Approval Authorities.

3. Fixing the EU's failed system of vehicles regulation

Chapter 2 of this report highlights the staggering scale of the Dieselgate scandal in Europe. Rather than affecting some 8.5 million VW group vehicles, it is clear that the number of **excessively dirty diesel cars on the EU's roads is of the order of 29 million vehicles**. This represents over three-quarters of all diesel cars and vans registered in the EU since 2011. The vast majority of these vehicles are on the roads of France, Germany, UK, Italy, Spain and Belgium. Unsurprisingly these Member States also infringe the EU air quality standards and are where the majority of NO_2-related premature deaths occur: 21,600 in Italy; 14,100 in the UK; 10,400 in Germany; 7,700 in France; 5,900 in Spain and 2,300 in Belgium.[28]

[28] For more country-specific figures, please refer to European Environment Agency, http://www.eea.europa.eu/media/newsreleases/many-europeans-still-exposed-to-air-pollution-2015/premature-deaths-attributable-to-air-pollution



Such a regulatory failure does not have a single cause and therefore a suite of actions is needed to address the problems. The following sections explain the solutions that are grouped into the following areas for action:

1. Enforcement of defeat device legislation, including recall of cars
2. Increased adoption of city low emission zones
3. Better and more tests
4. Better regulators and independent oversight
5. Better regulations
6. Stricter NOx limits
7. Discouraging dieselization

3.1. Enforcement of defeat device legislation including recall of cars

Europe has a serious problem with nitrogen dioxide pollution leading to the premature deaths of 72,000 citizens. Action to reduce emissions from new cars will eventually lead to a clean-up of the car fleet as older vehicles are progressively replaced. However, the 17-year average lifetime of a car means progress is painfully slow.

The vast majority of the 29 million Euro 5 and 6 dirty diesel cars on the road emit high levels of NOx because their exhaust treatment systems are switched down or off most of the time – they should not be. T&E believes that manufacturers' claims that they are operating within the law are wrong. Renault and Mercedes are already voluntarily recalling some vehicles due to excessive thermal windows that switch off the exhaust treatment systems at typical European ambient temperatures – these recalls must be mandated by Type Approval Authorities for all vehicles operating such unnecessary thermal windows. If the Member States will not act, the European Commission must bring infringement proceedings against countries that fail to enforce the law.

A mass recall of dirty Euro 5 and 6 vehicles need not be excessively complicated. Software upgrades could easily be implemented to ensure the exhaust treatment systems operate in normal driving conditions as the law clearly requires. If there are durability issues manufacturers should warranty the

exhaust system for 160,000 km, the distance that the Euro 5 and 6 legislation requires the system to operate within. If there are drivability or small fuel economy penalties, drivers should be compensated. The European Commission should coordinate an EU-wide recall to ensure fair treatment of car owners throughout the EU.

3.2. Increased adoption of city low emission zones

A mass recall and upgrade of dirty Euro 5 and 6 vehicles will make a measureable impact on NOx emissions and improve urban air quality. But in many heavily trafficked areas NO_2 limits are likely to continue to be breached. In these areas the only short term solution is to **exclude excessively polluting diesel cars from the area**. The traditional approach to do this is to ban older cars; but this report shows that there is little difference between the on-road emissions of many Euro 4, 5 and 6 cars. Blanket exemptions of Euro 6 cars permitting them to enter low emission zones freely will therefore allow many high emitting vehicles into the urban air pollution hot spots. To prevent this the design of a low emission zone should only exempt diesel cars that are clean on the road, not in lab tests. The new real-world driving emissions (RDE) test provides a basis to do this, and cities could for example only admit diesel cars as clean as gasoline models (emitting less than 60mg/km during the RDE test) as this information will in the future be publically available. Such cars are available (as they are already sold in the US) and such a local initiative would drive carmakers to produce a fleet of ultraclean diesel cars for cities to tackle the NO_2 problems they have created.

3.3. Better and more tests

The European Commission has made good progress to strengthen the system of testing cars with the introduction of the real-world driving emissions (RDE) test. There do however remain important gaps and limitations with the test protocol. There are 5 areas in which improvements are needed:

1. Cars emit much more pollution when the engine and exhaust after treatment system are cold – but the current design of the RDE tests fails to adequately take this into account. **A cold start factor** must be built into the regulation that reflects a very high proportion of short journeys made by cold cars that produce disproportionately high emissions. Such a proposal is expected to be made by the European Commission within weeks and officials must ensure it is representative of emissions in the real world.
2. The high emissions which are **generated during regeneration of diesel particulate filters** must be appropriately factored into the RDE procedure.
3. RDE tests must be **extended to all other pollutants** (starting with particles) and also to CO2 emissions and fuel efficiency as the most representative way to measure emissions.
4. The Commission must rapidly develop and bring forward proposals for **real world tests of cars to be conducted as in-service conformity checks**. Member States must also be mandated to perform an adequate number of such tests; but independent third-parties should also be empowered to verify in-use compliance. In-service tests will ensure that the emissions from a car continue to meet legal limits throughout its lifetime (defined as 160,000 km). At present, there is no systematic or independent in-service testing of cars and as a result many cars, as they age, produce much higher emissions as the exhaust treatment systems degrade.
5. The Commission must re-examine the most effective ways to measure NOx and other emissions of cars in use as part of the **system of periodic technical inspections** ('MOT' in the UK or 'controle technique' in France). The current system is obsolete and failing, and better technical solutions are now available such as measuring air pollution emissions via sensors at fixed points in the road network that can detect grossly polluting cars.

3.4. Better regulators and independent oversight

The regulatory system used to approve vehicles today (type approval) badly lacks any independent oversight, transparency or rigour. Following the Dieselgate scandal, the European institutions are currently discussing the new proposals on the Type Approval Framework Regulation (TAFR). To be truly effective, the EU vehicle testing system must include the following:

1. To ensure the 28 type approval authorities (TAAs) enforce the EU rules consistently – and in the absence of any political will to establish an independent EU vehicle enforcement agency that will have strong powers and **oversee the work of the 28 national regulators must be introduced**. This should include regular audits of their approval procedures, a spot check of a few type approvals issued and clear sanctions in case of non-compliance. In case of continuous lack of enforcement of the EU regulations, the national regulator should be stripped of its power to issue EU-wide type approvals.
2. The **European Commission should be given powers to carry out independent re-tests of new vehicles on the road**, take remedy action against non-compliant manufacturers, including dissuasive penalties. In the absence of such independent tests, national testing authorities will continue putting economic interests of carmakers and their technical agencies over those of citizens and public health, thus failing to scrutinize the emission performance of vehicles rigorously.
3. There must be **a clear separation of powers and functions among all the actors in the type approval chain**. Independence must be re-instated throughout the type approval chain: TAAs should not act as private technical services, and carmakers must test their vehicles in independent labs done from beginning to end by specialised testing services.
4. **Vehicles put on the EU market must be checked rigorously throughout their lifetime** to ensure their emission control systems continue to work properly during continuous use in all real-world conditions. Such effective market surveillance can only be achieved if there are enough financial resources to do the checks. T&E is proposing to **levy a fee of EUR 10 on manufacturers for every new vehicle they sell in the EU** to fund an effective in-use surveillance programme. That money will cover the costs of all checks performed at national and European level.
5. Transparency should be injected into the vehicles testing system in Europe; today no one knows which car was approved where and the whole procedure is shrouded in secrecy. There should be an **online portal with all the type approval and testing data submitted to the national authorities accessible to third parties**, in a digitally searchable format. It must be clear who approved which vehicle (or its separate component) and where to ensure regulatory accountability and openness.

3.5. Better regulations

In the absence of a single EU regulator to check vehicles' compliance on the road, the EU rules should be better and more clearly defined. The flexibility of the 28 national regulators to interpret the rules must be minimized to ensure they cannot bend the rules to favour home carmakers or put their commercial interest above those of citizens.

1. The current **Type Approval Framework Directive should be turned into a Regulation** with all the responsibilities, roles and powers clearly defined. No room for maneuver should be left in the way in which the national testing authorities enforce the future regulation, including requiring rigour and consistency on how they check cars performance on the road.
2. The current **rules banning the use of defeat devices should be strengthened to include very detailed engineering guidelines** for the national testing authorities on how any exemptions are to be granted. US EPA has over years developed a set of circular guidelines, which they regularly review in line with technology developments. The EU guidelines should specify all parameters (temperature, pressure, altitude, engine design, etc.) that must be considered when justifying, approving or rejecting the use of switch off devices, and any deactivation of emission control must

not be allowed if a carmaker is using inferior materials compared to the state-of-the-art systems on the market.

3.6. Stricter NOx limits

The current EU emission limits for NOx are at least double what they are in the US (and even weaker if compared to the Californian regulations) and allow diesel vehicles to emit 25% more pollution than equivalent petrol engines. This is an unfair advantage for a specific technology and should be swiftly closed; it does not stand scrutiny on either public health or technology availability grounds.

1. **The unnecessarily high conformity factor for NOx emissions under RDE test must be brought to 1 by 2020**. The current conformity factors allow industry to overshoot the European NOx limit of 80mg/km by 210% from 2017 and by 50% from 2020 open-endedly. These were agreed politically to give flexibility to car manufacturers, and the latest data confirms that their level was set too high and does not correspond to the technical uncertainty of the measurement equipment used in on-road tests (PEMS).

2. The Commission should, without delay, start to work on the **next set of Euro 7 standards for cars and vans to apply from 2025**. The future emission standards must be technologically neutral with the same NOx limit for all fuels. The level of the Euro 7 limits should be fixed with the aim of the WHO air quality guidelines finally being met in all urban areas across Europe.

3.7. Discouraging dieselisation

Ultimately, Europe needs to wean itself off its diesel addiction. Diesel engines are an expensive way to save carbon typically costing €2k more than a gasoline engine for modest carbon savings. In addition, emission limits for diesel and gasoline vehicles must be equivalent.

1. **Taxes on diesel cars must rise** in recognition of their higher air pollution emissions.
2. **Diesel fuel taxes should also rise** to reflect the higher energy content of the fuel. Cities must ban dirty diesels.

3.8. Concluding thoughts

12 months ago, Volkswagen claimed the cheating of emissions tests in the US was perpetrated by a handful of rogue engineers. We now know it is an endemic problem throughout the automotive industry with defeat devices systematically installed by VW Group on 11 million vehicles globally and cheating of tests by other companies exposed in Japan[29] and South Korea.[30] However, in Europe the scale of the cheating and resulting impact upon health are of an entirely different scale. **29 million grossly polluting diesel cars are on the EU's roads and will be there for more than another decade**. The high emissions are caused by companies programming their cars to turn down or off exhaust after treatment systems most of the time when the car is driven, misusing a loophole designed to protect the engine in extreme conditions. The illegality of the practice is clear and needs to be challenged by national approval authorities, or the European Commission if the authorities fail to act. The immorality of the companies that have designed their cars to grossly pollute and ignore regulations, significantly contributing to the 72,000 premature deaths from NO_2 pollution in the EU, is shameful.

Just as shameful is the refusal of national regulatory authorities to do their job and ensure vehicles properly comply with EU regulations. The EU Single Market relies on rules like these to create a level playing field for competition and ensure products are designed in a way that prevents excessive externalities like air pollution. The Single Market depends on honest and professional regulators to enforce rules. Instead, 12 months of the Dieselgate scandal have demonstrated regulatory capture by the automotive industry of national type approval authorities and their Transport Ministry masters. Either

[29] Reuters, http://www.reuters.com/article/us-mitsubishimotors-regulations-idUSKCN0XN0DV
[30] ABC news, http://www.abc.net.au/news/2016-05-17/nissan-faces-fine-for-emissions-cheating-in-south-korea/7419730

through unhealthy business relationships or a desire by member states to give an unfair advantage to their national car companies (which in some cases they partly own); the system has been shown to be corrupt. The failure to enforce the law is the primary cause of the Dieselgate scandal in Europe; not unclear regulations as member states claim.

The European Commission is far from blameless. It took too long to develop new real world tests that should have identified and resolved some of the issues much earlier. It acceded to the demands from the Member States to weaken new NOx limits for cars and delay their introduction. It designed the type approval regulation in a way that meant no effective checks and balances were built into the system. However, the Commission has acted promptly to reform the system of type approval with good (but not sufficient) proposals to strengthen the rules. It has also made clear its intention to bring infringement proceedings against member states that fail to enforce the law on defeat devices – it now must do this and coordinate an EU-wide recall of vehicles abusing emissions regulations that will ensure air pollution limits are met earlier throughout Europe and fewer people die prematurely.[31]

Recalling grossly polluting cars will remediate some of the harm done. It will also, hopefully, encourage an essential culture change in the industry to meet the standards honestly and not seek to circumvent environmental rules designed to manage the pollution caused by their products. But for this culture change to happen the automotive industry must believe that if they cheat - they will get caught and appropriately sanctioned. In the EU the system of type approval doesn't do this. There must be rigorous checks and tests performed on cars, and audits and independent oversight to check the work of national approval authorities and technical services. Those found to be consistently failing to do their job robustly must be prevented from testing and approving vehicles and skewing the single market. There must be funds available to ensure there are sufficient independent checks on cars in use to ensure emissions are within limits. There must be a culture of openness and transparency so the industry knows wrongdoing will be exposed and not covered up. The European Parliament and Council are currently considering and amending the Commission proposal on type approval to improve the system – Dieselgate points to where improvements are needed.

Diesel does not decarbonise transport, but green electrons in electric or hydrogen cars will and the new direction of the European Commission is finally recognizing this. [32] Electromobilty will ultimately solve the air pollution crisis in our cities; but the measures outlined in this report will make an important contribution to remediating the current problems and also putting the automotive industry on a more sustainable path.

[31] Commissioner Bienkowska, at the hearing with the European Parliament's enquiry committee into the Emission Measurements in the Automotive Sector (EMIS) in Strasbourg, 12 September 2016.
[32] Politico, http://www.politico.eu/article/europe-looks-to-electric-cars-after-diesels-dead-end/