

Forced retrofitting of VW Diesel engines successfully reduced nitrogen oxide emissions

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A Volkswagen Passat Diesel from 2011. Software updates after the Dieselgate-scandal in 2015 improved NO_x-Emissions of such cars significantly. Credit: Volkswagen, vwpress.co.uk

Using exhaust gas measurements taken from the roadside, a team from the University of York and Empa was able to prove the "Dieselgate" scandal has led to positive results. The forced retrofitting of thousands of VW diesel engines reduced considerable amounts of nitrogen oxide (NO_x) in the environment throughout Europe.

The VW [diesel](#) scandal began with a bang on September 18, 2015. On the opening day of the Frankfurt International Motor Show (IAA), the U.S. Environmental Protection Agency (EPA) published its "Notice of Violation": VW diesel engines with 1.6 and 2.0 liters displacement (type code EA 189) contained illegal software designed to manipulate emissions during testing. It quickly became clear that 11 million vehicles of the VW group were affected worldwide. Company boss Martin Winterkorn resigned. Expensive lawsuits followed. In many countries, the EA 189 engines

manufactured by the VW group had to be retrofitted with software or hardware updates.

Now, almost five years later, a study by the University of York and Empa shows that the retrofitting was successful from an environmental point of view. Retrofitted VW diesel engines emit up to a third less harmful nitrogen oxide in everyday use than engines with the original software dating from the Dieselgate era.

Exhaust gas measurement from the roadside

Stuart Grange works in Empa's Air Pollution/Environmental Technology Laboratory and also at the Wolfson Atmospheric Chemistry Laboratories at the University of York. Together with his colleagues, he used a special instrument to examine the exhaust plumes of 23,000 passing cars and analyzed the levels of NO_x and CO₂. The measurements took place in England between May 2012 and April 2018—before and after the Dieselgate scandal.

At each measurement, the [vehicle](#)'s registration number was also registered and the vehicle data were retrieved from the British registration database MVRIS (Motor Vehicle Registration Information System). Among the 23,000 correctly measured exhaust plumes, Grange recorded 4,053 times the emissions of the VW EA 189 diesel [engine](#), which formed the basis for his analysis. In April 2020, the results were published in the journal *Environmental Science & Technology Letters* of the American Chemical Society.

Significant improvement

The results of the measurements show a clear effect: NO_x emissions from the small 1.6-liter engines of the EA 189 series had decreased by

more than 36%. VW had offered software and hardware retrofitting for this engine: In addition to updating the engine software, a small supplementary component was installed in the engine's intake duct, allowing the air mass sensor to work more precisely.

For the larger 2.0-liter engine of the EA 189 series, only the software was modified. Here, the measured NO_x emissions fell by an average of almost 22%. The improvements for each individual car are even greater: In the UK, the retrofitting of the engines was voluntary and was only carried out by around 70% of VW owners. This means that a certain number of diesel engines that had not been retrofitted also passed the measuring device, thus worsening the average value.

For [commercial vehicles](#) with EA 189 engines—i.e., VW Caddy and VW Van—the results were significantly less impressive. The NO_x values for the 1.6-liter diesel were just 22% better than before (compared with 36% for passenger cars), and for the 2.0-liter diesel the emissions were actually 53% worse. The researchers suspect that fewer commercial vehicle operators had voluntarily carried out the retrofitting.

In Switzerland, retrofitting the EA 189 engine was mandatory. According to Amag company spokesman Dino Graf, all vehicles—both commercial vehicles and passenger cars—have meanwhile been retrofitted.

The good, the bad and the ugly

For comparison, Stuart Grange and his colleagues also examined the exhaust plumes of other vehicles before and after the diesel scandal, which did not need to be retrofitted. The [ambient temperature](#) plays a very important role here: The measurements before the diesel scandal were taken at an average of 20 degrees Celsius, the measurements after the diesel scandal at an average of 11 degrees Celsius. In another study last year, the researchers had already found dramatically higher NO_x emissions caused by diesel cars on cold days. This effect has now reappeared—but not for all manufacturers.

Cars from General Motors (Opel, Vauxhall, Chevrolet), Renault-Nissan and Fiat Chrysler Automobiles emitted almost twice as much NO_x into the environment on cold days as on warm days. VW's 3.0-liter diesel engine also had 55% higher NO_x values. But vehicles of the BMW Group (BMW, Mini), cars from Volvo and PSA (Peugeot, Citroën) and cars of the Indian brand Tata did not emit more NO_x on cold days. The engine management was obviously programmed more carefully.

However, VW demonstrated what happens when the engineers are allowed to make a real effort: After the diesel scandal and the software update, the NO_x values were significantly improved despite the significantly cooler weather.

Researchers recommend that all vehicles be retrofitted

In light of the results, the researchers now provide the approval and environmental authorities with a straightforward tip: The EU's NO_x limits are still being violated in many European cities. But depending on the European country, only between 30 and 90% of Dieseldate engines have been retrofitted. Since VW Group vehicles are very widespread, mandatory retrofitting could certainly make the NO_x limits easier to comply with.

Legislation has already tightened up in another area: Today's vehicles must pass the stricter WLTP cycle. Exhaust gases are now measured in the laboratory at 23 and 14 degrees Celsius; during road tests, outside temperatures down to -7 degrees are permitted. A car that emits significantly more NO_x in winter would no longer receive EU-type approval today.

More information: Stuart K. Grange et al. Post-Dieseldate: Evidence of NO_x Emission Reductions Using On-Road Remote Sensing, *Environmental Science & Technology Letters* (2020). [DOI: 10.1021/acs.estlett.0c00188](https://doi.org/10.1021/acs.estlett.0c00188)

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