A third of Euro VI trucks are still high emitters

Remote emissions measurement of trucks in Spain still show high on-road NOx emissions

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Remote emissions measurements of EURO VI trucks above 3.5 tonnes in two of Spain's largest cities (Madrid and Barcelona) over the course of three years (2017-2019) shows that the EURO VI truck fleet still includes high emitters. The trucks measured during the campaign represent a wide range of manufacturers and trucks on sale across the EU.

The data, obtained from the remote sensing company Opus shows that:

Overall, around a third of EURO VI trucks measured are high nitrogen oxides (NOx) emitters. Of the 587 measurements of light (3.5 to 12t, N2) and heavy (12t+) trucks, 169 exceeded the 7g/kg of fuel NOx remote sensing threshold above which the trucks are likely to be exceeding the legal NOx emission limits. High NOx emissions are of serious concern for air quality and public health as every year 50,000[1] people in Europe die prematurely due to nitrogen dioxide (NO_2) pollution[2] emitted from road transport and many cities still exceed the legal NO_2 air quality limits[3].

The presence of relatively new trucks sold post 2013 with high NOx emissions driving in or near EU cities shows that the EURO VI emissions regulation fails to safeguard air quality and the health of

[1] EEA. (2019) Air quality in Europe-2019 report .
[2] A component of NOx pollution, nitrogen oxide (NO), is also converted to NO_2 in the air.
[3] European Commision. (2018, 05, 17) Air quality: Commission takes action to protect citizens from air pollution.

Europe's citizens . While no conclusions can be drawn as to the reason for high emissions (such as poorly designed emission control systems or tampering) from remote sensing data alone, the EURO VI regulation fails to cover many normal on-road driving conditions such as low-speed driving and cold-start (emissions from when the engine is first turned on). Furthermore, the regulation itself does little or nothing to prevent tampering with emission critical systems. This is true even for the latest version (Step E) of the regulation.

The EU can improve air quality by shifting to zero emission trucks

Grossly polluting trucks driving on the EU's roads does not have to be the status quo. The Covid-19 crisis has shown that by reducing pollution from road transport it is possible to improve air quality in European cities.[4] To secure long term air quality improvements, in line with the EU's Green Deal 'Zero Pollution Ambition', a reduction in emissions from internal combustion engine (ICE) trucks and a shift away from polluting ICE towards truly clean, zero emission, options is necessary.

This requires the EU, as a priority, to rapidly increase the uptake of zero emission trucks, beyond the current fleet reduction targets in the truck CO2 standards. Zero emission trucks are now increasingly technologically ready and will enter the market for all haulage applications, including long-haul, over the coming years. The revision of the CO2 standards in 2022, needs to ensure that at least 50% of truck sales by 2030 are zero emission.

To achieve this, the current ZLEV (Zero and Low Emission Vehicle) incentive mechanism, which includes a super-credits scheme until 2024 and a voluntary bonus-only benchmark from 2025, needs to be replaced by a mandatory ZEV (Zero Emission Vehicle) target. In line with a gradually increasing ZEV target, the EU should adopt a differentiated sales phase-out for ICE heavy-duty vehicles, taking into account specific vehicle characteristics and operational needs. The sale of ICE trucks should end by 2035 for the vast majority of applications.

Besides, drastic improvements to the emissions performance of ICE trucks are critical, as even by the end of the decade ICE trucks are expected to account for a significant share of truck sales. Therefore, T&E calls on the Commission to consider the following key recommendations for inclusion in the Commission's new truck emissions regulation 'Euro VII' expected at the end of this year:

1. **Lower the emission limits for all pollutants to the lowest technically feasible levels.**

[4] T&E. (2021). Blue sky recovery: How to keep lockdown low levels of air pollution in European cities.

2. **Improve the heavy-duty on road Portable Emissions Measurement Systems (PEMS) testing procedure to cover all on-road driving conditions** to ensure that trucks meet the emission limits whenever and wherever they are driven.
3. **Introduce independent in use compliance testing run by the Commission and Member States** in order to ensure that vehicles meet the emission limits throughout their lifetime.
4. **Introduce a low load, low speed emission test** to ensure that trucks respect the emission limits when driving in cities.
5. **Extend the emission durability requirements to cover the entire truck lifetime** in order to ensure that emission limits are not exceeded as trucks age. This should cover a minimum of 1.3 million kilometers.
6. **Introduce robust anti-tampering measures** to prevent tampering with SCR systems.
7. **The Commission should develop a harmonised remote sensing procedure and publicly accessible cross-border database** to allow the Commission, Member States and cities to monitor the EU's vehicle fleet emissions and assist in identifying problem vehicles for further testing.

If implemented, these policies will help to ensure the transition to zero emission mobility in the heavy-duty sector, improve air quality for citizens across Europe and reduce the unnecessary public health burden that air pollution currently places on the EU.

1. Introduction

Air pollution is the largest environmental health risk in Europe and despite decades of tailpipe pollution limits, heavy duty trucks are still a large contributor to the air pollution crisis, with truck exhausts emitting many toxic pollutants which are harmful to human health or the environment.

One of the most harmful pollutants emitted from truck exhausts are nitrogen oxides (NOx), made up of both nitrogen oxide (NO) and nitrogen dioxide (NO_2). Nitrogen dioxide (NO_2), is responsible for over 50,000 premature deaths per year in Europe[5] as well as a cause of respiratory and cardiovascular disease and a potential death sentence for those suffering from asthma[6]. Nitrogen

[5] EEA. (2020) Air quality in Europe.
[6] T&E. (2020) Inquest into Ella Kissi Debrah's tragic death shows need for Clean Air Act.

oxide (NO) emissions are also a problem as the gas is readily converted to NO_2 in the air, hence emissions of both are regulated at the tailpipe through a combined NOx limit.

In Europe's big cities, trucks today contribute to between 12-26% of the total NOx emissions[7]. While emissions have generally decreased with the introduction of the Euro VI emission standard in 2013 , many Euro VI trucks still do not respect emission limits on the road. This occurs for a variety of reasons including regulatory loopholes, durability issues and tampering. Even the latest step of the Euro VI emissions regulation (Step E) fails to ensure emission limits are met under all conditions. This is partly due to the fact that the conditions covered in the emission measurement tests (conducted both in the laboratory and on the roads) fail to fully cover many normal on-road driving conditions, including cold-start (when the engine is first turned on) and low-load, low speed driving typical of driving in towns and cities. This can result in excessive emissions of pollutants[8], as engines and emission control systems are designed to meet the emission limits under conditions covered by the tests and not for good overall emissions performance on the road.

Independent truck emissions testing campaigns are therefore incredibly important for monitoring the real-world emissions performance of trucks throughout their lifetime. Remote emissions sensing (RS) is one of the technologies that can be deployed for the monitoring of truck fleet emissions and for identifying trucks which are at risk of exceeding the emissions limits on the road.

The main benefit of (RS) technology is that, unlike on road tests using Portable Emissions Measurement System (PEMS) or laboratory based tests, a large number of trucks can be screened very quickly without any intervention to the trucks itself, reducing the risk of test cheating and allowing a large number of vehicles to be screened quickly. Emissions are simply measured as the vehicle passes by the measurement device placed at the roadside. The emissions data can then be linked to other vehicle information, such as make, model, engine capacity and weight through number plate information. RS is particularly suitable for identifying high emitters i.e. those vehicles that emit many times higher than current emission limits or than the average vehicle on the road. When this data is combined with roadside police inspections, RS can also be an effective

[7] Based on Berlin, Budapest, London, Madrid, Paris and Brussels. Air Quality Consultants. (2021) Covid-19, Air Quality and Mobility policies: Six European Cities.
[8] Grigoratos. T. et.al.. (2019) Real world emissions performance of heavy-duty Euro VI diesel vehicles.

tool for finding and stopping tampered trucks, where the emission control system has been disabled and emitting large amounts of air pollution.

Many successful remote sensing campaigns have been carried out across the EU to date. Opus RSE (a European manufacturer of remote emissions sensing equipment) has to date, undertaken remote sensing campaigns in 10 EU Member States plus the United Kingdom resulting in hundreds of millions of vehicle emissions measurements[9], providing an invaluable insight into vehicles real world emissions performance.

This briefing highlights key results of three remote emissions sensing campaigns of Euro VI diesel N2 (3.5-12 tonnes) and N3 (> 12 tonnes) trucks conducted between 2017 and 2019 by Opus RSE in Spain, focusing specifically on high NOx emitters. The briefing also provides key policy recommendations for reducing pollution from the EU truck fleet.

2. Measurement campaign and data use

The NOx emission data of Euro VI diesel N2 (3.5 to 12t) and N3 (>12t) trucks presented in this briefing originates from two emission sensing campaigns undertaken by Opus RSE in Spain between March 2017 and October 2019. The details of each campaign are presented in table 1. In total 587 Euro VI trucks were measured using the Opus RSD5000 instrument. T&E obtained the results of the testing campaign directly from Opus RSE.

Table 1. Details of the Opus remote sensing measurement campaigns conducted in Spain in 2017-2019.

City	Location	Date	No. of N2 trucks	No. of N3 trucks	Avrage speed (km/h)	Average temperature (Celsius)
Barcelona	Mercabarna	March-May 2017	65	107	30	23
Madrid	Various locations on M-30 ring road	Nov. 2018 - Oct. 2019	337	78	37	18

Source: Opus

While official truck emissions tests undertaken either in the laboratory or on the road continuously monitor emissions throughout the entire test and the average results measured

[9] Opus website www.opusrse.com/about-us/our-businesses/. Accessed on the 11th of August 2021.

over the whole test are checked for compliance with the legal limit, remote sensing emission measurements provide a snapshot of tailpipe emissions at a single point in time. Remote sensing cannot therefore account for fluctuation in emissions that normally occur during driving. As such, to identify high emitters from remote sensing data it is necessary to set a higher threshold than the legal limit used for official type-approval tests in order to account for spikes in emissions. Emission spikes can exceed the legal limit at the point that the measurement is taken but on average the truck can still be compliant. Therefore, the high emitter threshold has to be set sufficiently high to not include false positives.

A recent study by the Danish Center for Environment and Energy set the NOx high emitter for Euro VI trucks at 7g/kg fuel. The study found this to be the threshold concentration at which the selective catalytic reduction (SCR) system used for reducing NOx emissions is probably malfunctioning or inactive, for example due to a cold engine at the start of the drive, therefore resulting in very high NOx emissions[10]. In comparison the current on road legal NOx limit for trucks is 0.69g/kWh, equivalent to approximately 3.26g/kg fuel[11], so the high emitter threshold is set at just over double the legal limit. The setting of the high emitter threshold at this level is also supported by a Flemish remote sensing study conducted in 2019 which found average truck Euro VI NOx emissions to be less than 4g/kg[12]. In line with these findings, T&E will use the 7g/kg fuel NOx threshold as the high emitter threshold for this briefing.

3. A third of trucks are NOx high emitters

During the measurement campaign, high emitting trucks were detected in both Barcelona and Madrid. In total 185 of the 587 Euro VI trucks measured in Spain between 2017-2019, exceeded the 7g NOx/kg of fuel threshold. This means that **around a third of the EURO VI trucks on the road are likely to be high emitters, exceeding the legal emission limits on the road**.

[10] Danish center for Environment and Energy. (2020) Control of SCR-systems using roadside remote sensing.
[11] Based on 40% brake specific fuel consumption as detailed in Pöhler, D., Roth, U., Bütler, T., Mossyrsch, A. (2019). Remote RDE measurement technology validation.
[12] Hooftman N., Ligterink N., Bhoraskar, A.(2020) Analysis of the 2019 Flemish remote sensing campaign. Commissioned by the Flemish Government - Flanders Environment Agency - Team Air quality policy.

Table 2. Number of high NOx emitting trucks measured at each location. N2 trucks are 3.5- 12 tonnes in size and N3 trucks are larger than 12 tonnes.

Location	No. of N2 trucks	% of trucks measured	No. of N3 trucks	% of N3 trucks measured	Total
Barcelona	24	37	43	40	67
Madrid	74	22	28	36	102
Total	**98**	**24**	**71**	**38**	**169**

Source: Opus

Particularly concerning are the driving conditions under which these high emissions were measured. In Barcelona and Madrid average driving speeds were 37km/h and 30km/h respectively, typical of driving speeds in cities and urban areas across the EU. High emissions in cities are the most concerning for human health as they occur where traffic is dense, next to where people go to school, work and live, polluting the air and worsening air quality for large numbers of citizens. A higher rate of N3 trucks were measured as high emitters, with 38% of the sampled trucks emitting above the high emitter threshold compared to 24% for smaller N2 trucks. This suggests that poor emissions performance in cities could be more endemic in larger trucks which are mostly used for long-haul haulage and whose emission control system may not be optimised for good urban emissions performance.

While it is impossible to determine from remote sensing data alone what is causing the vehicles' high emissions, this can be due to a number of reasons including tampering of the SCR NOx control system, a poorly designed emission control system that cannot deliver good performance under all driving conditions such as cold start (when the engine is first started) or which has durability issues and cannot therefore provide good emissions control throughout the lifetime of the vehicle.

Other independent studies measuring NOx emissions from trucks have also shown that Euro VI trucks can be high emitters and even the latest Euro VI D trucks can have poor emissions performance under a range of driving conditions[13]. However, the worst emissions performance is generally observed during low speed driving in cities and urban areas. Under those driving

[13] ICCT. (2020) Real world NOx performance of Euro VI-D trucks and recommendations for Euro VII.

conditions, NOx emissions for some truck exceed the legal limits many times over, in some cases by over eight times[14]. This poor emissions performance can be attributed to the loopholes in the Euro VI regulation which fail to ensure that trucks meet emission limits when driving slowly particularly at speeds between 10-30 km/h, i.e. speeds which are typical in cities.

Overall, it is clear from the remote sensing measurements in Barcelona and Spain, that many trucks on the road today are still high emitters, releasing large amounts of toxic NOx pollution into the air. Swift changes in EU regulation are needed to combat this problem. Section four of this briefing presents the policy recommendations that should take place in order to combat pollution from heavy-duty vehicles.

4. Summary and Policy recommendations

The continuing presence of high NOx emitters in the Euro VI truck fleet as identified by remote sensing in Spain is deeply worrying as ultimately what matters for air quality is how trucks perform on the road and not just on-paper compliance. While tweaks to the emissions regulation can reduce pollution from heavy-duty vehicles and reduce the risk of high emitters, this is only a temporary plaster on the problem of pollutant emissions from trucks. In the long term, for the EU to achieve it's 'Zero Pollution' ambition, pollutant emissions from trucks have to be eliminated altogether.

This requires the EU, as a priority, to rapidly increase the uptake of zero emission trucks, beyond the current fleet reduction targets in the truck CO2 standards. Zero emission trucks are now increasingly technologically ready and will enter the market for all haulage applications, including long-haul, over the coming years. The revision of the CO2 standards in 2022, needs to ensure that at least 50% of truck sales by 2030 are zero emission.

To achieve this, the current ZLEV (Zero and Low Emission Vehicle) incentive mechanism, which includes a super-credits scheme until 2024 and a voluntary bonus-only benchmark from 2025, needs to be replaced by a mandatory ZEV (Zero Emission Vehicle) target. In line with a gradually increasing ZEV target, the EU should adopt a differentiated sales phase-out for ICE heavy-duty vehicles, taking into account specific vehicle characteristics and operational needs. The sale of ICE trucks should end by 2035 for the vast majority of applications.

[14] ICCT. (2021, 11, 26) Findings from recent ICCT research on vehicle emission standards. Presentation to the Advisory Group on Vehicle Emission Standards.

In addition, the upcoming 'Euro VII' Commission proposal expected at the end of this year is the perfect opportunity for the EU to swiftly reduce pollution from all trucks sold in the EU and eliminate the loopholes which allow heavy-duty vehicles to emit more than the legal limits on the road. These improvements are crucial as even by the end of the decade ICE trucks are expected to account for a significant share of truck sales. T&E recommends that the following key recommendations are incorporated into the 'Euro VII' proposal:

1. **As a priority, reduce pollutants to the lowest possible.** Lower emissions limits than the Euro VI limits set more than a decade ago are already technically feasible. California has already set into law new emissions standards for trucks, which for NOx are more than ten times lower than the Euro VI limit[15]. The standard also requires emissions to be low during low speed driving in cities and urban areas. Similarly, CLOVE (the consortium working on future emission standards on behalf of the European Commission) has shown that emissions from trucks can be reduced, proposing 2.6 times lower NOx emission limits at cold start (when the engine is first started) and 5 times lower once the engine is hot[16].

   Emission limits for Euro VII must reduce emissions for all pollutants to the lowest technically possible level. They must also be fuel neutral and apply to all internal combustion engines, including compressed/liquified natural gas (CNG/LNG), advanced/synthetic fuels and hybrids.

2. **Introduce independent in use compliance testing run by the European Commission and Member States.** Robust and independent in-use emission compliance testing is critical to ensure that all trucks respect the emission limits under all driving conditions throughout their entire lifetime. Light-duty cars and vans are subject to mandatory independent in-use compliance testing undertaken by the Member States and the Commission, with the results made publicly available on a yearly basis. This is not the case for trucks or buses, for which in-use compliance testing is run by the vehicle manufacturer. This leaves the system open to potential abuse and cheating. Independent in-use compliance testing of heavy-duty vehicles is possible, with some Member States,

[15] Compared to the World Harmonised Transient Cycle limit.
[16] Compared to the World Harmonised Transient Cycle limit.

including The Netherlands[17] and previously the UK [18], already voluntarily undertaking such activities.

To ensure a comprehensive in-use emissions testing system that covers all trucks on sale in the EU, the regulatory obligation to independently test trucks and buses throughout their lifetime should be placed on the Member States as well as the Commission, in line with the requirements for light-duty vehicles.

3. **Improve the heavy-duty on road Portable Emissions Measurement Systems (PEMS) testing procedure to cover all on road driving conditions.** On-road PEMS tests are the most effective testing tool to ensure good emissions performance of trucks at type-approval and in-use. However, despite improvements with each subsequent step of the Euro VI regulation, the test procedure is still too narrow, excluding many typical driving conditions, essentially allowing trucks to exceed emission limits when driven outside of these conditions.

   To ensure low emissions under all driving condition, Euro VII must close these loopholes, on-road testing must begin from the first start of the engine (so-called 'cold start' emissions), there should be no minimum power or load threshold, and limits should apply on all tests including those during which a diesel particle filter (DPF) or lean NOx trap (LNT) cleaning a.k.a 'regeneration' takes place.

4. **Introducing a low load, low speed emission test to ensure that trucks respect the emission limits when driving in cities.** One of the driving conditions that is currently not well covered by any truck emission test is low speed, low load driving, typical of lightly loaded delivery trucks and garbage trucks operating in cities.

   To ensure that trucks meet the emission limits under these driving conditions a new low load, low speed emission test should be introduced for type-approval and in use compliance testing. Such a test has already been adopted for use in California by CARB (California Air Resources Board)[19].

[17] TNO. (2016) The Netherlands in-service emissions testing programme for heavy duty vehicles 2015-2016-annual report.
[18] DVSA. (2018) Vehicle Market Surveillance Unit Results of the 2019 vehicle emissions testing programme.
[19] CARB. (January 23rd 2019) Heavy-duty low NOx program workshop.

5. **Extend the emission durability requirements to cover the entire lifetime of a truck.** The emission durability requirements define the length of time/ distance during which trucks must respect the emission limits. At present, for trucks, this is only 7 years/700,000 km (whichever comes first) falling short of the average age of trucks in the EU (12 years) and far short of the average age in eastern and southern Europe which can be up to 19 years[20]. In order to ensure lifetime emissions compliance, the EU must substantially increase the truck emissions durability requirements by aligning them with real EU vehicle lifetimes including those in Southern and Eastern Member States. Failure to do so risks shifting the pollution problem to less affluent Member States when everyone in Europe has the right to breathe clean air irregardless of where they live.

   Euro VII should extend the minimum emission durability requirements for trucks to 1.3 million kilometers. This is the durability requirement set in California and as such has already been demonstrated to be technically feasible.

6. **Introduce robust anti-tampering measures to prevent emissions cheating.** Disablement of the selective catalytic reduction (SCR) system used for truck NOx control, results in huge NOx emissions and is a big problem in the EU. A recent Danish study found that 61% of high emitting trucks had been tampered with indicating that current regulatory measures are insufficient[21].

   Euro VII needs to require that all emission control systems are robustly designed to prevent any possible tampering. Additionally, Member States should step up their efforts in detecting and taking off the road trucks that have been tampered as those vehicles are a public health risk.

7. **Develop a harmonised remote sensing procedure and publicly accessible cross-border database.** Remote sensing measurements are an invaluable tool to detect high emitters and emissions issues.

   To ensure that collected remote sending data can be used to its maximum potential, a remote sensing procedure and publicly accessible cross-border database should be

[20] ACEA. (2019-2020) The Automobile Industry Pocket Guide.
[21] Danish center for Environment and Energy. (2020) Control of SCR-systems using roadside remote sensing.

developed. This would allow the Commission, Member States and cities to monitor the EU's vehicle fleet emissions and assist in identifying problem vehicles for further testing and investigation.

The Commission needs to propose an ambitious Euro VII proposal to reduce pollutant emissions from trucks in the short term. However, in order to ensure that the transition to a pollution free future happens as fast as possible mandatory sales targets for zero emission trucks are required as a priority as only the transition to zero emission transport will deliver the clean air that Europe deserves.

Further information

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