Euro 7: Europe's chance to have clean air

Recommendations for the upcoming Euro car and van emission standard.

September 2021

Summary

Five years on from the dieselgate scandal which rattled headlines and shook confidence in the EU's emissions regulation, the European Commission is set to finally propose a new tailpipe pollutant emission standards for cars and vans, known as Euro 7, at the end of this year. This gives the European Union the final opportunity to tackle toxic air pollution from cars and vans which continue to choke citizens across Europe. To be successful, the EU needs to be ambitious. It must regain the global regulatory leadership lost after dieselgate by proposing new comprehensive standards aligned with the EU's 'zero pollution ambition' as well as the objective of net-zero greenhouse gas emissions by 2050.

The need for another Euro emission standard for cars and vans is clear. Road transport remains the **main source of toxic NO2 (nitrogen dioxide) emissions** -the pollutant at the heart of the dieselgate scandal- and the **third largest source of PM2.5** (particulate matter smaller than 2.5 microns)[1]. Air pollution is particularly bad in traffic choked cities with many EU cities still exceeding the World Health Organisation's Air Quality Guidelines. Air pollution from road transport causes a wide range of health issues including inflammation of the airways, increased asthma attacks and premature deaths - disproportionately affecting those who are vulnerable including children, the elderly as well as those who are economically disadvantaged and costs tens of billions in health costs[2].

Despite myriad EV days and announcements by car makers, the reality is that the majority of new cars and vans sold today still have a polluting engine. Even with the EU proposing the potential goal to go to 100% zero emission cars from 2035 (which will not be agreed until 2023), new polluting internal combustion engine (ICE) cars and vans will continue to be sold in large numbers in the EU for another 14 years (and for much longer in the second hand market). In fact, more than half of all annual sales

[1] EEA. (2020) Air quality in Europe.
[2] EPHA. (2020). Health impacts and costs of diesel emissions in the EU.

will remain petrol or diesel until at least 2030. **T&E forecasts that almost 100 million more ICE cars will be sold between 2025 (when Euro 7 is expected to enter into force[3]) and 2035[4]**. These cars will remain on the road, on average, for more than a decade[5] and much longer in Eastern and Southern Europe, often in excess of 15 years[6]. This means **there is at least another quarter of a century of polluting cars on the EU's roads**.

Euro 7 is Europe's last chance to slash toxic pollution from engines and it cannot be missed, an ambitious Euro 7 could reduce total EU NOx emissions by 4.2 million tonnes by 2050 and avoid 35,000 premature deaths[7]. The proposal put forward by the Commission at the end of the year must be **a comprehensive revision of the outdated Euro 6 standard, reducing pollution to the lowest technically feasible levels and closing all loopholes left behind from the dieselgate era.** Such as: the 25% higher NOx emission limits for diesel compared to petrol, no emission limits during particle filter cleaning (a.k.a. DPF regeneration), fast accelerations or when driving in hilly regions. Thanks to technological progress like the development of electrically heated catalysts, and high efficiency particle filters, lower emission limits are already technically feasible. Tests show that half of new cars tested on the road already emit less than half of the nitrogen oxide (NOx) emission limit[8].

New Euro 7 proposals put forward in April by the consortium of emissions experts from across Europe known as CLOVE (Consortium for ultra Low Vehicle Emissions) working on developing Euro 7 on behalf of the Commission, go some way to achieving this by tackling the many shortfalls plaguing Euro 6. The proposals include: **lower emission limits for all regulated pollutants which apply on the road not just in the laboratory[9], extension of on road driving conditions covered by Real Driving Emissions (RDE) tests, enhanced durability requirements, regulation of additional pollutants including small particles and brake emissions and on-board emission monitoring (OBM)[10]**. The technology needed for cars to meet the standard is already available and relatively cheap. The European Commission recently announced that **Euro 7 will cost between 100-500 € per car**- depending on the

[3] Entry into force used for the European Commission's impact Assessment in between 2025-2027. European Parliament Committee on the Environment, public health and food safety. (15th June 2021).
[4] T&E modelling of car CO2 standards, EU27+UK sales (UK buys EU type-approved cars).
[5] ACEA. (2020) Automobile industry pocket guide.
[6] Sofiaplan. Programme for Sofia 1.6. Transport Infrastructure. Territorial area and analysis of the situation.
[7] ICCT. (2021) Comments to the European Commission on the development of Euro 7/VII pollutant emissions standards for cars, trucks and buses.
[8] CLOVE. (8th April 2021) Presentation to the Advisory Group on Vehicle emission standards: Light-duty.
[9] Since the introduction of RDE testing in 2017 on-road emission limits only apply for nitrogen oxides (NOx) and particle number (PN).
[10] As presented to the Advisory Group on Vehicle Emission Standards (AGVES) on the 8th and 27th of April 2021. Proposals put forward by CLOVE can be accessed within the library of AGVES on the European Commission's CIRCABC website.

stringency of the regulation[11]- less than a paint upgrade on an entry level car model such as the VW Golf or Ford Fiesta[12].

However, while the CLOVE Euro 7 proposals are good, with some improvement the European Commission's proposal expected at the end of the year can bring the clean air that Europe's citizens deserve. A few targeted improvements will ensure the adoption of best available emission control technology -such as electrically heated catalysts- are used to their full potential in order to reduce emissions down to the lowest technically possible levels. The improvements that are needed include:

1. **The minimum reduction of pollutant emission limits that should be considered for Euro 7 must be the ambitious pollutant emission limits proposed for Euro 7 by CLOVE.** Only the lowest limits proposed, will ensure that the best emission control technology is fitted to new cars and toxic pollution is reduced to the lowest levels. For regulated pollutants the proposed Euro 7 limits are shown in the table below. Alongside lower limits for regulated pollutants, limits for currently unregulated pollutants need to also be reduced to the lowest technically feasible levels. For the greenhouse gases methane and nitrous oxide this is 10mg/km or less and for the toxic gas formaldehyde 5mg/km or less. The emission limit for ammonia -which causes secondary particle pollution- needs to be reduced from the currently proposed 10mg/km, closer to 1mg/km to ensure that abatement technologies that can reduce ammonia emissions to the lowest such as ammonia slip catalysts (ASC) are fitted to all new cars.

Pollutant	Nitrogen oxides (NOx)	Particle number (PN)	Particulate Mass (PM)	Carbon Monoxide (CO)	Non-methane organic gases (NMOG)
Euro 6	80 mg/km[13]	$6x10^{11}$/km for particles larger than 23nm	4.5mg/km	1000 mg/km[14]	68 mg/km[15]
Euro 7	**20 mg/km**	**$1x10^{11}$/km for particles larger than 10nm**	**2mg/km**	**400 mg/km**	**25 mg/km**

[11] European Parliament Committee on the Environment, public health and food safety. (15th June 2021).
[12] Price checked on www.ford.de and www.volkswagen.de on 07/09/2021.
[13] Euro 6 diesel limit, 60mg/km is the petrol Euro 6 limit
[14] Euro 6 petrol limit, 500 mg/km is the petrol Euro 6 limit
[15] Euro 6 petrol non-methane hydrocarbon limit. Diesel emissions are regulated through a combined nitrogen oxide (NOx) and HC limit of 170 mg/km.

2. **Cold start emission requirements (i.e. emissions when the engine is first started, which can contribute to the majority of trip NOx emissions) need to be strengthened in order to improve air quality in towns and cities where the majority of cold starts happen.**
   a) The distance over which the proposed cold start emission budget applies needs to be reduced to 8km or less from the 16km proposed today, to ensure that typical city trips are adequately covered.
   b) The cold start budget emission limit should be decoupled from the overall emission limit and the NOx budget subsequently reduced to 200mg, i.e. closer to the lowest emissions feasible today when the best technology such as e-catalysts are used to their full potential. A reduction in the budget for other key pollutants should also be considered.

3. **The requirements which apply under 'extended' on road RDE driving conditions must be strengthened:**
   a) Emission limits applicable under 'extended' RDE boundary conditions need to be revised downwards, closer to the limits which apply under 'normal' driving conditions. CLOVE's data does not support the three times higher emission limits under 'extended' conditions -outside of the cold start period (when the engine is first started)- suggested currently. Such a high multiplier would give Euro 7 cars an unfair license to pollute when driving at higher altitude or in hot weather and is much higher than the 1.6 multiplier applicable in extended conditions to Euro 6d-temp and 6d cars today.
   b) Only driving conditions which are very rare and extreme should fall under 'extended' driving conditions for on-road RDE tests in order to ensure that cars are as low emission as possible when driving on the road. Normal RDE temperature boundaries should be extended to include all temperatures regularly experienced in the EU, between -10 to 40 ℃.

4. **Durability requirements must be extended to cover the entire vehicle lifetime** in order to prevent the export of pollution to Eastern, Southern and Central European Member States which import large numbers of second hand cars. As a minimum, the durability requirement must be increased from the 15 years (proposed by CLOVE) to 20 years, with deterioration factors applicable thereafter. In addition, the introduction of an emissions warranty scheme for emission critical components should be considered to ensure that car manufacturers design their emission control systems to last and protect consumers from repair bills that are due to inadequate durability or design flaws.

5. **More ambitious brake particle emission limits for all powertrains are needed to reduce this large source of particle pollution.** The Euro 7 limit put forward by the Commission must be below the most ambitious 5mg/km limit proposed by CLOVE in order to drive a quick adoption of the most effective technology for reducing brake particle pollution such as vacuum aspiration.

6. **If, for Euro 7, conformity factors (CF) are to be integrated within the emission limits for each pollutant, as proposed by CLOVE, the Commission needs to ensure that the CF's applied reflect the actual measurement uncertainty of future best in class emission measurement equipment and not provide car makers with an unjust license to pollute**. Current CLOVE proposals include a conformity factor of 1.15 for nitrogen oxide (NOx) and 1.5 for particle number (PN). However, the Commission's own Joint Research Center (JRC) have recently found that with improvements to the Portable Emissions Measurement System (PEMS) the conformity factor can be reduced to 1.1 for NOx and 1.34 for PN[16]. Conformity factors have been misused in the past to drastically undermine the real world effectiveness of Euro 6d-temp and 6d emission regulations. If Euro 7 is to include any sort of CF in the limit, it may only reflect actual measurement uncertainties and be based on the newest science and best in class equipment.

For Euro 7 to be successful, **all aspects proposed by CLOVE need to be introduced together as a comprehensive package of measures.** Anything less, such as a limited revision of Euro 6 which, for example, only reduces pollutant emission limits while disregarding improvements to durability or testing conditions will do little to improve cars' real world emissions performance. It will also show that the EU failed to learn from the dieselgate scandal reducing Euro 7 to a greenwashing exercise.

Without an ambitious and comprehensive Euro 7 standard in 2025, unnecessarily polluting cars will remain on the EU's roads for another quarter of a century. For the sake of its citizen's health and the environment, the EU cannot afford to squander its last opportunity to clean up toxic pollution from internal combustion engines. It is now in the Commission's hands to bring forward an ambitious proposal at the end of the year and prove that the EU is committed to the anti-pollution promises made in the Green Deal.

[16] JRC. (2020) Real Driving Emissions (RDE): 2020 assessment of Portable Emissions Measurement Systems (PEMS) measurement uncertainty.

1. Introduction: Why are new car and van emission standards needed?

EU emission standards for cars were first introduced almost thirty years ago in 1992 to tackle toxic air pollution from cars and vans. The new standards, in effect, required for the first time the fitting of catalytic converters to reduce dangerous air pollution from the tailpipe. Since then, there have been five progressively more stringent 'Euro' standards, with the latest Euro 6 limits agreed upon in 2008. However, an over reliance on laboratory tests and failure to check on-road emissions compliance lead to the 'dieselgate' scandal uncovered in 2015. Car makers were found to be cheating on tests and cars were found to be emitting up to 18 times the legal NOx limits on the road[17]. Several EU car makers, including PSA and VW, were implicated and the scandal resulted in a legacy of 51 million grossly polluting cars on EU roads[18]. Steps taken by the EU afterwards to fix the regulatory errors which allowed dieselgate to happen include the introduction of on-road Real Driving Emissions (RDE) tests in 2017, in-use on-road compliance testing and fines. These finally forced car makers to comply with EU limits on the road for the first time in history.

While the improvements brought in after dieselgate have generally reduced emissions from cars on the road, loopholes lobbied in by the car industry[19] and weak, outdated Euro 6 limits set over a decade ago mean that even the latest Euro 6d-temp/6d internal combustion engined cars continue to emit large amounts of pollution and frustrate efforts to clean up the EU's air. Examples of the regulation's shortcomings include 25% higher NOx emission limits for diesel compared to petrol, NOx emissions limits which are more than double those already set in the U.S.A and China and many normal on-road driving conditions not covered by RDE tests. This includes fast accelerations, driving in hilly regions[20] or particle filter cleaning[21]. Under those conditions limits do not need to be met, essentially giving car makers a license to pollute. T&E testing[22] of the latest diesel cars in 2019 showed that particle number emissions can be more than double the legal limit on tests where a particle filter cleaning (a.k.a DPF regeneration) occurs.

Yet, a more stringent Euro standard is technically feasible. Technological progress - such as the development of electrically heated catalysts and dual dosing Selective Catalytic Reduction (SCR) systems- since the last Euro 6 standard was set in 2008 means that already today drastically lower emission limits are possible, demonstrated by lower NOx limits set in other regions such as China. Public opinion on air pollution has also shifted since the advent of Euro 6, EU citizens' now overwhelmingly demand cleaner

[17] T&E. (2018) Cars with engines: can they ever be clean?
[18] T&E. (2019) Dirty diesels grow to 51 million across EU, as carmakers still put profit before clean air.
[19] ACEA. (17th February 2015) ACEA RDE Compromise Status.
[20] Suarez-Bertoa,.R., Et. al.. (2019) On-road emissions of passenger cars beyond the boundary conditions of the real-driving emissions test. Environmental Research.
[21] For particle number and mass emissions.
[22] T&E. (2020) New diesels, new problems.

air- a pan European YouGov survey across 21 of Europe's largest cities shows that 2 in 3 city dwellers don't want to go back to pre-lockdown air pollution levels[23].

The need for another Euro standard is clear, sadly, road transport remains the main source of toxic NO2 (nitrogen dioxide) emissions -the pollutant as the heart of the dieselgate scandal- and the third largest source of PM2.5 (particulate matter smaller than 2.5 microns)[24]. Air pollution is particularly bad in traffic choked cities with many EU cities still exceeding the World Health Organisation's Air Quality Guidelines. Despite the ongoing transition to electromobility and the recently proposed EU phase out of internal combustion engined cars by 2035, ICE cars will still continue to be sold in large numbers in the EU for another 14 years (and for much longer in the second hand market). In fact more than half of all annual sales will remain petrol or diesel until at least 2030. T&E forecasts that 95.8 million more ICE cars will be sold between 2025 (when Euro 7 is expected to enter into force[25]) and 2035[26]. These cars will remain on the road in the EU for more than a decade[27] and much longer in Eastern and Southern Europe, often in excess of 15 years[28]. This means there is at least another quarter of a century of polluting cars on EU roads. In essence, the transition to zero emission mobility is simply not happening fast enough to make a new Euro 7 standard obsolete.

In 2020, T&E published its position paper[29] outlining key principles and recommendations for a new vehicle emission standard 'Euro 7'. This new policy brief is an update on T&E's position, based on the latest data and zooms in on aspects of CLOVE's (Consortium for ultra Low Vehicle Emissions working on Euro 7 on behalf of the Commission) Euro 7 proposal for cars and vans that should be strengthened in the upcoming Commission proposal to deliver the clean air benefits that Europe needs.

2. How close is the EU to proposing a new car and van emission standard?

Since 2018, the European Commission has been working on a new vehicle emission standard known as post Euro 6, or Euro 7, to further reduce pollution from light and heavy duty vehicles i.e. cars, vans, trucks and buses. The new regulation is an integral part of the EU's Green Deal, Sustainable and Smart Mobility Strategy and Zero Pollution Action Plan.

As part of the Euro 7 policy development process, the Commission assigned a cross-European consortium of car emission experts known as CLOVE to investigate how the EU vehicle emissions regulation could be

[23] T&E. (2020) No going back: European public opinion on air pollution in the Covid-19 era.
[24] EEA. (2020) Air quality in Europe.
[25] Entry into force used for the European Commission's impact Assessment in between 2025-2027. European Parliament Committee on the Environment, public health and food safety. (15th June 2021).
[26] T&E modelling of car CO2 standards, EU27+UK sales (UK buys EU type-approved cars). Further details available upon request.
[27] ACEA. (2020) Automobile industry pocket guide.
[28] Sofiaplan. Programme for Sofia 1.6. Transport Infrastructure. Territorial area and analysis of the situation.
[29] T&E. (2020) Road to Zero: the last EU emission standard for cars, Vans, buses and trucks.

improved. For over two years CLOVE have been investigating air pollution issues in Euro 6d-temp and 6d cars, assessing the effectiveness of the Euro 6 regulation including RDE testing and exploring the potential, costs and feasibility of new exhaust emission control technologies to set new emission limits and test conditions to further reduce emissions from road transport.

In April of this year the CLOVE consortium presented to the Commission's Advisory Group on Vehicle Emissions Standards (AGVES) the results of their work. This included proposals for a wide range of changes to the cars and vans emissions regulation, among many suggested improvements:

- **Lower emission limits** presented as two potential emissions limit scenarios 1 and 2 (table 1). Scenario 2 is the most ambitious proposal requiring the largest decrease in tailpipe emissions of key pollutants.

Table 1: Euro 6 and CLOVE Euro 7 proposed car emission limits for currently regulated pollutants[30].

Pollutant	NOx (mg/km)	PN (#/km)	PM (mg/km)	CO (mg/km)	NMOG (mg/km)
Euro 6	80/60 (Diesel/petrol)	$6x10^{11}$ inc. all >23 nm PN	4.5	500/1000 (Diesel/petrol)	68 (petrol) as non-methane hydrocarbon limit
CLOVE Scenario 1	30	$1x10^{11}$ inc. all >10nm PN	2	400	45
CLOVE Scenario 2	20	$1x10^{11}$ inc. all >10nm PN	2	400	25

- **Regulation of additional pollutants** including very small 10-23nm particle number emissions, ammonia, formaldehyde and the greenhouse gas nitrous oxide as well as the introduction of the non-methane organic gases (NMOG) limit instead of the current non-methane hydrocarbon limit in order to cover a wider range of organic pollutants. Emission limits for brake particles are also included.

- **New testing requirements** which cover a wider range of on-road driving conditions as part of RDE testing than required for the latest Euro 6d cars and vans (table 2).

Table 2: Summarised Euro 6 and CLOVE Euro 7 proposed Real Driving Emissions (RDE) test boundaries

[30] Separate limits not detailed here are proposed for vans with a permissible maximum laden mass (TPMLM) >2500kg and a power-to-weight ratio of <35 kW/t.

Parameter	Euro 6 RDE boundaries	Euro 7 normal boundaries	Euro 7 extended boundaries
Temperature (℃)	Moderate: 0 –30 ℃ | Extended: -7 –0 ℃ & 30 –35 ℃	-7 to 35 ℃	-10 to +45 °C
Maximum altitude (m)	Moderate: 0 –700 | Extended: 700 –1300	1600	2200
Speed(km/h)	Maximum: 145 km/h with maximum 5 minutes at 160 km/h | Average urban: 15-40 km/h	Maximum: <160km/h | Average urban: as per normal use	Maximum: All EU conditions | Average urban: as per normal use
Trip distance (km)	Min. 16km in each segment (urban, rural, motorway), restrictions on trip composition	Any	Any
Driving dynamics and altitude gain	Restrictions on acceleration and positive altitude gain	Restrictions the first 1-2km	As per normal use
Towing/ aerodynamic modifications	Not allowed	Not allowed	Allowed

- **Enhanced durability requirements** increasing the period during which emission limits must be met and in-service conformity testing can be performed from 5 years/100,000km (whichever comes first) to 15 years/ 240,000km.

- **Introduction of on-board monitoring (OBM) of pollutants** to constantly monitor tailpipe concentrations of pollutants using sensors and models to verify compliance with limits and detect tampering thus aiding emissions compliance monitoring.

Based on CLOVE's research and proposals as well as the work of the Commission's Joint Research center and independent studies, the Commission is expected to publish a draft Euro 7 regulation along with an Impact Assessment at the end of this year.

3. A strong emission standard is at risk

While CLOVE's proposals are a significant improvement on the current Euro 6 regulation, the biggest risk for cleaner air remains that, pushed by the automotive industry which has been vocal in their opposition to Euro 7[31], the European Commission decides to not proceed with a new Euro standard. This would be bad news for air quality as the latest research shows that an ambitious Euro 7 could reduce total NOx emissions by 4.2 million tonnes by 2050, avoiding 35,000 premature deaths and 568,000 years of life lost across the EU[32]. If the Commission fails to bring forward a proposal, the EU would miss the last opportunity to reduce ICE emissions and make improvements to air quality, human and environmental health. If the EU is serious about its commitment to the recently published Zero Pollution Action Plan, which includes reducing pollution from transport, it should not allow this to happen.

Another risk is that the Commission decides to make minimal cosmetic changes to Euro 6 only, such as by setting emission limits to levels already achievable by many cars on sale today. These changes would appear to be an improvement on paper but in reality, would result in minimal real world emissions reductions and only requiring improvements to the dirtiest of new cars. The Commission could also choose to only implement some of the improvements proposed by CLOVE for example by reducing limits but not improving durability or testing requirements. This would result in a new regulation riddled with the same loopholes as Euro 6 again bringing about only very limited improvements to car emissions.

To be effective in driving large reductions in emissions from cars and vans that the EU needs, Euro 7 must include a wide range of measures that tackle the emission issues faced by Euro 6d-temp/6d cars today. Since the Commission plans for Euro 7 to be the last emission standard for internal combustion engines it must ensure that the standard tackles all loopholes left behind by Euro 6 and reduces pollution from cars and vans to lowest feasible levels. There is no longer time to bring in small incremental changes as with previous Euro standards. Euro 7 needs to be a full overhaul of the current regulation and must bring in all of the most ambitious aspects proposed by CLOVE. As already covered in T&E's Euro 7 position paper published last year[33] this requires Euro 7 to:

1. **Set the EU car and emission limits to the lowest levels technically possible.** As a minimum reduction this would be the scenario 2 limits proposed by CLOVE.
2. **Regulate all pollutants which are harmful to human health and the environment and can be effectively regulated at the tailpipe.** This includes smaller than 23nm particles, ammonia, formaldehyde, non-methane organic gases and the greenhouse gas nitrous oxide. Particle pollution from brakes should also be regulated for all cars.

[31] Euroactiv. (2nd March 2021) EU plotting ban on internal combustion engines as of 2025: industry.
[32] ICCT. (2021) Comments to the European Commission on the development of Euro 7/VII pollutant emissions standards for cars, trucks and buses.
[33] T&E. (2020) Road to Zero: the last EU emission standard for cars, vans, buses and trucks.

3. **Improve testing, approval and certification of vehicles to make sure that cars meet emission limits whenever and wherever they are driven.** This should be achieved by extension of on-road testing to all possible driving conditions that can be encountered on the EU's roads.
4. **Ensure that emission limits are met throughout the lifetime of the vehicle.** This should include an extension of the durability and in-service testing requirements to a minimum of 20 years/240,000km with deterioration factors applicable thereafter. On-board emissions monitoring (OBM) technology should also be introduced to aid with compliance monitoring. Remote sensing for fleet emissions monitoring should also be considered.

Implemented together with a new Euro VII emission standard for trucks and buses, this will ensure that pollution from road transport is reduced to the lowest possible levels.

Overall, T&E welcomes CLOVE's proposals for Euro 7 which are a significant improvement on Euro 6 and tackle many of the standard's loopholes and shortfalls such as emission limits only applying under a narrow range of driving conditions or for a very short period of the car's or van's lifetime. If all of the most ambitious aspects of CLOVE's proposals are included as a combined package within the Commission's upcoming Euro 7 proposal there would be a significant reduction in pollutant emissions from internal combustion engines. However, despite the improvements, some areas still lack the necessary ambition required to bring emissions from internal combustion engines down to the lowest technologically possible levels and thus the greatest air quality benefits. The next part of the briefing provides recommendations on how CLOVE's proposals can be further strengthened to provide the most robust Euro 7 regulation.

4. Emission limits

More stringent pollutant emission limits than in force today are required for all pollutants emitted from internal combustion engines, which are harmful to human health or the environment, and can be effectively regulated at the tailpipe in order to improve air air quality and reduce the impact that cars and vans have on human and environmental health.

4.1 Regulated pollutant limits

As part of the proposals for Euro 7, CLOVE have proposed emission limit reductions for all regulated pollutants. Two different technology neutral emission limit scenarios have been proposed, with scenario two being the most ambitious. The proposed limits for already regulated pollutants: nitrogen oxides (NOx), particle number (PN), particle mass (PM) and carbon monoxide (CO) are shown in table 3. CLOVE have also proposed to regulated hydrocarbons, previously regulated through a non-methane hydrocarbon limit (NMHC) for petrol cars and a combined hydrocarbon and NOx limit (HC+NOx) for diesel cars through a new non-methane organic gas (NMOG) limit as used in the U.S.A in order to cover a wider range of organic gases.

Table 3: Euro 6 and CLOVE Euro 7 proposed car emission limits for currently regulated pollutants

Pollutant	NOx (mg/km)	PN (#/km)	PM (mg/km)	CO (mg/km)	NMOG (mg/km)
Euro 6	80/60 (Diesel/petrol)	$6x10^{11}$ inc. all >23 nm PN	4.5	500/1000 (Diesel/petrol)	100 (petrol) as hydrocarbon limit
CLOVE Scenario 1	30	$1x10^{11}$ inc. all >10nm PN	2	400	45
CLOVE Scenario 2	20	$1x10^{11}$ inc. all >10nm PN	2	400	25

While the reduction in emission limits under both scenarios is welcome, scenario 1 does not go far enough to reduce NOx emissions from internal combustion engines. Data both from CLOVE and independent tests shows that many petrol and diesel 6d-temp and 6d cars sold today can already meet the NOx limit of 30 mg/km both inside and outside of current RDE test boundary conditions .

CLOVE's own RDE tests of Euro 6d-temp and 6d cars show that 75% of tests meet the Scenario 1 NOx limit in urban driving, and 87% on the overall test. Even outside of current RDE test boundaries - i.e. in more challenging driving conditions that are outside compliance with Euro limits today - more than half of tests were below the limit[34]. Similarly, on road RDE tests commissioned by T&E of Euro 6d-temp BMW X5, Volvo XC60 and Mitsubishi Outlander plug-in hybrid petrol cars in 2020 showed similar results. NOx emissions were less than half of the CLOVE scenario 1 limit, not exceeding 14 mg/km on any of the tests including during urban driving[35]. These results highlight that the scenario 1 NOx emission limit would in reality only require a marginal improvement in the emissions performance of most petrol and diesel cars. Only a few car makers, which did the minimum to meet the current Euro 6 standards, would need to make larger changes to their cars.

The more stringent, 20mg/km NOx emission limit (CLOVE scenario 2) is achievable for both diesel and petrol cars. CLOVE have demonstrated that cars fitted with Euro 7 emission technologies such as electrically heated catalysts and larger exhaust treatment systems emit 10mg/km or less of NOx outside of the cold start period (i.e when the engine is first started) both under the normal and extended RDE boundary conditions proposed by CLOVE[36] for Euro 7. Independently of CLOVE's work, the engineering company AVL[25] has built diesel and petrol demonstrator cars which can achieve below this limit. The

[34] CLOVE. (8th April 2021) Presentation to the Advisory Group on Vehicle emission standards: Light-duty.
[35] Emissions Analytics. (2020) Transport & Environment: Plug-in hybrid RDE testing.
[36] CLOVE. (8th April 2021) Presentation to the Advisory Group on Vehicle emission standards: Light-duty.

petrol demonstrator emitted 1.2 mg/km of NOx on an RDE test and the diesel demonstrator 1.3mg/km on the laboratory World Harmonised Light Vehicles Test Cycle (WLTC)[26].

Similarly, for non-methane organic gases (NMOG), the largest technically feasible reduction (CLOVE scenario 2) should be targeted for Euro 7 rather than what is easily achievable. An NMOG limit is already used both in the U.S.A and California (which has its own car emission regulation) for regulating emissions of these harmful gases from cars and vans. In California, an emission limit of 6.25mg/km for NMOG[37] was already applicable to the lowest emission cars under the previous LEV II emission standards (now replaced by LEV III which has a gradually reducing combined NMOG and NOX fleet average limit down to 18.75mg/km) indicating that very low NMOG emissions are technically feasible.

For particles, particle number (PN) and particulate mass (PM) emissions are identical under both scenario 1 and 2. The Commission should consider if further reductions to the PN and PM emission limit are feasible based on improvements to the regulation of cold start emissions discussed in section 4.3.

For Euro 7 to drive the adoption of best available emission control such as electrically heated catalysts (e-catalysts), dual dosing selective catalytic reduction (SCR) systems and advanced engine calibrations to reduce pollution for all cars to the lowest technologically feasible levels, CLOVE scenario 2, notably on nitrogen oxides (NOx) and non-methane organic gases (NMOG) , should be the minimum emission reduction considered.

4.2 Unregulated pollutants

T&E welcomes CLOVE's proposal to introduce emission limits for pollutants which are harmful to human health and the environment but are currently unregulated. The proposals are summarised in table 3 and include the regulation of:

- **Ammonia (NH3)** which contributes to particle pollution; each 1mg of ammonia is estimated to contribute 1mg to particle air pollution smaller than 2.5 micrometer (PM2.5)[38] and of which road transport is a large source in cities[39].
- **Greenhouse gases methane (CH4) and nitrous oxide (N2O)** which have very high global warming potential of 298 and 86 times that of CO2, respectively[40].
- **Formaldehyde (HCHO),** the toxic cancer causing chemical formaldehyde which irritates the lungs, skin and eyes[41].

[37] For Super Ultra Low Emissions Vehicles (SULVES) at 240,000km.
[38] JRC. R. Suarez-Bertoa. (2019) Current non-regulated emissions in the EU. Integer Emissions Summit & AdBlue Conference. Munich.
[39]Fenn, E., M. (2018) On-road emissions of ammonia: An underappreciated source of atmospheric nitrogen deposition.
[40] Based on 20 year GWP for methane and 100 year for nitrous oxide due to different atmospheric lifetimes of the pollutants.
[41] ATSDR. (No date) Medical management guidelines for formaldehyde.

Table 3: Euro 6 and CLOVE Euro 7 proposed car emission limits for currently unregulated pollutants

Pollutant	Ammonia (mg/km)	Methane (mg/km)	Nitrous oxide (mg/km)	Formaldehyde (mg/km)
CLOVE Scenario 1	10	20	20	5
CLOVE Scenario 2	10	10	10	5

However, the methodology used by CLOVE for setting the emission limits for these pollutants is of concern. The approach is based on what is achievable by current technology on Euro 6d-temp/6d cars, rather than basing the limits of these pollutants on the lowest emissions achievable by the newest, best emission control technologies.

For example, the proposed ammonia emission limit of 10mg/km is set based on the performance of today's Euro 6d-temp/6d petrol cars which are not fitted with any technologies in the exhaust to reduce ammonia emissions. This is despite an ammonia catalyst being included as one of CLOVE's Euro 7 petrol emission control technology options[42] . The diesel equivalent is already fitted to some cars on sale today and can reduce ammonia emissions to very low levels. A Euro 6d-temp diesel Nissan Qashqai fitted with a diesel ammonia slip catalyst tested by T&E in 2019 emitted less than 1mg/km of ammonia on RDE tests[43], a tenth of CLOVE's proposed limit. If ammonia emissions from petrol cars could be further reduced to similar levels through the use of ammonia catalysts then the emission limit should be set at a level which drives the adoption of such technology. Instead the present ammonia limit proposed by CLOVE appears to only exclude the worst emitters (figure 1).

[42] CLOVE. (8th April 2021) Presentation to the Advisory Group on Vehicle emission standards: Light-duty.
[43] T&E. (2020) New diesels, new problems.

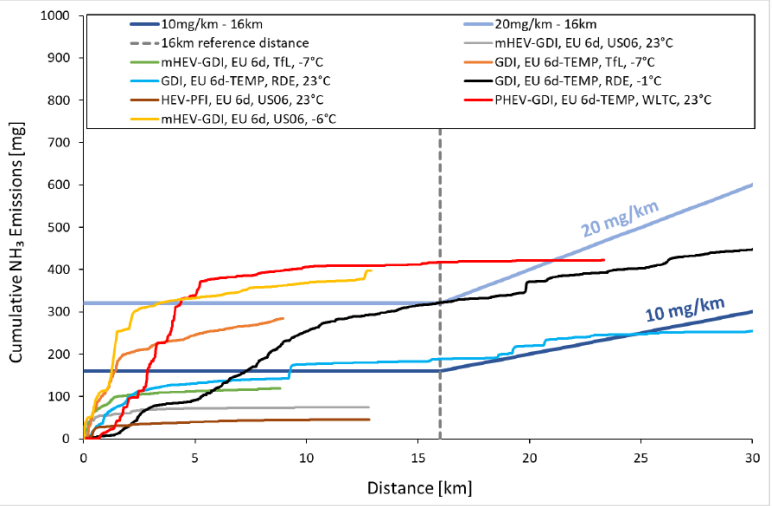

Figure 1: Ammonia emissions from Euro 6d-temp and Euro 6d petrol cars on a variety of different test cycles run by CLOVE[44]. Several petrol cars emitted less than the proposed ammonia emission limit without an ammonia catalyst.

Equally concerning are the scenario 1 emissions limits set for the greenhouse gases methane and nitrous oxide which are again based on the performance of Euro 6d-temp and 6d cars. Based on CLOVE's tests[45], the 20mg/km limit set for both effectively only restricts emissions under very cold driving conditions. Otherwise the limit is achievable by cars already on sale today. Hence the 20mg/km limit proposed will do very little to reduce the emissions of these potent greenhouse gases, as demonstrated on CLOVE's tests in figure 2 , showing diesel test emissions of N2O; all but one car already meets the scenario 1 20mg/km N2O emission limit.

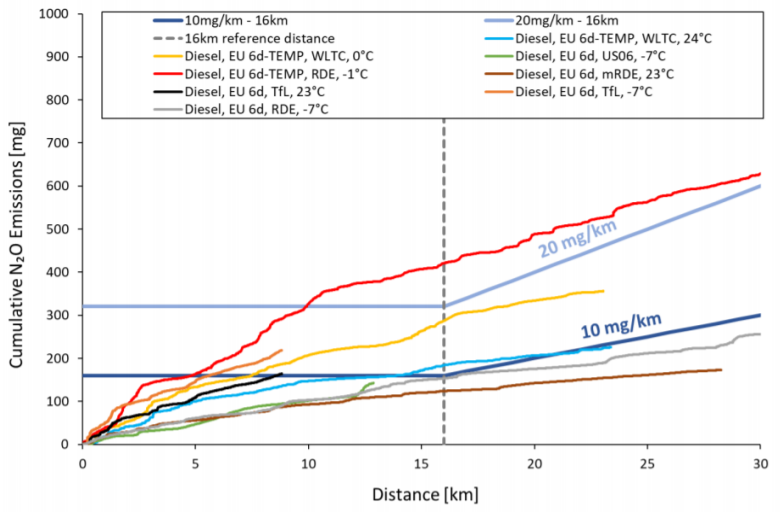

Figure 2: Nitrous oxide emissions from Euro 6d-temp and Euro 6d cars on a variety of different test cycles run

[44] CLOVE. (27th April 2021) Presentation to the Advisory Group on Vehicle emission standards: Light-duty.
[45] CLOVE. (27th April 2021) Presentation to the Advisory Group on Vehicle emission standards: Light-duty.

by CLOVE[46]. Only one test would fail the scenario 1 20mg/km N2O limit.

To reduce emissions of unregulated pollutants to the lowest possible level, CLOVE scenario 2 emission limits for methane and nitrous oxide of 10mg/km is the minimum reduction which should be considered for Euro 7. For ammonia a further reduction of proposed emission limits closer to 1mg/km should be considered to drive the adoption of ammonia catalysts on both petrol and diesel cars.

4.3 Cold start emissions

Ensuring low emissions during the cold start period, i.e. when the engine is first started and exhaust treatment technologies are still warming up, is critical to improving urban air quality. Cold start can contribute to the majority of trip NOx emissions, especially on shorter journeys. On city driving trips of around 10km, cold start has been shown to contribute around 80% of total NOx emissions for Euro 6d-temp and 6d petrol and diesel cars . Even on longer RDE style trips of up to 100km, cold start can constitute ~20-70% of the total NOx emissions depending on the car and test[47]. In cities, where many vehicle engines are started from cold within a small geographical area this can have a large impact on local air pollution.

Table 4: Euro 6 and CLOVE Euro 7 proposed cold start limits:

Euro 6:	CLOVE proposal:
No specific cold start emission limit, urban emissions including cold start are regulated over a minimum 16km distance on RDE tests.	Cold start emissions regulated through a cold start 'budget' over 16km. The budget is set at 16 times the emission limit and allows cars to emit the whole of the budget on any trip shorter than 16km. E.g. Within 'normal' RDE driving conditions, if the NOx limit is set at 30mg/km[48], the cold start budget will be 480mg. For trips falling under extended RDE driving conditions, the budget would be further multiplied by a factor of three e.g. to 1,380mg.

The proposed introduction of a cold start emission budget makes sense to ensure that cold start emissions, as well as emissions outside of the cold start period, can be reduced to the lowest technically feasible levels. However, CLOVE's proposal to link the cold start budget with the overall emissions limit

[46] CLOVE. (27th April 2021) Presentation to the Advisory Group on Vehicle emission standards: Light-duty.
[47] CLOVE. (8th April 2021) Presentation to the Advisory Group on Vehicle emission standards: Light-duty.
[48] In line with CLOVE scenario 1.

does not make sense. This approach 1) sets the cold start budget over an excessively long period of driving (16km) and 2) at a level which is unlikely to maximise the use of new technology that can bring down cold start emissions to the lowest technologically possible level, such as electrically heated catalysts. These catalysts can warm up much quicker than currently in use three way catalysts due to their use of electricity for heating instead of relying on hot exhaust gases from the engine. The quicker warm up means that harmful pollutant emissions released from the engine can be reduced much quicker after the engine is started than with traditional catalysts.

4.3.1 The length of the cold start budget

The distance of 16km over which CLOVE proposes the cold start budget to apply is too long and not an improvement on the current Euro 6 RDE test requirements which check a car's urban emissions performance on trips >16km. It is also not representative of typical car journeys, especially in towns and cities where a lot of trips are shorter than 16km. For example, the average trip distance of a PSA customer is only 9.8km[49] and urban trips in Paris are even shorter with the median trip being just 5.2km long[50]. CLOVE's data also shows that the majority of cold start emissions are released over a much shorter distance than the 16km proposed - largely in the first 1-2km of driving for both normal and extended RDE boundary conditions(proposed by CLOVE for Euro 7) with emissions reducing after this period. Therefore, the necessity for such a long distance for the cold start budget appears excessive .

Requests by T&E[51] and ICCT[52] to reduce the distance over which the cold start budget applies in order to align the budget distance with the length of typical city trips were countered with proposals from CLOVE to simultaneously increase the overall emission limit in order to continue the alignment between the cold start budget and the overall emission limit (figure 3). For example, for NOx, a reduction of the budget to 8km would result in an increase of the overall emission limit to 60mg/km[53], in other words the emission limit which already applies to petrol cars today, resulting in virtually no improvement in the stringency of the regulation compared to Euro 6.

[49] T&E. PSA. (2017) Real world fuel economy measurements: technical insights from 400 tests of Peugeot, Citroen and DS Cars.
[50] IFPEN. (2020) Etude Emissions Euro 6d-temp pur le MTE.
[51] T&E. (27th April 2021) Presentation to the Advisory Group on Vehicle emission standards.
[52] ICCT. (27th April 2021) Presentation to the Advisory Group on Vehicle emission standards.
[53] CLOVE. (27th April 2021) Presentation to the Advisory Group on Vehicle emission standards: Light-duty.

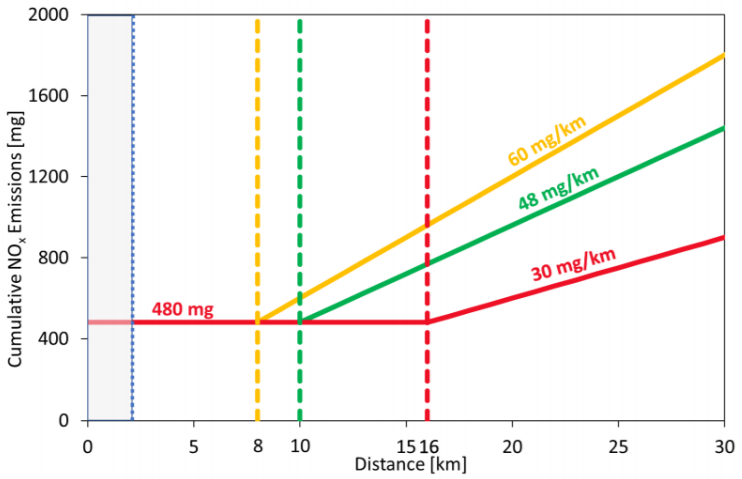

Figure 3: Variation in the emissions limit depending on the distance over which the cold start budget applies as presented by CLOVE to the Advisory group on Vehicle Emission Standards on the 27th of April 2021.

However, the increase in the overall emission limit with a decreased emission budget distance would not be necessary if the cold start budget emission limit was decoupled from the overall emission limit. This would allow for the cold start emission budget limit and the distance over which it applies to be set independently of the overall emissions limit. Both emission limits could be set at an amount which effectively limits emissions to the lowest possible levels during both cold start and normal driving.

The cold start budget should be decoupled from the overall emission limit thereby allowing a reduction of the distance over which the cold start budget applies to 8km or less, which is more representative of typical urban car use.

4.3.2 The cold start budget emission limit needs to be reduced.

T&E is also concerned by the magnitude of the cold start budget, especially for NOx, which for both Euro 7 emission scenarios presented by CLOVE is set far above what has been demonstrated by CLOVE as achievable by the best performing Euro 7 technology options.

Table 5: Clove proposed Euro 7 NOx cold start budget which applies over 16km.

CLOVE Scenario	Normal RDE conditions	Extended RDE conditions
1	460mg	1380mg
2	320mg	960mg

While CLOVE proposes an emission budget up to 460 mg under normal on-road driving conditions, their own data shows that under those conditions diesel and petrol NOx emission can be reduced to much lower levels. When fitted with an electrically heated catalyst - which is preheated for a few seconds before the engine starts - NOx emissions of less than 200 mg over a 16km distance can be achieved under normal EURO 7 RDE condition proposed by CLOVE. The e-catalyst technology, needed to reduce NOx emissions to those levels, is already available from EU companies such as Faurecia and Vitesco.

Tests of Euro 6d-temp BMW X5, Volvo XC60 and Mitsubishi Outlander plug-in hybrid petrol cars in conducted by T&E in 2020 show that cars already on the road today can achieve less than the proposed Euro 7 cold start budget under normal Euro 6 RDE driving conditions even when driving powered with an internal combustion engine only due to an empty battery or because the engine is used to charge the battery. The XC60 and Outlander both emitted less than 100 mg of NOx over the first 16km, and even the worse performing X5 emitted 266 mg, just over half of the least stringent CLOVE proposal. While the tests did not cover all the possible conditions that could be encountered under the normal RDE test boundaries proposed by CLOVE for Euro 7, the findings highlight that cars already on the road today, which are not even fitted with an e-catalyst, can emit less than the proposed CLOVE Euro 7 NOx limits. Similar findings have also recently been published by the International Council on Clean Transportation (ICCT)[54].

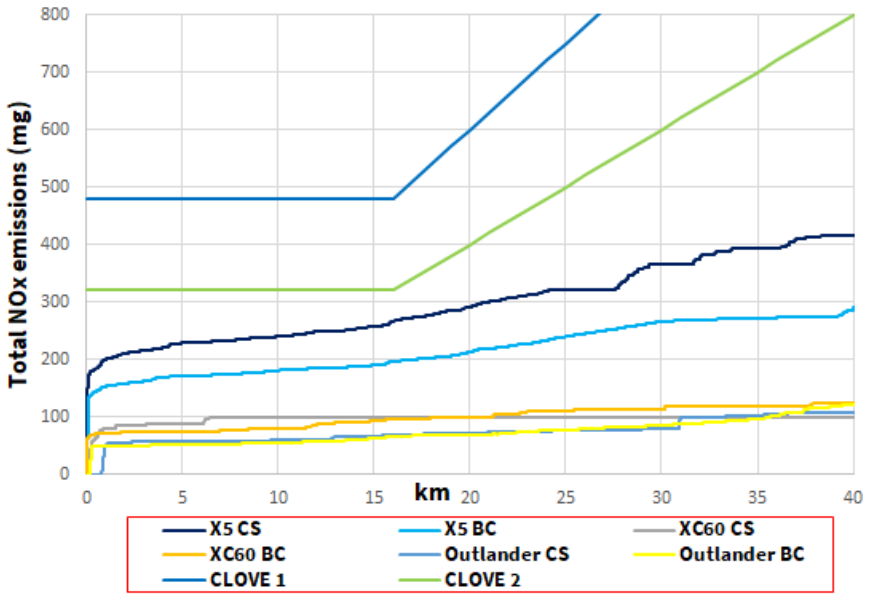

Figure 4: On road NOx emissions of Euro 6d-temp BMW X5, Volvo XC60 and Mitsubishi Outlander. On all tests, all three cars already emit less than the cold start budget under normal driving conditions even when driving using the internal combustion engine only, including when driving with an empty battery (CS) or using the engine to charge the battery (BC).

[54] ICCT. (2021) ICCT's comments and technical recommendations on future Euro 7/VII emission standards.

This means that for Euro 7 to significantly reduce cold start emissions for the improvement of urban air quality the size of the NOx cold start budget needs to be significantly lower than the budgets proposed by CLOVE. Otherwise, Euro 7 will fail to drive the adoption of the best available emission control technology i.e. e-catalysts for the control of NOx emissions. Without stricter cold start requirements the improvement to vehicles cold start performance could be marginal.

The NOx cold start emission budget needs to be revised downwards, closer to 200mg, to drive the adoption of the best available emission control technologies and to ensure that the technology is utilized and calibrated to its maximum potential under all driving conditions. Similarly, the cold start budget for other pollutants including particle number (PN), carbon monoxide (CO) and hydrocarbons (HC) should also be reviewed to ensure that it is set at the lowest possible level based on what is achievable with the best available technologies.

5. Better tests

Despite the introduction of on-road Real Driving Emissions testing from 2017, there are still many normal driving conditions which are not covered by the RDE test procedure such as fast accelerations, driving in hilly regions[55] or particle filter cleaning (a.k.a DFF regenerations[56]). To ensure low emissions wherever and whenever a car or van is driven, it's important that all driving conditions are included in the RDE test as part of Euro 7.

CLOVE's proposal to extend the range of driving conditions covered by the RDE test procedure compared to those applicable to the latest Euro 6d cars is a big step in the right direction. Under the proposals more driving conditions would be covered by 'normal' RDE driving conditions. This includes improvements such as the removal of restrictions on accelerations, trip composition and elevation gain. More challenging conditions such as high altitude driving or trailer towing are proposed to be covered by 'extended' driving conditions where a multiplier of three would be applied to the emission limit. Under the proposals, cars are also required to meet all applicable pollutant emission limits and not just for NOx and PN as is the case at present. However, despite the improvements some tightening adjustments to the proposal are needed.

5.1. Temperature boundaries

Firstly, under the CLOVE proposals, on road driving conditions which occur frequently in some Member States would fall into the 'extended' RDE category, allowing cars to emit three times the legal pollutant emission limits. Of particular concern are the proposed temperature boundaries.

[55] Suarez-Bertoa,. R., Et. al. (2019) On-road emissions of passenger cars beyond the boundary conditions of the real-driving emissions test. Environmental Research.
[56] T&E. (2020) New diesels, new problems.

Table 6: Euro 6 and CLOVE Euro 7 proposed RDE temperature boundaries.

Euro 6	CLOVE proposal
Normal: 0 to 30 ^{0}C Extended: -7 to 35 ^{0}C	Normal: -7 to 35 ^{0}C Extended: -10 to 45 ^{0}C

The CLOVE proposed 'normal' temperature boundaries fail to cover all temperatures regularly experienced in Member States. In Finland temperatures down to -10 ^{0}C are common[57], as are temperatures in excess of 35^{0}C in Southern Europe during the summer months. These now occur more frequently and more and more prevalent in the rest of Europe as a result of climate change. Allowing cars to emit three times more pollution under conditions which are regularly experienced in Europe will do little to improve air quality in those Member States when it's cold or hot outside.

Essentially, for NOx this would allow cars to emit as much as 90mg/km under the less stringent emission limit proposed by CLOVE and 60mg/km under the more ambitious scenario. This is only as ambitious as the current Euro 6 emission limits for petrol which should have already been met under all normal conditions of use.

Light duty cars and vans should meet the emission limits under all driving conditions in which they are designed to operate and which occur normally and regularly in EU Member States. Only driving conditions which are very rare and extreme should fall under the 'extended' RDE boundary conditions. In the Commission's upcoming proposals 'normal' RDE temperature boundaries should be extended to include all temperatures regularly experienced in the EU.

5.2 Extended boundary emission limits

Secondly, CLOVE proposes allowing cars to emit three times more pollution under 'extended' RDE driving conditions which include events such as driving at higher altitude, higher speed or when towing a trailer. While data from CLOVE shows that a higher cold start budget under 'extended' conditions is justifiable due to higher cold start emissions, data does not support applying the multiplier once the cold start period has passed. As shown in figures 5 and 6, NOx emissions from petrol and diesel cars fitted with Euro 7 emission control technologies can be well controlled to 10mg/km or less once the cold start period has passed. This is a fraction of the 60 mg/km (scenario 1) and 90mg/km (scenario 2) extended RDE emission limit allowable under CLOVE's proposal.

[57] CLOVE. (8th of April 2021) Presentation to the Advisory Group on Vehicle emission standards: Light-duty.

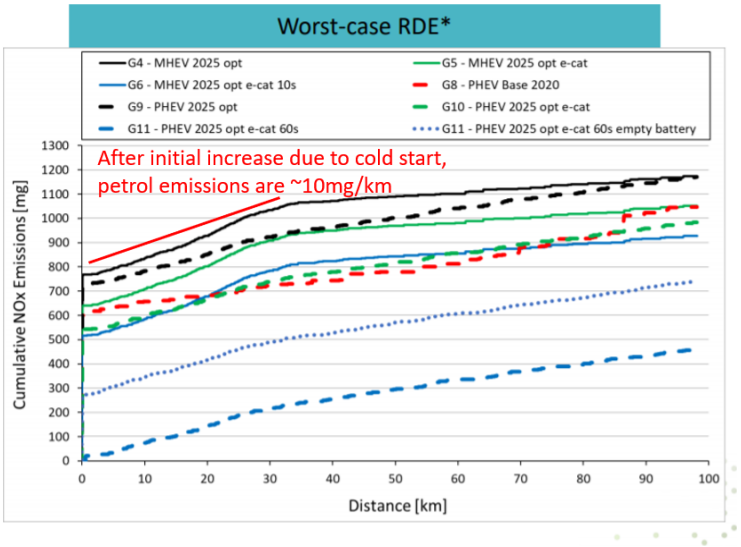

Figure 5: Cumulative NOx emissions for petrol cars under worst case extended RDE conditions as tested by CLOVE[58]. Emissions are well controlled to around 10 mg/km after the initial cold start period.

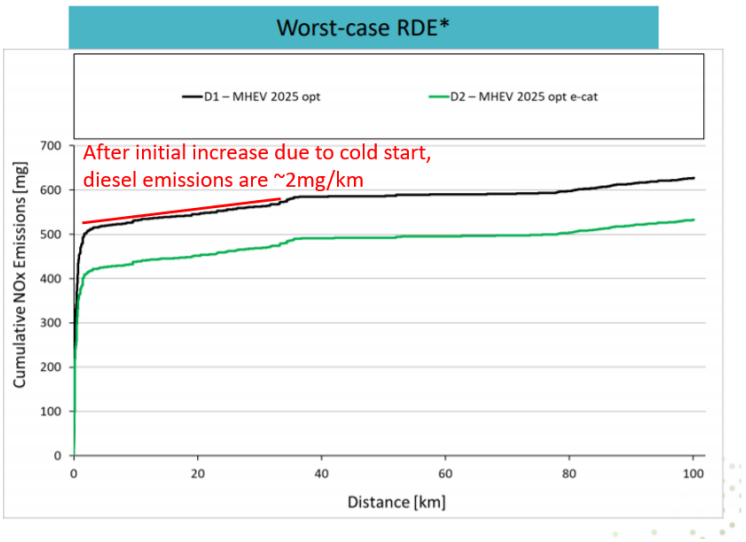

Figure 6: Cumulative NOx emissions for diesel cars under worst case extended RDE conditions as tested by CLOVE[59]. Emissions are well controlled to around 2 mg/km after the initial cold start period.

Allowing cars to emit three times more pollution under 'extended' driving conditions once the engine is hot would leave a large gap between what Euro 7 emission technologies can achieve and the emission limit, essentially giving cars a license to pollute. This is demonstrated well in figure 7. The gap between the green shaded area representing modelled worst case NOx emissions of diesel cars (fitted with Euro 7 emission technology) and the blue line showing what cars would be allowed to emit under CLOVE's scenario 1 proposal[60] shows a large divergence after the cold start period. Even under the more ambitious

[58] CLOVE. (8th of April 2021) Presentation to the Advisory Group on Vehicle emission standards: Light-duty.
[59] CLOVE. (8th of April 2021) Presentation to the Advisory Group on Vehicle emission standards: Light-duty.
[60] CLOVE scenario 1 emission limit with a three times multiplier.

CLOVE scenario 2 limit a growing gap would appear after around 24km (red line on figure 7), providing an unnecessary license to pollute on longer trips. The large limit applied after the cold start period appears to stem from the alignment of the cold start budget with the overall emission limit as already discussed in section 4.3. This alignment is counter-productive as it gives cars a large license to emit between 4-6 times more NOx than the Euro 7 technology has been shown to emit in the worst case[61].

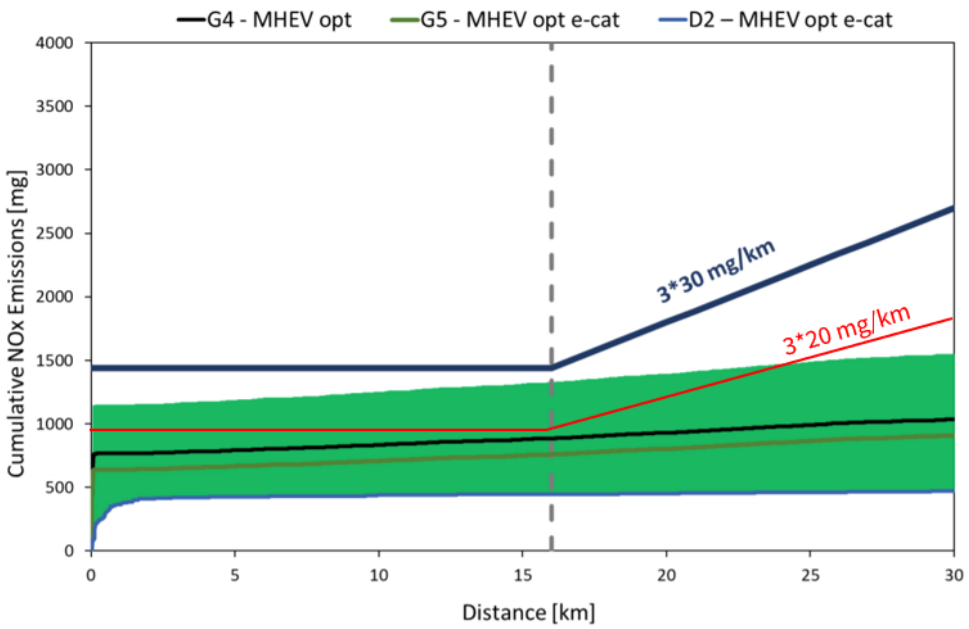

Figure 7: CLOVE simulation showing worst case NOx emissions from diesel cars fitted with Euro 7 emissions control technologies under 'extended' RDE driving conditions[62]. Red line added by T&E represents the CLOVE scenario 2 extended RED limit of 3 x 20mg/km.

To ensure emissions are reduced to the lowest technically possible level under all driving conditions, the extended boundary condition cold start budget and the overall emissions limit need to be decoupled. Additionally, the emission limits applicable under 'extended' RDE boundary conditions for NOx as well as particle number (PN), carbon monoxide (CO) and hydrocarbons (HC) should be set at the lowest technically feasible level.

5.3 Portable Emissions Measurement System uncertainty

Back in 2016, in the middle of the Dieselgate scandal, the EU decided to relax on-road pollution limits for nitrogen oxide (NOx) and particle number (PN) emissions through so-called 'conformity factors', allowing cars to pollute over the legal limits, as part of the transition from laboratory to real world 'Real Driving

[61] Based on worst case emissions (green shaded area) shown in figure 7, after the cold start period worst case modelled emissions are ~15 mg/km.
[62] CLOVE. (27th April 2021) Presentation to the Advisory Group on Vehicle emission standards: Light-duty.

Emissions' (RDE) testing. The Commission argued that such flexibilities were needed to take account of statistical and technical uncertainties when switching from laboratory measurements to 'Portable Emissions Measurement Systems' (PEMS). However, what should have been a reflection of genuine measurement uncertainties was turned into a 'license to pollute' after pressure from EU governments[63], allowing cars to emit 2.1 times over the legal NOx limit until the end of 2020, and 43% more with no set end date. This was despite the Commission's own Joint Research Center (JRC) reporting as early as 2017 that the uncertainty of the better PEMS devices was as low as 24%[64] for NOx. Since then the EU's lower court decided that the European Commission had no right to adopt laxer pollution limits, through conformity factors, for on-road tests for Euro 6 cars. To get around this the Commission has brought back conformity factors through the ordinary legislative procedure which is stuck in trialogues. However, while no compromise has been reached yet, current discussions focus on the time by which the conformity factor should be phased out.

To get around the sticky issue of conformity factors, CLOVE proposes to include the conformity factor within the Euro 7 limit instead of on top of the limit, as applied under Euro 6. The issue is that the conformity factors proposed by CLOVE of 15% for NOx and 50% for PN are much higher than the PEMS measurement uncertainty reported by the JRC in their latest 2021 report. PN uncertainty is already estimated to be significantly lower at 34% and with improvements to the PEMS equipment, NOx uncertainty could be reduced to 10%[65].

Given that Euro 7 is a future emission standard, the emission limits should be set at the lowest level possible based on what is achievable through use of the best future technology, both in terms of emissions control systems as well as the emission measurement technology. The regulation should also set clear incentives for PEMS manufacturers to further improve the accuracy of these devices, which is currently not the case with worst case scenarios used as the yardstick for annual reviews of the NOx conformity factor. A conformity factor integrated within the emission limit which is larger than the actual PEMS measurement uncertainty would unjustly provide an additional margin for cars to pollute more on the road than the best Euro 7 emission control technology can achieve. This is not justifiable from an air quality perspective.

If, for Euro 7, conformity factors (CF) are to be integrated within the emission limits for each pollutant, as proposed by CLOVE, the Commission needs to ensure that the CF's applied reflect the actual measurement uncertainty of future best in class emission measurement equipment and not provide car makers with an unjust license to pollute.

[63] T&E. (2015) Governments double and delay air pollution limits for diesel cars.
[64] JRC. (20) Real Driving Emissions (RDE): 2017 assessment of Portable Emissions Measurement Systems (PEMS) measurement uncertainty.
[65] JRC. (2020) Real Driving Emissions (RDE): 2020 assessment of Portable Emissions Measurement Systems (PEMS) measurement uncertainty.

6. Durability

For air quality it is important that cars respect the legal emissions limits throughout the whole lifetime of the car or van and not just during the first few years of use. For as long as a vehicle is driven on the road it should obey the emission limits regardless of age or mileage. Lifetime emission durability, market surveillance and in use testing requirements are needed to ensure this. However, at present, the EU has generally the lowest durability requirements when compared to other major car markets such as China or the U.S.A.. This disproportionately affects central, eastern and southern Member States which generally have the oldest car fleets and import large numbers of used cars from western or northern Member States, the majority of which fall outside of the Euro 6 durability requirements.

Table 7: Euro 6 and CLOVE Euro 7 proposed emission durability requirements:

Euro 6	CLOVE proposal
160,000 km emission durability 5 years/100,000 km market surveillance and in-service conformity testing	15 years/240,000km emissions durability, market surveillance and in-service conformity testing

T&E supports the extension of durability, market surveillance/ in-service conformity testing requirements to 240,000km which would align EU durability requirements with the globally most stringent standards already in force in the U.S.A.. However, the proposed maximum age requirement of 15 years still falls far short of the lifetime of many cars found on EU roads and risks allowing grossly polluting cars in those parts of the EU which already suffer from bad air quality. Even in Germany where the average car age is 9.4 years[66], almost a fifth of passenger cars are 15-25 years old[67]. In Eastern and Southern Member States the share of older vehicles is even higher. In Sofia, Bulgaria, 55% of cars are above 15 years old[68]. Given that in 2017 alone second hand car imports to Bulgaria exceeded 100,000 cars, of which 43% were 15-20 years old[69] durability requirements which fail to cover the vehicles exported from western Member States will simply export the problem of toxic car pollution to less affluent countries. Such a regulation would be discriminatory as everyone across the European Union has the same right to breathe clean air and contradicts the EU's Zero Pollution Ambition of reducing pollution at source.

T&E recommends that the Commission include lifetime emission durability requirements in its upcoming proposal . As a minimum this should require new cars and vans to meet the emission limits for the first twenty years and 240,000km of a vehicle's lifetime with deterioration factors applicable thereafter.

[66] ACEA. (2020) Automobile Industry Pocket Guide 2020-2021.
[67] KBA. (2021) Passenger car stock on January 1st, 2021 by vehicle age.
[68] Sofiaplan. Programme for Sofia 1.6. Transport Infrastructure. Territorial area and analysis of the situation.
[69] T&E. (2018) Dirty diesels heading East.

6.1 Emission Warranty Scheme

Ensuring compliance with emission limits throughout the whole lifetime of the car or van should be the responsibility of car manufacturer's who should fit cars with emissions control technology which is built to last. To ensure that this happens and to protect consumers from high repair bills when emission control components fail, an emission warranty program specifically covering emission critical components should be introduced as part of the Euro 7 emission standard.

An emissions warranty scheme is already in place in the U.S.A and the introduction of a similar scheme in the EU would provide customers with much better protection in the case that vehicle manufacturers fail to ensure lifetime emissions compliance. It should also encourage manufacturers to robustly design their vehicles. To be most effective the warranty should cover the entire emissions durability period covered under Euro 7 as well as multiple ownership. The warranty should be complemented by an emission warranty tracking database to aid the Commission and Member States in identifying compliance and durability issues. This must include pre-defined thresholds which trigger mandatory investigation and remedial action and it can be combined with the current online database put in place under RDE4 provisions for in-service conformity tests.

7. Emissions from Brakes

Brake practical emissions are a substantial source of particles in urban areas, increasing the total number of particles in the air and contributing to PM2.5 pollution. EU cities[70] as well as T&E and its NGO network have long campaigned for this source of particle pollution to be regulated for all cars. While T&E welcomes CLOVE's proposals[71] to regulate brake wear particle emissions for the first time as part of the Euro 7 EU vehicle emission standards, the limits proposed are insufficient.

Table 8: Current brake emissions of cars and proposed CLOVE limit options.

2020 reference emissions	CLOVE limit option 1	CLOVE limit option 2
11 mg/km	7 mg/km	5 mg/km

CLOVE proposed limits would result in a reduction of brake emissions of between 40-60% compared to current cars. Nonetheless, the proposed limits do not come close to the reduction achievable by the best available technology for brake emissions reduction. Vacuum aspiration technology, which essentially sucks up brake particle emissions has been shown to be effective in reducing brake particle mass (PM)

[70] EUROCITIES.(2013) Cleaner air in our cities: Eurocities answer to the Commission questionnaire on the consultation on options for revision of the EU Thematic Strategy on Air pollution and related policies.
[71] CLOVE. (27th April 2021) Presentation to the Advisory Group on Vehicle emission standards: Evaporation & Brake wear control

emission by 85% and particle number emission by up to 90%[72]. With current average brake PM emissions of 11mg/km this equates to emissions of 1.67mg/km, a third of the most ambitious 5mg/km limit proposed by CLOVE. Such technology is already available from French company Tallano and is ready for implementation as part of Euro 7.

To ensure that the best available technology for reducing brake particle emissions is fitted, more stringent brake particle emission limits are needed. Otherwise the brake emission limits could be met through increased regenerative braking and different brake pad formulations which would not deliver the maximum brake particle emissions reductions which EU towns and cities need.

The Commission should propose more ambitious brake particle emission limits which are set at a level below 5mg/km which drives adoption of the most effective technology for reducing emissions.

8. What about costs?

The Euro 7 proposals put forward by CLOVE are technically feasible and are expected to be affordable. The Commission recently announced that they expect the additional Euro 7 compliance cost to be in the region of 100-500 € per car, depending on the stringency of the Euro 7 standard[73]. The cost of adding an e-catalyst or a dual dosing SCR system - that would allow cars to meet a number of stricter requirements of Euro 7 - falls between 100-200 euro for each technology[74]. Similarly, mass deployment of brake particle vacuum technology is expected to cost around € 100 per vehicle[75]. To put this into perspective, the cost of putting much less polluting cars on the road is less than a paint upgrade on an entry level car model such as the VW Golf or Ford Fiesta, which can cost in excess of €700[76]. It should also be noted that company cars make up 55% of EU car sales[77], rising to as much as 73% in Eastern Europe[78] which are largely paid by companies, not individuals, and are therefore less sensitive to purchase price fluctuations.

In contrast air pollution from road transport costs EU citizens tens of billions in health costs. In 2015, the figure stood €66-80 billion[79]. Aside from the costs, it also causes tens of thousands of avoidable,

[72] Tallano. (22nd April 2021) Feedback on the recommendations of the CLOVE consortium on the issue of brake emissions presented at the AVES meeting of the 8 April.
[73] European Parliament Committee on the Environment, public health and food safety. (15th June 2021).
[74] Joshi, A., (2021, 04, 15) Review of vehicle engine efficiency and emissions. WCX Digital Summit. The costs of the e-catalyst does not include the cost of mild hybridization, however current EU car production plans show that 93% of ICE cars produced in 2030 will be mild hybrids to help meet the fleet average CO2 standards (T&E. (2021) Promises, but no plans.). As such the costs associated with adding mild hybrid technology should not be attributed to Euro 7 for the majority of vehicles since car manufacturers have been clear that they do not make production plans based on emissions regulation until the relevant implementing/delegated acts are published and known to industry (ACEA. (2021, 04, 25) ACEA comments to material presented in AGVES on 8 April 2021 and technical recommendations on key future Euro 7/VII requirements).
[75] Tallano (private communication, 10th September 2021)
[76] Price checked on www.ford.de and www.volkswagen.de on 07/09/2021.
[77] Dataforce (2021) 2020 passenger car sales data for the EU's 17 largest car markets as analysed by T&E
[78] Dataforce (2021) 2020 passenger car sales data for Poland as analysed by T&E.
[79] EPHA. (2018) Health impacts and costs of diesel emissions in the EU.

premature deaths a year[80]. Low emission cars, vans, buses and trucks - equipped with technology to reduce pollution to lowest technologically possible levels - are urgently needed to reduce these health costs.

9. Conclusion

To bring about a much needed improvement in air quality across Europe and reduce it's negative effects on human and environmental health it is critical that the European Commission puts forward an ambitious Euro 7 proposal at the end of this year. To be effective in reducing on-road pollution from cars and vans, the proposal must be a comprehensive revision of the Euro 6 standard, closing all loopholes left behind from the dieselgate era and reducing toxic pollutant emissions to the lowest technically possible levels under all conditions. Anything less, such as only a limited revision of the Euro 6 standard focusing, for example, on reducing pollutant emission limits while disregarding improvements to other critical aspects of the regulation such as durability requirements or testing conditions will only bring about marginal emission reductions and will fail to bring about the air quality improvements that Europe and it's cities desperately need. It will also show that the EU failed to learn from the dieselgate scandal; over-reliance on individual tools, such as emissions limits, is ineffective at driving on-road emissions reduction.

A new standard is urgently needed as the Euro 6 emissions limits for cars and vans set in 2008 are now outdated and full of loopholes lobbied in by the automotive industry. Over a decade of technological progress including the development of dual dosing SCR systems and high efficiency petrol particle filters, means that much lower emission limits for harmful pollutants are already technically feasible and additional pollutants, such as ammonia, can be regulated. Even on road tests of new cars show that more than half already emit less than half of the nitrogen oxide (NOx) emission limit[21]. Electrically heated catalysts (e-catalysts) can drastically reduce NOx emissions during cold start operation, when the engine is first started, a particular problem in towns and cities, where many cold starts can happen within a small geographical area.

New Euro 7 proposals put forward in April by the consortium of emissions experts from across Europe known as CLOVE, working on Euro 7 on behalf of the Commission, tackle the many shortfalls of the Euro 6 regulation and are a significant improvement on Euro 6. The proposed lower emission limits, extension of on road driving conditions covered by RDE tests, enhanced durability requirements, regulation of additional pollutants including brake emissions and on-board emission monitoring (OBM) incorporated together will significantly improve the emissions performance of new vehicles. However, to reduce emissions of all pollutants to the lowest technically feasible levels and to ensure the adoption of the best available emission control technology, such as electrically heated catalysts, further tightening of the requirements is needed. In particular:

[80] EEA. (2020) Air quality in Europe.

1. **The minimum reduction of pollutant emission limits that should be considered for Euro 7 must be the ambitious pollutant emission limits proposed for Euro 7 by CLOVE.** Only the lowest limits proposed, will ensure that the best emission control technology is fitted to new cars and toxic pollution is reduced to the lowest levels. For regulated pollutants the proposed Euro 7 limits are shown in the table below. Alongside lower limits for regulated pollutants, limits for currently unregulated pollutants need to also be reduced to the lowest technically feasible levels. For the greenhouse gases methane and nitrous oxide this is 10mg/km or less and for the toxic gas formaldehyde 5mg/km or less. The emission limit for ammonia -which causes secondary particle pollution- needs to be reduced from the currently proposed 10mg/km, closer to 1mg/km to ensure that abatement technologies that can reduce ammonia emissions to the lowest such as ammonia slip catalysts (ASC) are fitted to all new cars.

Pollutant	Nitrogen oxides (NOx)	Particle number (PN)	Particulate Mass (PM)	Carbon Monoxide (CO)	Non-methane organic gases (NMOG)
Euro 6	80 mg/km[81]	$6x10^{11}$/km for particles larger than 23nm	4.5mg/km	1000 mg/km[82]	68 mg/km[83]
Euro 7	**20 mg/km**	**$1x10^{11}$/km for particles larger than 10nm**	**2mg/km**	**400 mg/km**	**25 mg/km**

2. **Cold start emission requirements (i.e. emissions when the engine is first started, which can contribute to the majority of trip NOx emissions) need to be strengthened in order to improve air quality in towns and cities where the majority of cold starts happen.**
   a) The distance over which the proposed cold start emission budget applies needs to be reduced to 8km or less from the 16km proposed today, to ensure that typical city trips are adequately covered.
   b) The cold start budget emission limit should be decoupled from the overall emission limit and the NOx budget subsequently reduced to 200mg, i.e. closer to the lowest emissions feasible today when the best technology such as e-catalysts are used to their full potential. A reduction in the budget for other key pollutants should also be considered.

3. **The requirements which apply under 'extended' on road RDE driving conditions must be strengthened:**

[81] Euro 6 diesel limit, 60mg/km is the petrol Euro 6 limit
[82] Euro 6 petrol limit, 500 mg/km is the petrol Euro 6 limit
[83] Euro 6 petrol non-methane hydrocarbon limit. Diesel emissions are regulated through a combined nitrogen oxide (NOx) and HC limit of 170 mg/km.

a) Emission limits applicable under 'extended' RDE boundary conditions need to be revised downwards, closer to the limits which apply under 'normal' driving conditions. CLOVE's data does not support the three times higher emission limits under 'extended' conditions -outside of the cold start period (when the engine is first started)- suggested currently. Such a high multiplier would give Euro 7 cars an unfair license to pollute when driving at higher altitude or in hot weather and is much higher than the 1.6 multiplier applicable in extended conditions to Euro 6d-temp and 6d cars today.

b) Only driving conditions which are very rare and extreme should fall under 'extended' driving conditions for on-road RDE tests in order to ensure that cars are as low emission as possible when driving on the road. Normal RDE temperature boundaries should be extended to include all temperatures regularly experienced in the EU, between -10 to 40 ℃.

4. **Durability requirements must be extended to cover the entire vehicle lifetime** in order to prevent the export of pollution to Eastern, Southern and Central European Member States which import large numbers of second hand cars. As a minimum, the durability requirement must be increased from the 15 years (proposed by CLOVE) to 20 years, with deterioration factors applicable thereafter. In addition, the introduction of an emissions warranty scheme for emission critical components should be considered to ensure that car manufacturers design their emission control systems to last and protect consumers from repair bills that are due to inadequate durability or design flaws.

5. **More ambitious brake particle emission limits for all powertrains are needed to reduce this large source of particle pollution.** The Euro 7 limit put forward by the Commission must be below the most ambitious 5mg/km limit proposed by CLOVE in order to drive a quick adoption of the most effective technology for reducing brake particle pollution such as vacuum aspiration.

6. **If, for Euro 7, conformity factors (CF) are to be integrated within the emission limits for each pollutant, as proposed by CLOVE, the Commission needs to ensure that the CF's applied reflect the actual measurement uncertainty of future best in class emission measurement equipment and not provide car makers with an unjust license to pollute**. Current CLOVE proposals include a conformity factor of 1.15 for nitrogen oxide (NOx) and 1.5 for particle number (PN). However, the Commission's own Joint Research Center (JRC) have recently found that with improvements to the Portable Emissions Measurement System (PEMS) the conformity factor can be reduced to 1.1 for NOx and 1.34 for PN[84]. Conformity factors have been misused in the past to drastically undermine the real world effectiveness of Euro 6d-temp and 6d emission regulations. If Euro 7 is to include any sort of CF in the limit, it may only reflect actual measurement uncertainties and be based on the newest science and best in class equipment.

[84] JRC. (2020) Real Driving Emissions (RDE): 2020 assessment of Portable Emissions Measurement Systems (PEMS) measurement uncertainty.

The Euro proposals for cars and vans put forward by CLOVE are both economically and technically feasible. Emission control technology has progressed significantly since 2008 - when the current Euro 6 limits were agreed upon - including the development of dual dosing SCR systems and high efficiency petrol particle filters. Tests by CLOVE show that half of cars tested today in on-road conditions under EU tests already emit less than half of the nitrogen oxide (NOx) emission limit[21]. E-catalysts can drastically reduce emissions during cold start operation (when the engine is first switched on) and new technology can regulate new pollutants. For example, ammonia slip catalyst mean that ammonia emissions can be brought down to levels close to 1mg/km in everyday driving[23].

In terms of cost, the Commission has recently announced that they expect Euro 7 compliance to cost in the region of 100-500 € per car, depending on the stringency of the Euro 7 standard[31]. For example the cost of adding an e-catalyst or a dual dosing SCR system - that would allow cars to meet a number of stricter requirements of Euro 7 - falls between 100-200 euro for each technology[32]. To put this into perspective, the cost of putting much less polluting cars on the road is less than a paint upgrade on an entry level car model such as the VW Golf or Ford Fiesta, which can cost in excess of €700[33]. In contrast, air pollution from road transport costs each EU city dweller €1,276 a year on average due to its negative health effects increasing to as much as €3,000 in Eastern Europe[85].

The Commission's Euro 7 proposal expected at the end of this year is the EU's last chance to reduce pollution from internal combustion engines. For the sake of EU citizen's health the Commission cannot afford to be complacent and put forward a weak proposal. Almost 100 million ICE cars will be sold between 2025 (when Euro 7 is expected to come into force) and the full transition to zero emission mobility in 2035. Without any action, unnecessarily polluting cars will remain on the EU's roads for another quarter of a century damaging both EU citizens' health and the environment.

Further information

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[85] EPHA. (2020) Health costs of air pollution in European cities and the linkage with transport.