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Guest Editorial

Emissions Standards Delivering Cleaner Air on the Road to Net Zero

NON-PEER REVIEWED FEATURE

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Clean air. It should be a basic right for everyone, yet the World Health Organization estimates that in 2019, ambient air pollution in cities and rural areas caused 4.2 million premature deaths worldwide (1). Heart disease, stroke and pulmonary disease are the key causes of premature deaths related to poor air quality and this burden falls largely on people living in low- to middle-income countries.

The transport sector is a known major contributor to ambient air pollution (2) with tailpipe emissions containing pollutants such as oxides of nitrogen (NOx), hydrocarbons, carbon monoxide and particulate matter which are the products of incomplete hydrocarbon fuel combustion.

Thankfully, major advances in engine technology, engine calibration, fuel quality and catalytic air pollution control systems have made significant progress in cleaning up road transport over the past four to five decades. We can largely commit to the past the frequent and lasting days of photochemical smog shrouding urban environments such as Los Angeles in the USA: thanks to the humble catalytic convertor, pioneered by Johnson Matthey in the 1970s (3) and developed by the industry alongside increasingly stringent emissions standards around the world. Today, as the need for global mobility continues to grow, so does the need for improved emission control technology.

Ensuring a Cleaner Future

The key driver for advancing clean vehicle technology comes from governments enacting next-step emissions legislation standards. Leading legislators promoting clean transport have been the California Air Resources Board (CARB) and Environmental Protection Agency (EPA) in the USA and the European Commission (EC). In more recent years, the governments of China and India have taken significant steps in progressing their own vehicle emissions standards. Existing, newly proposed and anticipated legislation in development (**Figure 1** in the online version of this feature) mean that internal combustion engine (ICE) and ICE hybrid vehicles continue to get cleaner. These key regions continue to set the benchmark for other areas of the world, which collectively improves air quality and health for billions of citizens around the globe.

Two recent examples of leading legislation are the proposed Euro 7 standards (4), released by the EC on the 10th November 2022 and the US EPA's Heavy Duty Low NOx final rulemaking (5) issued on the 20th December 2022. Euro 7 is an opportunity for the European Union to continue driving down emissions from road transport, playing an important role towards a zero-emission ambition for Europe and continuing to set an example for other world regions.

The heavy-duty standards propose a good level of ambition for cleaner trucks and buses with a 'warm' NOx emissions reduction of just over 80% compared to today's limits. The proposed particulate number (PN) limit is 66.6% lower than today. The size of particles which are included within the new 2×10^{11} kWh^{-1} PN limit has also been reduced from 23 nm to 10 nm, ensuring more harmful particulates are now stopped from entering the atmosphere. Euro 7 will also shift the heavy-duty segment across to follow Real-world Driving Emissions (RDE), an on-road emissions testing framework which was introduced for light-duty standards in 2016/2017. Additionally, Euro 7 regulates ammonia and nitrous oxide emissions. The timing for introduction of the heavy-duty legislation is 1st July 2027.

The Euro 7 proposal for light-duty, at face value, does not look as ambitious as its heavy-duty

counterpart. Here the EC strayed from the more ambitious scenarios in the impact assessment and seemingly took a more cautious approach. For the gaseous emissions, there is a 'tidying up' of the existing Euro 6 standards which currently differ between gasoline and diesel vehicles. For passenger car or M1 and N1 category vehicles, the EC took the lowest limits for each pollutant type across Euro 6 gasoline and diesel and selected this as a common limit for Euro 7. For example, permitted Euro 6 NOx emissions currently sit at 80 mg km^{-1} for diesel and 60 mg km^{-1} for gasoline cars. Euro 7 sets a 'fuel consistent' limit of 60 mg km^{-1}. The PN limit for light duty cars and vans remains at the Euro 6 level of 6×10^{11} km^{-1}, albeit with the 10 nm particle size requirement. However, more ambitious cold-start and extended boundary conditions which develop stricter RDE requirements for cars and vans compared to Euro 6 means Euro 7 is not such a trivial set of standards as some critics claim. Additionally, the introduction timing of 1st July 2025 for cars and vans can certainly be considered ambitious.

While implementing Euro 7 still needs to be worked through, the 'art of possible' for advanced emissions control systems which will help enable Euro 7 at an affordable cost is well exemplified by demonstrator vehicles run by the Association for Emissions Control by Catalyst (AECC) (6).

The EPA's Heavy Duty Low NOx or 'clean trucks' final rulemaking, set to be implemented in 2027, is an ambitious new standard where NOx emissions are very much a focus. We will see an 82.5% reduction in permitted tailpipe NOx emissions (over Federal Test Procedure) compared to today's limits. Trucks will also need to be cleaner for longer as heavy-duty trucks' durability requirements increase to 650,000 miles. The EPA estimate that in 2045 the final rule will result in numerous public health benefits including up to 2900 fewer premature deaths per year. The total health related benefits are estimated to outweigh the costs by up to US$29 billion (7).

A Combined Approach

As world regions set out regulations to reduce both criteria pollutant and carbon dioxide emissions, it is clear that both regulatory frameworks need to work together as a pathway to zero emission transport. The transition to zero emission vehicles at tailpipe will not happen overnight. While battery electric vehicles and fuel cell electric vehicles increase in market share, there will remain a significant portion of ICE vehicles in the global car parc. Indeed, considering the average age of cars and trucks is ~12 and ~14 years respectively in Europe (8), even with ambitious CO_2 reduction targets, we need to ensure those vehicles are as clean as possible while in operation over their lifetime. We should also consider how technologies such as hydrogen ICE can move us up a gear on the road to net zero.

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