Remote Emission Sensing

as a means of detection and enforcement of gross-polluting vehicles

Participants

- China, Tsinghua University
- Denmark, EPA, MoE&F
- Finland, VTT
- Sweden, IVL
- Switzerland, Empa

Policy Relevance

In order to meet air quality guidelines and crucial environmental objectives, and to protect human health and nature in both Europe and China, there is a need to ensure that the strict emission standards for road vehicles implemented in recent years (i.e., Euro/China 6/VI) are fully complied with in all real-world operating conditions.

Major Conclusion

Remote Emission Sensing (RES) techniques have substantially improved in recent years and are continuously being further developed. RES is important as a complementary real driving vehicle emission measurement tool to help identify vehicles with failing emission control systems (SCR systems, DPF, TWC). RES may also be used to cost-effectively follow up the future evolvement of fleet average real-world emissions, i.e., to track the efficiency of the recently implemented strict emission legislation in both Europe and China.

Background

Despite a gradual introduction of increasingly stringent emission legislation for road vehicles over the past two to three decades, air quality is still a major concern for citizen health in many large cities in both Europe and China. Road transport is still being considered a main source contributing to this problem. One explanation to the slow improvement is that not until recently emission legislation has started to address emissions under real driving conditions. Because of this, recent data shows that emissions in particular nitrogen oxides (NO_X) from new diesel powered vehicles – both light- and heavy-duty – have started to decrease substantially, as was the case for petrol powered vehicles already in the early 1990's. Emission reductions are dependent on properly operating emission control systems. However, even with today's emission legislation there appears to be vehicles operating on public roads with malfunctioning exhaust aftertreatment systems. This contributes to the lingering problem of poor urban air quality and also of reaching environmental objectives to protect nature.

The gradual development and improvements over the last +30 years of remote emission sensing techniques offer an important part to solve these problems.

The IEA-AMF TCP Task 61 was initiated to answer the key question: How can remote emission sensing (RES) be used for policy purposes as well as for direct or indirect enforcement of high-emitting/gross-polluting road vehicles detected in real-world traffic.

Research Protocol

Five partner organizations (three research institutes, one university and one national environmental authority) in Europe (Denmark, Finland, Sweden and Switzerland) and China, with profound experience of remote emission sensing, legislative emission measurements and exhaust plume modelling, collaborated in Task 61. The objective of the task was to review recent research on the development and application of the three main RES types (see Figure 1):
1) conventional/commercial RES (type 1),
2) point sampling RES (type 2) and
3) plume chasing RES (type 3).

An important part of the task was to review the knowledge regarding validation and potential improvements of the various RES instruments ability to
1) identify individual gross-polluting vehicles and
2) measure the average emission performance by vehicle-sub fleets, such as by emission standard, vehicle brand, engine family, etc., therefore results from onboard emission measurement studies (PEMS, SEMS) and from advanced simulations of exhaust plumes in the vehicle wake were included.

Following dieselgate in 2015, a lot of research and development within the field of real driving emission measurements in general, and remote emission sensing measurements in particular, have been carried out in both Europe and China. For Task 61 the cornerstones have been the four-year (2019-2023) EU Horizon 2020 flagship projects CARES (City Air Remote Emission Sensing) and MODALES, together with the CARES "sister project" in China running in parallel.

Task 61 was coordinated by Åke Sjödin, IVL Swedish Environmental Research Institute.

Key Findings

The key findings of Task 61 are:

- A good agreement for NO_X emissions has been observed between RES type 1, RES type 2 and PEMS in a real-world setting (Figure 2). Also, RES type 3 agrees well for with PEMS for NO_X, and RES type 2 agrees well with PEMS for PN (although not shown in Figure 2).
- RES type 1 has proven useful to measure average emissions on fleet level, e.g., by emission standard, vehicle brand, engine family, etc., in good agreement with onboard RDE measurements.
- Both RES type 1 and type 2 have proven capable to substantially increase the efficiency of roadside inspections catching gross-polluting vehicles with regard to both NO_X and particulate matter (PN).
- PEMS and SEMS measurements demonstrate that Euro 6 diesel cars as well as Euro VI heavy-duty trucks that comply with the emission limits set in the RDE regulation, may still occasionally produce significant spikes of NO_X emissions under certain driving conditions. Single RES type 1 and type 2 measurements are therefore of limited use to correctly identify high-emitters; to do so at least 3-5 repeat measurements on the same individual vehicle are required.
- RES type 1 has proven a useful tool to derive relationships between emissions, e.g., by emission standard, and vehicle age/mileage as well as ambient temperature. It has also proven useful to validate underlying emission models to emission inventories.
- RES type 3 has proven very capable of identifying NO_X gross-polluting Euro/China V and VI heavy-duty trucks, gross-polluters that have been found in substantial shares on motorways in both Europe and China, frequently due to tampering of the SCR system. Tampering may result in an increase of the truck's NO_X emissions by up to one order of magnitude or even more. In China, these observations led to the conclusion that the 2019 national emission inventory underestimated overall NO_X emissions by 18%.
- Advanced numerical simulations for a passenger vehicle show that the exhaust gas plume is strongly diluted in the near vehicle wake, so that no significant proportion of exhaust gas can be measured 1.5-3 m downstream of the vehicle. That is, for all investigated speeds (30-80 km/h) and wind conditions, with the peak concentration of exhaust gases found less than 0.5 m down-stream of the vehicle, explaining the lower hit-rates for RES type 2 compared to RES type 1, due to the lower measuring frequency.

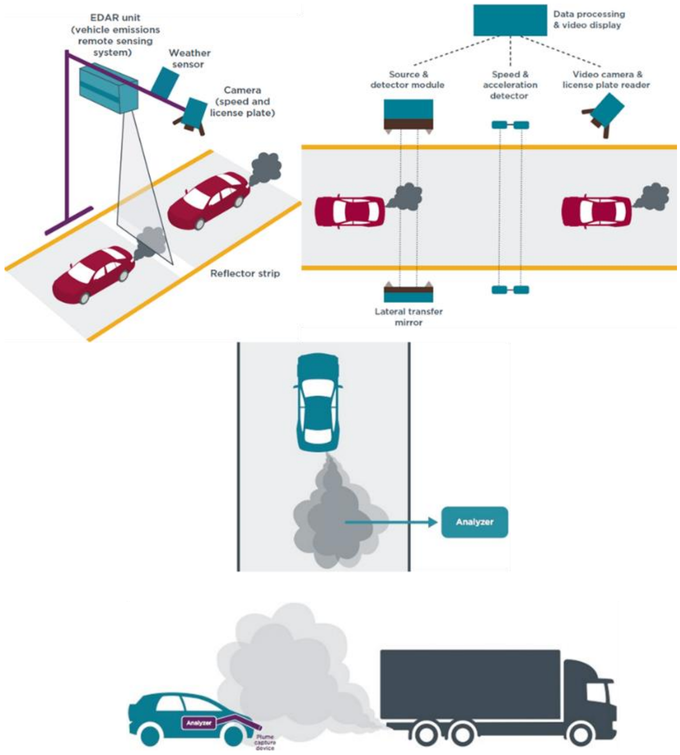

Figure 1. Schemes of the different types of Remote Emission Sensing: Top: RES type 1 – conventional/commercial RES. Left: vertical; right: cross-road. Middle: RES type 2 – point sampling RES. Bottom: RES type 3 – plume chasing RES.

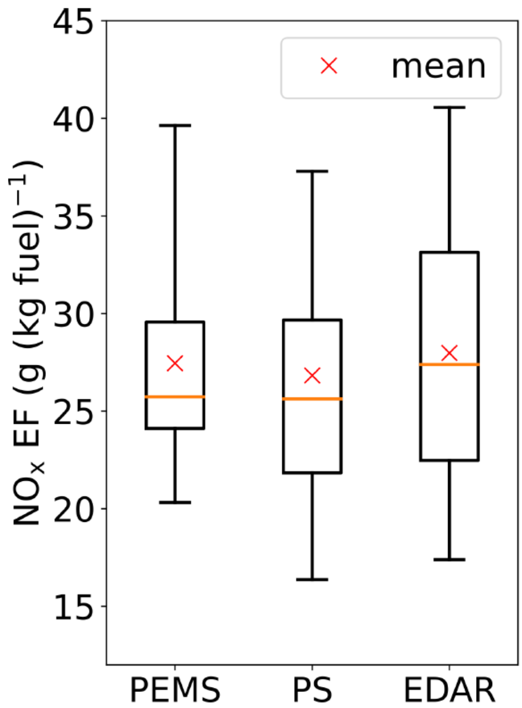

Figure 2. Comparison of NO_X emissions from petrol and diesel cars measured with PEMS, RES type 2 (PS) and type 1 (EDAR) in Milan in 2021 in CARES (https://cares-project.eu/).