



Economic Commission for Europe**Inland Transport Committee****Seventy-sixth session**

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Strategic questions of a horizontal policy nature:**Climate change and transport – Mitigation of environmentally harmful effects of inland transport****Diesel Engine Exhausts: Myths and Realities****Note by the secretariat***Summary*

The note provides the Inland Transport Committee with a brief review of discussion paper (Informal document No. 2) titled “Diesel Engines Exhausts: Myths and realities”. It is submitted to the Inland Transport Committee for consideration and in order to facilitate the development of a position by the Committee.

The note, as well as the discussion paper, analyse the main air pollutants emitted by diesel engine exhausts, in particular, the particulate matters PM₁₀ and PM_{2.5}. Furthermore, they provide information on historical trends of these emissions in Canada, Japan, the United States of America and the European Union. The analysis draws attention to the role of the different economic sectors and especially of inland transport as the main source of these emissions. Moreover, they provide information on main international and national regulations and measures addressing diesel exhaust emission. The Committee is invited to consider the recommendations and develop its position.

I. Introduction

1. Every day throughout the world, millions of diesel-powered vehicles busily move passengers, consumer goods and raw materials from homes, offices, ports, distribution centers and rail yards to stores and industrial facilities. Diesel powered ships, trains, cars and trucks play a pivotal role for local, regional and global mobility and commerce. Most of the river barges, freight trains and ocean-going ships are also powered by diesel, as are the

overwhelming majority of road vehicles. Furthermore school buses, buses and other service vehicles facilitate our daily lives.

2. Diesel-powered mechanization is also a major part of the agricultural supply chain that moves crops from farms to the dinner table. Diesel-powered farm tractors, combines and irrigation pumps are just a few examples of the types of equipment that literally drive one of the most important industries of national economies.

3. Diesel engines are present not only in mobile vehicles and machinery, but also widely employed as stationary power generators such as pipeline pumps, electric and water plants, industrial machinery, mining tools, factories and oil fields.

4. With unmatched reliability, durability, and fuel efficiency, diesel engines play a fundamental role in economic development of human society.

5. However, along with their economically productive role in national economies, comes diesel engines emissions' harmful effect on human health. Emissions from diesel engines in trucks, boats, locomotives, buses, agricultural and construction equipment — especially the microscopic soot known as “particulate matter” (PM) — create serious health problems for adults and have extremely harmful effects on children and the elderly.

6. The objective of this note is to provide information about some recent and important developments related to trans boundary air pollution and elsewhere; illustrate the results of recent studies on the harmful effects of diesel exhausts on public health; list the negative contribution of different economic sectors and of inland transport to these emissions but also to inform about recent policy developments on the reduction of pollutant emissions to address health and environmental concerns, and about the technological developments of diesel engines that eliminate the harmful effects to public health.

II. Main Air pollutants from Diesel Engine Exhausts

7. Particulate matter (PM) is one of the main emissions of diesel engine exhausts and is a complex heterogeneous mixture comprising both primary and secondary PM. Primary PM is the fraction of PM that is emitted directly into the atmosphere, whereas secondary PM forms in the atmosphere following the oxidation and transformation of precursor gases (mainly SOX, NOX, NH3 and some volatile organic compounds (VOCs)). From a regulatory perspective, PM is divided into PM₁₀ and PM_{2.5}, defined (ISO, 2008) as the size fractions where the median aerodynamic diameter of the particles is respectively 10 and 2.5 microns (this means that 50 per cent of the particles in these fractions have diameters respectively greater, or smaller, than 10 microns and 2.5 microns. Sources of coarse particles include crushing or grinding operations, and dust stirred up by vehicles traveling on roads. Sources of fine particles include all types of combustion, including motor vehicles, power plants, residential wood burning, forest fires, agricultural burning, and some industrial processes. Considering the potential to harm human health, PM is one of the most important pollutants as it penetrates into sensitive regions of the respiratory system.

8. The concentration of air pollutants in the lower part of the atmosphere not only depends on levels of emission of pollutants and their precursors, but also on specific characteristics of the pollutant (such as their average lifetime against phenomena like photolysis), as well as changes in meteorological conditions (Jacobson, 2012 and EEA, 2009). Specific climatic conditions like the thermal inversion, for instance, can lead to high concentrations of secondary aerosol in the air, in such a way that the latter may become the predominant contribution to PM₁₀ and PM_{2.5} as compared to primary particles.

9. According to the European Environmental Agency (EEA) (which builds on the results obtained with these modelling instruments), air pollutant emissions in Europe (including EEA Member States and Countries of the Western Balkans) have decreased since 1990. In 2010 (EEA, 2012a):

(a) SOX emissions were 82 per cent lower than in 1990;

(b) emissions of the other main air pollutants have dropped significantly since 1990, including emissions of the three air pollutants primarily responsible for the formation of ground-level ozone: CO (62 per cent reduction), NMVOC (56 per cent reduction) and NOX (47 per cent reduction);

(c) Total Suspended Particles (TSP) have seen a reduction of 48 per cent from 1990. For PM₁₀ and PM_{2.5}, the aggregated EU-27 emission reduction achieved since 2000 is 14 per cent and 15 per cent, respectively.

10. In Canada, the emissions of air pollutants experienced significant reductions in recent years. Between 1990 and 2010, Canada's total SOX emissions have decreased by 57 per cent, CO emissions have been reduced by 40 per cent, PM_{2.5} by 35 per cent and NOX emissions by 18 per cent.

11. In Japan, environmental monitoring of the atmosphere is conducted by prefectural governments in compliance with the Air Pollution Control Law and reported to the Ministry of the Environment. According to their reports, the evolution of the atmospheric concentration of SO₂, suspended particulate matter (SPM) and NOX, illustrates that the atmospheric concentration of all these pollutants has been on a downward trend in the past few decades.

12. Downward trends are also observed in the United States of America, where, between 1990 and 2012, SO₂ emissions fell by more than 70 per cent, CO emission by more than 60 per cent, NOX emission decreased by more than 40 per cent, and PM (both PM₁₀ and PM_{2.5}) emissions declined by roughly 20 per cent.

III. Diesel engine exhausts harmful effect on human health and the environment

13. Notwithstanding the progress in reducing anthropogenic emissions of the main air pollutants over recent decades, poor air quality remains an important public health issue (EEA, 2010). This is particularly relevant for airborne PM, tropospheric (ground-level) ozone (O₃) and nitrogen dioxide (NO₂).

14. In June 2012, the World Health Organization's International Agency on Research on Cancer (IARC) concluded that diesel engine exhaust is carcinogenic to humans based on sufficient evidence that exposure is associated with an increased risk for lung cancer (IARC, 2012). IARC thereby changed its finding from 1988, when it classified diesel exhaust as probably being carcinogenic to humans. The finding from a previous evaluation in 1989, that gasoline exhaust is possibly carcinogenic to humans, remained unchanged.

15. It is noteworthy that the IARC decision was unanimous and was based on "compelling" scientific evidence. It urged people worldwide to reduce their exposure to diesel fumes as much as possible. Large populations are exposed to diesel exhaust in everyday life, whether through their occupation or through the ambient air. People are exposed not only to road motor vehicle exhausts but also to exhausts from other diesel engines, including those from other modes of transport (e.g. diesel trains and ships) and stationary sources (e.g. power and motion generators used in the energy industry).

16. However, the mounting concern about the cancer-causing potential of diesel exhaust was based on findings in epidemiological studies which were re-emphasized by the publication of the results of a study of occupational exposure to such emissions by underground miners by the US National Cancer Institute and National Institute for Occupational Safety and Health. The study showed an increased risk of death from lung cancer (IARC, 2012).

17. Dr. Kurt Straif, Head of the IARC Monographs Program, indicated that the main studies that led to the above mentioned conclusion were on highly exposed mine workers, and that this conclusion was based on the impact of other carcinogens, such as radon. Initial studies showing risks in some occupational groups were followed by positive findings for the general population (IARC, 2012).

18. Dr. Christopher Wild, IARC Director, answering the question if the new diesel engines are so clean are the findings from this monograph no longer relevant to today's situation, replied: "the new diesel engines contain far fewer particles and chemicals compared to the older technology engines. In addition to that, there are also qualitative changes, so the composition of the mixture in the exhaust is different". He also added that "what we do not know at this stage is if this composition and the decreased levels of these components translate to a different health factor in exposed people, and here we should encourage further research in the future" (Wild, 2012). He also underlined that in many developing countries the transition from the old to new technology will take time and therefore, many people in the world, are still exposed to the exhaust of old diesel engines (Wild, 2012).

IV. The role of different economic sectors

19. In addition to total emissions, the EEA estimated the role of different economic sectors in Europe with respect to the emissions of different pollutants. Energy, agriculture, transport (road and non-road transport), industrial processes, the use of solvents and other similar products, as well as the commercial and household sectors have emerged as the key sources of emissions of a wide range of air pollutants, including NO_x, SO_x, NMVOC, CO, and PM (EEA, 2012a).

20. The EU-27 key categories for air emissions are the individual sources that have overall contributed most to emissions of pollutants in 2010, determined by assessment of a level of emission for each of the main air pollutants, PM, HMs and POPs. From a total of 109 categories of emission sources, 49 were identified as key categories for at least 1 pollutant. A number of categories were identified as key categories for more than 1 of the 15 pollutants assessed. Thirteen times was the number of occurrences for residential/ Stationary plants, 11 times for public electricity and heat production, 10 times for Iron and steel production and six times for road transport (NO_x, CO, NMVOC, Pb, PM₁₀, PM_{2.5}).

V. The Role of Inland Transport

A. Road Transport

21. Diesel engines provide important fuel economy and durability advantages for heavy-duty trucks, buses and non-road equipment. Although they are often the preferred choice for heavy-duty vehicles, diesel engines have the disadvantage of emitting significant amounts of PM and the oxides of nitrogen (NO_x), although lesser amounts of hydrocarbon (HC), carbon monoxide (CO) and toxic air pollutants.

22. However, rapid developments in engine technology and more rigorous norms have made possible continuous tightening of emissions standards over time. This can be illustrated by nitrogen oxides (NO_x) and PM limits for heavy-duty vehicles. The Euro VI (heavy-duty) limits for both NO_x and PM are 95 per cent more stringent than those of Euro I (ICCT 2011).

B. Rail Transport

23. Exhaust emissions from rail diesel traction in Europe (EU27 & EFTA) are generally very low. Rail diesel traction accounts for less than 2.5 per cent nitrogen-oxide and 4.5 per cent particulate matters (EEA 2008) emissions out of the total emissions from the European transport sector. European railways are committed to reduce their total exhaust emissions of NO_x and PM by 40 per cent by 2030. From 1990 to 2008, NO_x and PM emissions from rail diesel traction have already decreased by approximately 35 per cent. Calculations by the CleanER-D consortium suggest a further potential substantial decrease of NO_x by approximately more than 20 per cent and more than 25 per cent for PM from 2008 to 2020 (UIC, 2013).

24. The reasons for this significantly better future emission performance are mainly:

(a) The introduction of cleaner engine technologies and limit values (NRMM stage IIIB) into the European vehicle fleet;

(b) A smaller diesel locomotive fleet (UIC statistics indicate that a high share of diesel locomotives in Europe no longer in active service) and lower mileages of old vehicles with old engines;

(c) More efficient operation of diesel locomotives and diesel multiple units (DMU);

(d) Further electrification of railway lines (e.g. EU TEN-T corridors).

C. Inland Water Transport

25. Inland Waterway Transport (IWT) is an efficient, safe and environmentally friendly mode of transport. However, the previously undisputed advantageous position of IWT in regard to emissions is increasingly being contested. The gap – regarding emissions – between road transport and IWT is rapidly becoming narrower. A major concern therein, is the poor progress made on the emission of air pollutants particularly the emission of nitrogen oxides (NO_x) and PM. In contrast to the road haulage sector, the emission standards for new engines are much less stringent and the average lifetime of engines in inland vessels is very long. As a consequence, inland waterway transport already has higher air pollutant emission levels than road transport per tonne kilometre for certain vessel types (Panteia 2013).

26. Because the innovation rate of engines for other transport modes is faster, the reduction of emission levels of IWT is stagnating. The long lifetime of inland barge engines (30,000 to over 200,000 hours, depending on the engine type) results in a slow uptake of the new engines in the fleet. Breakthrough and large-scale innovations are introduced at a relatively slow pace. In inland water transport self-propelled dry cargo and tank vessels, push boats, and tugs are the most commonly used vehicles. Inland vessels thereby, have a longer life span than maritime vessels. Bulk vessels on the Rhine are on average about 50 years old; the average age of liquid cargo ships is about 35 years.

VI. Emissions' regulations contribution to the improvement of diesel engines environmental performance

27. Canada, Japan, Switzerland, the United States and the European Union have recently undertaken measures to address diesel exhaust emissions.

28. Canada regulates new on-road light passenger cars and trucks, as well as on-road heavy-duty trucks and off-road machinery. Most recently, Canada aligned with the Tier 4 air pollutant standards of the United States of America for off-road diesel engines used in mining, agriculture and construction. Canada has also implemented regulations to reduce the maximum allowable content of sulphur diesel fuel to 15 part per million (ppm) in order to ensure the effective operation of exhaust after-treatment systems used on diesel engines to meet increasingly stringent emission standards.

29. The current Japanese "Post New Long Term Regulation" for diesel vehicles came into force in October 2009, in accordance with the Eighth Report of Future Policy for Motor Vehicle Emission Reduction published by the Central Environment Council on April 2005. In addition, the Tenth Report of Future Policy for Motor Vehicle Emission Reduction published on July 2010 recommends the adoption of Worldwide harmonized Heavy Duty Certification (WHDC) and reinforcement of NOX permissible limit for heavy-duty diesel vehicles effective from 2016 (CEC, 2005 and 2010).

30. Having considered that solutions to limit particle emissions with efficient filters are enforced for several diesel source categories (passenger cars, buses of public transport, construction machinery, ships, locomotives, heavy duty vehicles), the Swiss Federal Council modified the emission control provisions for construction equipment, specifying more stringent maximum emission levels which, given current developments in technology, can only be met by employing efficient particle filter systems (Switzerland, 2009 and 2012).

31. The United States of America has a full suite of regulatory actions that address emissions from diesel engines and diesel fuel. Since 2007, diesel engines introduced into the United States of America market must meet the most stringent standards. Diesel sulphur levels were also dramatically reduced at that time. Diesel engines used in non-road sources like agriculture or construction will need to meet strict Tier 4 emissions requirements beginning in 2014. Additionally, within the last five years the United States of America has adopted regulations for emissions control from locomotives and marine vessels.

32. The high share of light vehicles running on diesel in the European Union is one of the reasons why the European Union was an early adopter (as a result of the entry into force of Euro 5 emission regulation) of technologies like the diesel particulate filter (DPF) on light vehicles. DPFs are also necessary to comply with heavy duty emission regulation.

33. Regulatory measures aiming to limit pollution from road transport were not frequently mirrored by comparable measures in other transport sectors and in other economic domains, such as residential and commercial/institutional sectors. This is especially relevant when looking at pollutants associated with diesel exhausts (namely PM and NOX), since substantial amounts of diesel and residual fuel oil are combusted in applications widely employed in the energy, industry and residential/commercial sector, and since significant fraction of these emissions (namely those originating in the residential and commercial sector, which is responsible for the largest fraction of PM emissions) is likely to be present in urban agglomerations, i.e. the areas subject to the largest exposure to air pollution.

VII. Activities of the Inland Transport Committee and its subsidiary bodies towards elimination of diesel engines exhaust emissions

34. UNECE World Forum for Harmonization of Vehicle Regulations (WP.29) is the major contributor towards global reduction of the emissions of air pollutants from all motor vehicles engines, and it has already done extensive work on air pollution containment.

35. In 1997, WP.29 initiated a process aimed at the world-wide test cycle harmonization for heavy-duty engines. This began with the creation, of a working group on the World-wide Heavy-Duty Certification procedure (WHDC). The work of this group resulted in the establishment, in 2006, of a harmonized UN Global Technical Regulation (UN GTR No. 4) on the certification procedure for heavy-duty engines (UNECE, 2013a).

36. In 2001, the working group World-Wide harmonized Heavy duty On-Board Diagnostics (WWH-OBD) was established to develop harmonized prescriptions for technical requirements for road vehicles' on-board diagnostic systems. This activity led to the adoption, in 2006, of the UN GTR No. 5 (UNECE, 2013b), a regulatory text that is directed at OBD requirements for heavy-duty engines/vehicles that are necessary to maintain emissions-related performance (i.e. emissions-OBD).

37. A similar process started in 2003 for Non-Road Mobile Machinery (NRMM), with the creation of a working group aiming to develop new worldwide harmonized provisions for NRMM engines. Similarly to the case of heavy duty vehicles, the work of the NRMM group led to the establishment, in 2009, of the UN GTR No. 11 (UNECE; 2013e).

38. UN Regulations Nos. 49 (heavy duty vehicles) (UNECE, 2013g) and 83 (light vehicles) (UNECE, 2013h) specify limit values for emissions of particulate matter (expressed, in the last updates, both in terms of particulate mass and particle number), carbon monoxide, hydrocarbons (also specifying the part of non-methane hydrocarbons, in the last updates) and oxides of nitrogen. They build on the emission regulations enforced in the European Union (Euro pollutant emission standards, enacted through directives and, in recent years, regulations).

39. In 2010, WP.29/GRPE established an informal working group on Retrofit Emission Control devices (REC) to evaluate harmonized requirements for the treatment of diesel exhaust emissions. The working group's aim was to develop a new UN Regulation for REC to be installed on heavy duty vehicles, non-road mobile machinery and tractors already in use. The activities of the group follow a number of initiatives aiming to contain pollutant emissions, including in particular the adoption of low emission zones.

40. In 2001, the World Forum WP.29 established an informal working group on the Particle Measurement Programme (PMP). The main focus of this group is the development of standardized methodologies to measure emissions of solid tailpipe particles from vehicles and engines. This has been the basis for the development of regulatory instruments targeting the emission reduction of pollutants, notably PM and particle number (PN).

41. Since 2012, the Special Resolution No. 1 (UNECE, 2013k) and the Consolidated Resolution on the Construction of Vehicles (R.E.3) (UNECE, 2013l), developed in the framework of the 1998 Agreement on UN Global Technical Regulations and the 1958 Agreement concerning the Adoption of Uniform Technical Prescriptions, administered by WP.29, contain recommendations developed to inform governments about appropriate market fuel quality that is protective of vehicle emission control technologies.

VIII. Recommendations for the Inland Transport Committee

42. Noting the purpose and the argumentation for the WHO reclassification, there is now strong evidence in favour of continued development of regulatory provisions (such as UN GTRs and UN Regulations) concerning air pollutant emissions, including diesel exhaust not only from the transport sector but from all other economic activities.

43. The example set by the pollutant emission regulation in road transport should also be extended (with greater ambition in comparison with current practice) to other transport modes whenever their contribution to the concentration of air pollution in high exposure areas like cities is relevant. Pollutant emission mitigation should target all transport modes, including those that have not been targeted with the same stringency used for road transport applications (such as IWT, maritime, etc.)).

- More stringent regulations are warranted for all modes of transport and the relevant Working Parties are invited to follow up accordingly.

44. Action limiting the exposure to air pollution, especially considering diesel engines, is urgently needed in all economic sectors and applications, and should not be limited to the transportation sector. Diesel engines provide important fuel economy and durability advantages for agriculture, construction, mining, etc.

- Diesel fuel cannot be ruled out, at least not in the near future and not only from transport but also from other sectors of the economy.

45. In some high exposure areas, there might be the need to set up policy measures aimed at replacing vehicles equipped with older engine technologies with new vehicles which comply with the new regulations or to retrofit the engines with appropriate emission control devices. The work to further reduce exhaust emission limits should continue, as new needs arise and new technologies are developed, taking into account all parameters, including cost/efficiency and impact assessment. Promotion and further improvement of public transport, use of electric vehicles, implementation of eco-driving practices, reducing the loads (weight, rolling and air resistance and accessory loads) on the vehicle, promotion of fuels switching, could be some of the measures taken by Governments to address this issue.

- Diesel — similarly to other fossil fuels used — has other emission problems, not just the particulate matters and often there is a trade off in reducing one component at the cost of the increase of another; the real issue is in special areas, like tunnels, toll-gates, congested cities. The solution is more in demand management than in technological improvements.
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