Executive Summary

Non-exhaust particle emissions from road traffic consist of airborne particulate matter (PM) generated by the wearing down of brakes, clutches, tyres and road surfaces, as well as by the suspension of road dust. A growing body of evidence shows that PM emissions have significant implications for human health. Furthermore, the damages to human health caused by PM emissions from road traffic can be disproportionately large relative to other sources of PM emissions, as the highest emission levels tend to be localised in areas with the greatest population density, leading to high levels of exposure. Despite the significant burden of non-exhaust emissions on public health, few public policies target them explicitly.

While emission standards for exhaust particles from motor vehicles are becoming more stringent worldwide, non-exhaust PM emissions are largely unregulated. As a result, the proportion of PM emissions from non-exhaust sources has increased in recent years due to the significant reductions in PM from exhaust emissions over this period. Non-exhaust emissions are expected to be responsible for the vast majority of PM emissions from road traffic in future years.

This report analyses the nature, drivers and health consequences of non-exhaust emissions and reports estimates of total PM emission factors for electric and conventional vehicles, including primary and secondary PM from exhaust sources as well as primary PM from non-exhaust sources. Based on these estimates, the report explores the implications of anticipated electric vehicle uptake for non-exhaust PM emission levels. It then provides an overview of existing policies that contribute to the reduction of non-exhaust PM emissions and proposes a framework for the design of targeted policy action to address the negative externalities associated with these emissions. The report emphasises that the development and implementation of such targeted policy action depends on a robust understanding of the processes that generate non-exhaust emissions, the relationship between exposure to these emissions and health impacts, and the effectiveness of various mitigation measures in reducing emission rates and exposure.

What are the causes and impacts of non-exhaust emissions?

Four main processes are responsible for the bulk of non-exhaust emissions: the wearing down of brakes, tyres, and road surfaces, and the resuspension of road dust. The amount of PM emissions that a vehicle emits is determined by many factors, including vehicle weight, the material composition of brakes, tyres, and roads, the amount of dust on road surfaces, and driving styles. Although uncertainty remains with respect to the amount of PM emitted from non-exhaust sources under real-world driving conditions, non-exhaust emissions will increase in the coming years along with increases in the demand for urban passenger travel, which is projected to more than double by 2050.

In the context of growing travel demand, electric vehicles are widely regarded as a solution to mitigating greenhouse gas emissions and other air pollutants from road transport. While they stand to eliminate exhaust emissions, this report shows that electric vehicles are not likely to provide substantial benefits in terms of non-exhaust emissions reductions. Regenerative braking systems can reduce brake wear, but tyre wear, road wear, and road dust resuspension remain significant sources of non-exhaust emissions from electric vehicles. Non-exhaust emissions from these sources can in fact be higher for electric vehicles than for their conventional counterparts, as the heavy batteries in electric vehicles imply that they typically weigh more than similar conventional vehicles. This is particularly the case for electric vehicles with greater autonomy (driving range) that require larger battery packs.

Epidemiological studies have established that exposure to non-exhaust PM emissions, and to PM2.5 in particular, is associated with a variety of adverse health outcomes in the short and long term, such as increased risks of cardiovascular, respiratory, and developmental conditions, as well as an increased risk of overall mortality. The oxidative stress induced by the metals and organic compounds found in PM emissions is considered to be a main biological mechanism responsible for these negative health impacts. Recent research has also suggested that air pollution exacerbates coronavirus epidemics such as SARS and Covid-19. Impacts are greatest in urban areas, where emission levels – due *inter alia* to congestion – and population exposure are highest.

What is the current situation and how will it evolve with the uptake of electric vehicles?

Globally, road traffic is responsible for an estimated quarter of ambient PM in urban areas. Given increasingly stringent standards regarding the PM content of exhaust emissions, non-exhaust emissions are quickly becoming the dominant source of PM emissions from road traffic, and are expected to comprise the vast majority of all PM from road traffic as early as 2035. While the uptake of electric vehicles (EVs) will contribute to reducing exhaust PM in future years, non-exhaust PM will not noticeably fall unless targeted policies are undertaken.

Electric vehicles are estimated to emit 5-19% less PM10 from non-exhaust sources per kilometre than internal combustion engine vehicles (ICEVs) across vehicle classes. However, EVs do not necessarily emit less PM2.5 than ICEVs. Although lightweight EVs emit an estimated 11-13% less PM2.5 than ICEV equivalents, heavier weight EVs emit an estimated 3-8% more PM2.5 than ICEVs. In the absence of targeted policies to reduce non-exhaust emissions, consumer preferences for greater autonomy and larger vehicle size could therefore drive an increase in PM2.5 emissions in future years with the uptake of heavier EVs.

Projection exercises presented in this report show that the total amount of non-exhaust PM (PM2.5 and PM10) emitted by passenger vehicles worldwide will rise by 53.5% along with transport demand, from approximately 0.85 Mtonnes today to 1.3 Mtonnes in 2030 in a business-as-usual scenario with low uptake of heavier weight EVs. The reduction in PM emissions made possible by a scenario assuming greater overall EV uptake is very slight: a doubling of EV uptake leads to an estimated 1.29 tonnes in non-exhaust PM in 2030, or a 52.4% increase.

How should policymakers address non-exhaust emissions?

The evidence presented in this report reveals a need for policy action to reduce non-exhaust emissions and mitigate their consequences for public health. The majority of public policies addressing PM from road traffic target exhaust emissions. Given the lack of robust understanding of many aspects of non-exhaust emissions, addressing them effectively and efficiently will hinge on advancing the state of knowledge in critical areas, including regarding their magnitude, their impacts and the effectiveness of measures designed to mitigate them. To the extent that the development and implementation of public policies targeting non-exhaust emissions will rely on the use of standardized measurement methodologies, establishing standardized approaches to measuring non-exhaust PM and developing an understanding of how various factors (e.g. vehicle characteristics) influence the amount of PM generated, should be a first priority. Some progress has been made in this regard for brake wear, but similar work remains to be done with respect to tyre wear, road wear and road dust resuspension.

PM from non-exhaust sources can be mitigated by reducing the amount of PM emitted per vehicle-kilometre travelled and by reducing the number of vehicle-kilometres travelled. A distance-based charge designed to internalise the social costs of non-exhaust emissions is a theoretically effective mitigation instrument insofar as it incentivises both a reduction in emission factors as well as in vehicle-kilometres travelled. No precedent currently exists for such a charge, in part because non-exhaust emissions have largely been overlooked in policymaking to date, but also due to the uncertainty surrounding the amount of PM emitted, the factors that influence this amount, and the social costs of the attendant impacts.

While the quantitative evidence basis regarding the magnitude, causes and consequences of non-exhaust emissions continues to be developed, other measures should be implemented to reduce these emissions in the near term. Policy options for reducing non-exhaust emission factors (i.e. the amount of non-exhaust PM emitted per vehicle-kilometre travelled) include vehicle lightweighting and regulations on tyre composition. Insofar as lighter vehicles emit less brake and tyre wear, vehicle lightweighting measures constitute a particularly useful technological measure for reducing emission factors.

Vehicle-kilometres travelled in urban areas can be reduced using a variety of policies that disincentivise the use of private vehicles and incentivise the use of alternative modes such as public transport, cycling, and walking. As population exposure to PM from non-exhaust emissions is greatest in urban areas, urban vehicle access regulations (UVARs) such as low-emission zones and congestion pricing schemes can also be an effective means of reducing the social costs of non-exhaust emissions.

The insights that issue from the findings of this report stand at odds with prevailing policy stances regarding electric vehicles. In the context of most climate and air pollution mitigation policies, increasing electric vehicle uptake is generally considered desirable insofar as it reduces exhaust emissions and their associated social costs. In practice, this means that electric vehicles are often exempt from policies to discourage conventional vehicle use, such as congestion charges and tolls. However, given that electric vehicles emit similar levels of non-exhaust emissions as conventional vehicles, and potentially more PM2.5, this analysis suggests that electric vehicles should not be exempt from such policies. Policymakers seeking to reduce non-exhaust PM emissions from road transport should therefore reconsider policy approaches that provide blanket support for electric vehicles. Instead, they should pursue the implementation of more sophisticated instruments that are designed based on the determinants of a vehicle’s non-exhaust emissions rather than on its drivetrain only.

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