Air Quality in Transport Hubs

Transport hubs (for example railway and bus stations) may be important air pollution hotspots contributing significantly to overall pollutant exposure. This briefing note examines the current evidence and regulatory landscape, and explores potential opportunities to reduce exposure in these environments

Overview

- People using transport hubs can experience high levels of air pollution. These areas are largely unregulated as indoor environments.
- There is more existing knowledge of air quality challenges in railway stations compared to bus station environments.
- The transition to 'low-emission' public transport alternatives is an important opportunity to deliver long-term air quality benefits.
- There is a need to generate urgent solutions to reduce air pollution exposure in public transport settings.

Background

Air pollution is a prominent public health concern in the UK, responsible for between 28,000 – 36,000 early deaths each year[1] and strongly linked to a range of harmful health effects.[2] Transport remains a significant source of air pollution, accounting for 34% of nitrogen oxide (NO_x) emissions and 13% of fine particulate matter ($PM_{2.5}$) emissions in 2018.[3] Exposure to traffic-related air pollution is known to be associated with harm to human health[4], including increased risk of childhood asthma[5], cardiovascular and respiratory disease[6], and daily mortality.[7] To identify how air pollution exposure can be reduced, it is necessary to understand how, where and when an individual is exposed.[8] Transport microenvironments are commonly associated with elevated pollutant concentrations[9] and consequently individuals can receive a significant portion of their daily exposure while travelling.[10] Spending just 6-10% of a day in transport environments can account for up to 30% of an individual's daily pollutant exposure.[11] Previous research has predominantly focused on how commuting in different transport modes can contribute to overall individual exposure.[12,13] However, this has largely ignored the potentially significant impact of time spent in transport hubs. Railway and bus stations are among the most common transport hubs, and serve an important role in the UK transport network. Public transport modes are responsible for a small share of total UK air pollutant emissions, with rail and bus sectors both contributing approximately 1% or less to national NO_x and $PM_{2.5}$ emissions.[14] However, these transport modes can still contribute substantially to air quality conditions at the local scale, especially while operating in transport hubs. These frequently enclosed (or partially enclosed) environments encourage the accumulation of emissions, leading to relatively high pollutant concentrations that pose a potentially significant risk to those using or working in these locations. Currently, emissions from diesel fuel-sources are the most concerning of these emissions.

Diesel emissions

Diesel engines emit a mixture of gaseous and particulate pollutants, collectively referred to as diesel engine exhaust emissions (DEEEs). The most important components include nitrogen oxides (NO_x), carbon monoxide (CO), unburned hydrocarbons (HC) and particulate matter (PM) which have well established adverse impacts on human health.[15] In 2012, DEEEs were classified as a Group 1 carcinogen, with individuals who are regularly exposed (for example bus/train drivers and station staff) up to 40% more likely to develop lung cancer compared to the general public.[16]

Currently 29% of the UK passenger rail fleet, 90% of the freight fleet and 79% of the bus fleet operate solely on diesel fuel.[17] and, despite the known health risks, often go under- or un-regulated. Older diesel trains, that form an appreciable portion of the current rail fleet, are not required to meet DEEE regulations introduced to rail in 2006.[18] Only 52% of the UK bus fleet meets the latest Euro VI vehicle emissions standards introduced in 2015.[17] Consequently these transport modes can serve as major emission sources. For example, diesel buses can contribute substantially to urban emissions[19], and generate up to 70% of NO_x emissions and 56% of $PM_{2.5}$ emissions.[20] Older diesel buses are some of the highest intensity emitters in the whole UK vehicle fleet.[21]

What we know

In the UK, only a handful of air quality studies have been conducted at a small number of mainline railway stations, with assessments undertaken at London Paddington[22], London King's Cross[23], Birmingham New Street[24, 25], and Edinburgh Waverley.[23,26] All of these studies reported pollutant concentrations that exceed ambient air quality standards, and substantially exceed the 2021 World Health Organisation (WHO) Global Air Quality guidelines.[15] For bus stations in the UK there is very limited published air quality data, however evidence from around the world has identified their potential as important pollution hotspots.[27,28,29] Interestingly, a number of local authorities have explicitly identified bus stations as targets for air quality improvements through their respective Air Quality Action Plans[30,31,32] indicating awareness of potential concern for these environments.

Regulatory landscape

Whilst ambient air is regulated in the UK under the 2010 Air Quality Standards Regulation[33], there is no such regulatory framework for indoor environments such as transport hubs. As places of work however, transport hubs are required to conform to EH40/2005 Workplace Exposure Limits (WELs) which set legal limits on the amount of substances that can be present in workplace air.[34] There is limited publicly available data on rail staff exposure[35] although a recent personal monitoring report found staff exposure was distinctly under current WELs.[36] These limits are considerably higher (up to 10 times) than ambient standards, as workers are considered to be fit and healthy. Therefore, these regulations do not consider the general public, or those demographics who may be more vulnerable to the detrimental health impacts of air pollution.

Government and sectoral responses

In the rail sector, these air quality concerns have been acknowledged by both government[37] and industry.[35] The 2019 Clean Air Strategy specifically outlines a need to "reduce emissions from rail and reduce passenger and workplace exposure to air pollution".[38] There are ongoing efforts to better characterise these concerns, for example the £4.5 million Stations Air Quality Monitoring Network (AQMN) investment, a comprehensive programme that involves air quality monitoring at over 100 train stations across England and Wales.[39] Such measures will be important in establishing the extent and magnitude of exposure in these environments. There is also a pressing need to use this information to address how these exposures can be reduced.

Whilst air quality concerns in railway stations have received relatively comprehensive coverage by government, industry and academia, there has been comparatively limited policy interest regarding air quality in UK bus stations. The National Bus Strategy for England only briefly mentions the need to "set out air quality issues which improved bus services could address".[40] There is a need to specifically address air quality in bus stations, to replicate targets and measures outlined for the rail sector.

This apparent lack of research data could have important socio-economic implications, as it is low-income and minority ethnic groups which comprise the highest share of UK bus users.[17] Buses are also more likely to be used by groups who have lower levels of car access such as the elderly, people with disabilities, and young people, including for accessing education.[41] These demographic groups are also known to be more susceptible to the health effects of air pollution[2] implying an element of environmental injustice. A better characterisation of air quality risks at bus stations and potential health impacts could help alleviate these disparities, reduce health inequalities, and provide important steps towards a more equitable transport system.

Transport hub intervention opportunities

The impacts of poor air quality in transport hubs can be reduced by 1) reducing emissions at source and/or 2) reducing exposure. Following the public health principle of primary prevention the progressive removal of diesel vehicle emissions should be the highest priority and can be achieved through a number of methods.

HydroFLEX: The UK's first hydrogen-ready passenger train showcased at Glasgow Central Station for the UN Climate Change Conference (COP26) in November 2021

1) Reducing emissions

Zero-emission technologies

The transition to 'zero-emission' technologies is necessary to achieve decarbonisation and air quality goals. By 2050 the UK plans to deliver a net-zero rail network, removing all diesel-only trains by 2040[42], and has committed to introduce 4000 new zero exhaust emission buses by 2025.[43] Electrification is the primary route through which both rail and bus sectors will achieve net-zero ambitions. Hydrogen power is likely to play a smaller yet important role in supporting net-zero aims, where commercially viable. This includes regions where track electrification would be prohibitively expensive, or based around emerging hydrogen hubs like the UK's first planned hydrogen transport hub in Tees Valley.[44] Hydrogen technology is continuously maturing, with demonstratable success evidenced through HydroFLEX, the UK's first hydrogen-ready passenger train showcased at COP26.[45] At present however less than 2% of the bus fleet is zero-emission[17] and 62% of rail tracks remain unelectrified.[46] While the transport sector navigates the transition towards net-zero, heavily emitting diesel engines will continue to contribute to poor air quality in transport hubs, and there is a need for more immediate action. There is also a need to address the role of non-exhaust emissions (NEEs) (including those from brake/wheal wear and from road/rail friction), which will not be reduced by these technologies. The contribution of NEEs to PM concentrations in transport hubs remains largely unknown. Further policy efforts will also be required to address freight sector emissions.

Hybridisation

Hybrid engines combine conventional diesel power with emission-free technologies. At COP26 a new hybrid battery-diesel passenger train debuted, which produces 90% less PM, 70% less NO_x and 25% less CO_2 whilst also being 75% quieter[47] than pure diesel. Transport modes can then switch to emission-free operation in sensitive environments such as transport hubs.

Exhaust after-treatment

A range of exhaust after-treatment technologies can be retrofitted to diesel engines to effectively reduce emissions[48] with successful applications for both buses[49,50] and trains.[51] A recent proof of concept trial successfully retrofitted after-treatment technologies to a diesel train, reducing emissions of NO_x by 80% and emissions of PM, CO and HC by 90%.[52] Under certain conditions these technologies can be ineffective[53], and retrofitting can be challenging due to additional space and maintenance requirements.[54] Their implementation may also increase fuel consumption, reducing their cost-effectiveness.[55]

Idling

Idling (running an engine when stationary) is associated with greater exhaust emissions[56], therefore implementing control measures in transport hubs, where idling frequently occurs, can improve air quality.[57,58] This can be achieved by simple better driver training, or by retrofitting stop-start technologies.[54,59] Turning off engines can present potential risks of re-start failure, and furthermore for some vehicles idling is required to power important functions such as air conditioning and lighting.

Alternative fuels

Biodiesel and diesel-blends can produce lower emissions, and in some cases do not require major engine changes.[60,61,62] However wide-scale implementation may see large technological and environmental challenges that potentially limit long-term suitability in the transport sector.[63,64]

2) Reducing exposure

Station ventilation

Efficient station ventilation systems can substantially reduce (~60%) pollutant concentrations. Improving ventilation however can be prohibitively expensive (considering both installation and operational costs), and may further increase a station's carbon footprint and noise levels.[65] Ventilation options (natural and mechanical) should be considered when designing or renovating future stations.

Other station improvements

Some authors suggest using platform doors to physically separate emission sources[22], as used in underground systems[66], however this would be challenging to implement due to differing train sizes. Other suggestions include installing green walls and photo-reactive surfaces.[54,67] Evidence to support these measures is however limited, and are generally thought to have a very low impact on exposure reduction.[54,68]

Case study: Birmingham New Street

Birmingham New Street is the fifth busiest UK railway station, and the busiest outside London.[69] Each day about 600 diesel trains move through the station, most of which are unregulated.[24] Its unique underground nature makes it particularly susceptible to pollutant accumulation[70] and consequently observes the highest measured station pollutant concentrations in the UK. During 2016 station redevelopments, mechanical ventilation systems were installed to help disperse pollution, effectively reducing daily concentrations of NO_2 and $PM_{2.5}$ by 23-42% and 62-81% respectively.[25] Furthermore, the effect of national COVID-19 restrictions provided a unique insight into how reduced train activity benefits station air quality. Through this 'natural experiment' significant reductions in NO_2 (50%) and $PM_{2.5}$ (55%) concentrations were observed[25], supporting claims that reducing diesel emissions is the most effective mitigation strategy.[65]

Authors

This briefing note was prepared on behalf of the TRANSITION Clean Air Network by Harry Williams (University of Birmingham).

Contact

Institute of Applied Health Research
University of Birmingham
Edgbaston B15 2TT
Email: info@transition-air.org.uk

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