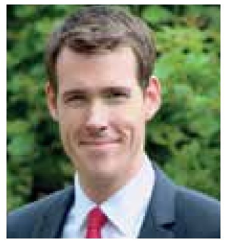
environmental SCIENTIST

April 2017
Journal of the Institution
of Environmental Sciences

TIME FOR A NEW CLEAN AIR ACT?

Tackling air pollution: We need to get our Act together



A hazard that is invisible is one that people will generally choose to ignore – that's just human nature. But when it comes to air pollution, this natural tendency is literally killing us.

Experts have been warning about a build-up of toxins in the atmosphere for years. Yet, it is only in recent years that the issue has begun to rise up the political agenda.

As a country, our response to poor air quality has been lacklustre. That failure is of course most evident in the breach of legal pollution limits. But it is no less manifest in the obstructive approach the UK has often taken toward European efforts to tackle the problem, and the delay and lack of ambition that have characterised the Government's approach to a national air quality plan.

There is no question that improving air quality is a difficult undertaking and both the causes and the potential solutions to the problem are complex, but neither can be an excuse for inaction. Air pollution is a public health crisis and it deserves a commensurate response from Government.

It is also an issue of social justice. No one is immune from the impact of toxins present in the air we breathe, but air pollution disproportionately affects the poorest and most vulnerable among us. As the Member of Parliament for a South East London constituency that includes the Blackwall Tunnel approach roads, I know all too well that it's those who live in, and often cannot escape the less affluent parts of our cities that bear the brunt; that it is children and the elderly who are most at risk; and that it is minority ethnic and deprived communities that are hardest hit by this invisible killer.

Cleaning up the foul air so many of us breathe requires action from Government. Despite the great work being done in towns and cities across the country, no one locality can solve this problem alone. This is the case not just because of the obvious fact that air pollution recognises no geographic boundaries, but because local air quality strategies will have to work in tandem with action at a national level if they are to be effective.

Of course, Brexit presents new challenges. But in seeking to ensure that the Government protects environmental regulation in the process of exiting the EU, there is a danger we come to view the defence of existing regulation as our sole objective. That would be a mistake. We must protect existing environmental regulation but we must also set our sights higher: an ambitious national air quality plan and a 21st century Clean Air Act. The moment to take responsibility is long overdue.

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Acknowledgement

This edition of the environmental SCIENTIST has been produced with the support of the Institute of Air Quality Management. Particular thanks go to Claire Holman, Chair of the IAQM, who is guest editor for this issue. (www.iaqm.co.uk)

IAQM Institute of Air Quality Management

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environmental SCIENTIST
The Journal of the Institution of Environmental Sciences

Volume 27 No 2
ISSN: 0966 8411 | Established 1971

The environmental SCIENTIST examines major topics within the field of environmental sciences, providing a forum for experts, professionals and stakeholders to discuss key issues. *Articles in this issue were prepared in December 2016 and do not necessarily take account of developments since then.*

Views expressed in the journal are those of the authors and do not necessarily reflect IES views or policy.

Published by
The Institution of Environmental Sciences
3rd Floor
140 London Wall,
London, EC2Y 5DN

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Cover image © Uncoated | Pexels
Cover design Michelle Reeve
Designer Kate Saker Limited katesaker.com
Printers Lavenham Press Ltd.

This journal is printed on paper produced by a Programme for the Endorsement of Forest Certification (PEFC) certified supplier.

INTRODUCTION

Improving air quality: Are vehicle emission limits all smoke and mirrors?

Claire Holman discusses how the controversial history of European vehicle emission limits has shaped the UK Government's policy on managing local air quality.

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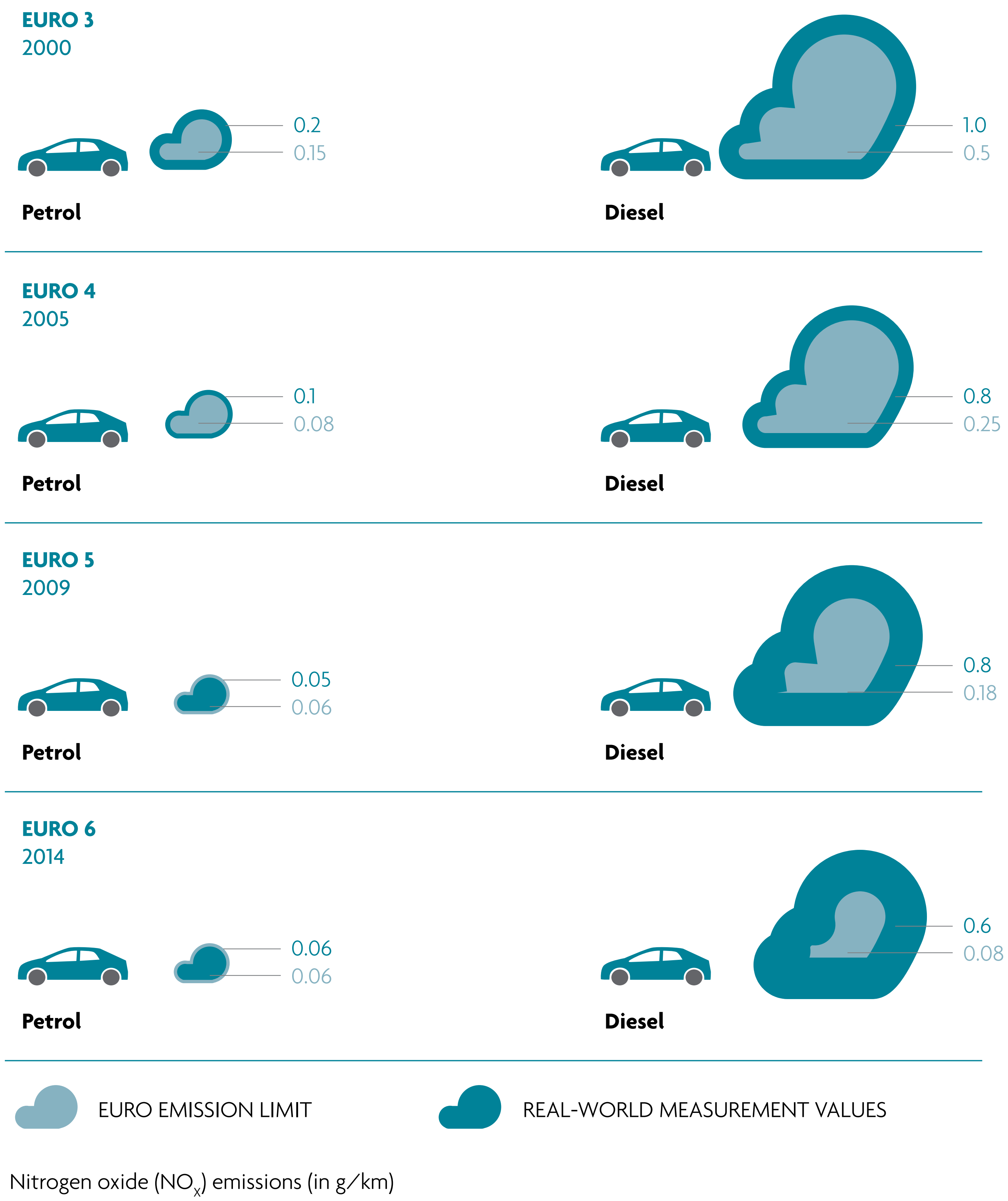
It seems that Britain has suddenly woken up to the fact that there is a severe air quality crisis in many of our larger towns and cities. Newspaper headlines such as "Ministers slammed for inaction over London air pollution"[1] are becoming more common. Yet government policy appears moribund with little decisive action. The Government has twice been ordered to rewrite the national Air Quality Plan, first by the Supreme Court and more recently by the High Court last November, yet it does not show any signs of being willing to address the issue with any urgency.

The Department for Environment, Food and Rural Affairs (Defra) knows that the main cause of the nitrogen dioxide (NO_2) levels being above the legal limits are the emissions from diesel vehicles; this has been clear for many years. Concern over air pollution from road transport is not new. The Quality of Urban Air Review Group, known as QUARG, concluded in 1993 "The two urban air pollutants which will be of greatest future concern are nitrogen dioxide and fine particulate matter… to achieve an elimination of episodes of severe nitrogen dioxide pollution… will require a halving of nitrogen oxides emissions from low level sources (mainly motor vehicles). This can be achieved by a strategy including widespread adoption of three way catalyst cars, but will take longer if the market penetration of diesel is substantially increased."[2] At that time, approximately 7 per cent of cars were diesel; today they account for nearly 40 per cent[3] and growing.

CONTROLLING VEHICLE EMISSIONS – THE EUROPEAN WAY

The first European Directive on vehicle emissions for petrol cars was adopted in 1970, almost 50 years ago[4], but the emission limits were voluntary; Member States did not have to adopt them into national law, but had to allow vehicles meeting the standards to use their roads. The first emission limits on diesel car emissions had to wait until 1983, but were not adopted by the UK Government. In 1988, the Council of Ministers agreed standards equivalent to those in the USA for large petrol cars, which effectively mandated the fitting of three way catalysts for the first time in Europe; weaker standards were permitted for mass market cars.

The first mandatory emission standards for petrol and diesel cars were introduced 25 years ago with the introduction of the Euro 1 standards. Virtually all new petrol cars (a few exemptions were permitted) first registered after 1992 were fitted with three-way catalysts. These catalysts have proved, after a few teething problems, to be very effective at controlling emissions from conventional petrol cars both during the regulatory laboratory based test procedure, and when driven on the road (see **Figure 1**).



▲ **Figure 1. Comparison of NO_x Emissions and Standards for Different Euro Classes. (Source: European Environment Agency, Copenhagen, 2016[6].)**

The picture for diesel cars has been very different. First, the Euro standards, which have become progressively more stringent over time, have always permitted these vehicles to have higher emissions of nitrogen oxides (NO_x) than petrol cars (**Figure 1**), unlike in the United States, where the legislation is technology neutral. Emissions of particulate matter (PM) from diesel vehicles are also much higher than from petrol vehicles, to such an extent that for most petrol vehicles there are no limits on PM emissions (with the exception of direct injection gasoline (GDI) engines in the Euro 6 - these perform more like diesel engines with lower carbon dioxide but higher PM emissions). Secondly, worldwide emissions of NO_x have not declined for two decades. This is illustrated by the on-road NO_x emissions from Euro 5 being similar to those from Euro 1 diesel cars[5].

In the early 1990s, the European Commission adopted a new approach to the setting of vehicle emission limits. Instead of relying on the motor industry to tell the European Commission what technology was available, emission limits were based on environmental capacity. That is, the most cost effective package of measures would be identified to meet air quality targets set for the protection of human health.

The European Auto Oil Programme in the mid-1990s was a collaborative project between the European Commission and the oil and motor industries. It was regarded as an exemplar approach and culminated with the development of new fuel quality standards: the Euro 3 and 4 standards for light duty vehicles and the III and IV standards for heavy duty vehicles. (Roman and Arabic numerals are used to distinguish between heavy duty and light duty vehicles because the limits and test procedures are very different.) In-use standards were also introduced across the EU via mandatory road worthiness tests, although this made little difference in the UK due to the long established MOT test. New methods for identifying the most cost effective measures to improve air quality were also developed.

This approach of using environmental capacity to identify appropriate emission limits continues to be widely used today despite criticisms that industry has too much influence in the negotiation of new limit values, test procedures and the detail of vehicle emission control legislation. This is not surprising given that there are very few truly independent experts with no financial links to the industry.

A second Auto Oil Programme was initiated, which had much wider participation and was able to investigate air quality in more cities and the potential benefits of non-technical measures in greater depth. It concluded in 2000 that there would be widespread issues with PM but more limited exceedances of the NO_2 ambient limit values[7]; another example of NO_2 issue being under estimated.

THE RISE AND FALL OF 'DIRTY' DIESEL EMISSIONS

By the early 2000s, the vehicle and engine manufacturers were still not fitting diesel particle filters to diesel vehicles despite reducing emission limits. These filters are very effective at reducing emissions, but manufacturers were resistant to using after treatment devices that added complexity and costs to vehicles. The UK Government led the development of a new test procedure that effectively forced the industry to use this technology by measuring and setting emission limits on the number of particles rather than the mass emitted. It achieved its aim and since then, Euro 5 vehicles have been fitted with these filters.

This work has helped reduce exhaust emission from newer vehicles, but has not solved the PM emissions. Non-exhaust particles from the abrasion of tyres and brakes and the wearing of road surfaces is a growing proportion of road transport emissions, and their management does not seem to be on any political agenda. Their composition is very different to the particles emitted from vehicle exhausts, and may have different health effects. Reducing ambient PM levels is difficult due to the large contribution of secondary particles formed in the atmosphere from a range of gaseous pollutants. Today the UK meets the air quality limit values for PM_{10} (particles with a diameter of less than 10 micrometres), although a number of other EU member states continue to experience high concentrations of this pollutant.

INTRODUCTION OF REAL-ROAD TESTS

By the early 2010s, improved methods for measuring real-world driving emissions enabled vehicle emissions to be quantified when driven on the roads. This data has shown that whilst the engine and vehicle manufacturers successfully passed the laboratory based test, once on the road the pollution abatement technology was much less effective. As a result there has been little change in roadside NO_2 levels for many years.

Why has this occurred? Volkswagen's admission to using 'defeat devices' in the USA raised public awareness of the issue. In Europe their software has been shown to recognise the laboratory emissions test. Other manufacturers have used different emission control strategies when cars are driven on the road, and whilst defeat devices are illegal in the US, they are allowed in the EU if a pollution control system may damage an engine. It has yet to be proved in a court of law whether any manufacturer was acting illegally. Interesting work by the European group Transport & Environment showed that devices that work during the laboratory test are often switched off in 'cold' weather[8]. The problem is that while the temperature during 'cold' weather may be as warm as 17 °C, the average UK temperature is closer to 10 °C, and so the NO_x control does not work for the majority of the time. This issue should be addressed by the introduction of real driving tests to supplement the laboratory tests in two phases between 2017 and 2021 (see **Table 1**), but in the meantime these vehicles are able to continue to pollute. Even after 2021 there may continue to be a disparity between real world and the laboratory emissions as manufacturers will be allowed to reject some high emission data, such as when a car accelerates rapidly; the implications of this for air quality will not be known for many years. In the meantime, NO_2 concentrations may remain high and exceed the ambient air quality limit values in many places.

DATE	MODEL	CONFORMITY FACTOR[9]	LIMIT VALUE MG/KM	
			LABORATORY TEST	REAL DRIVING EMISSIONS
September 2017	New models	2.1	80	168
September 2019	All new cars	2.1	80	168
January 2020	New models	1.5	80	120*
January 2021	All new cars	1.5	80	120*

* 2 x higher than the Euro 6 petrol laboratory test limit which is also achieved on the road

▲ **Table 1. Real Driving Emissions (RDE) requirements for diesel cars.**

▲ **Figure 2. Potentially harmful particles are also produced by abrasion of tyres and wearing of road surfaces.**

WHAT LIES AHEAD FOR THE UK'S AIR QUALITY PLAN?

The High Court agreed with ClientEarth that the UK Government's 2015 Air Quality Plan was based on over-optimistic modelling, and ordered them to produce a draft amended plan by 24th April 2017 and a final amended plan by 31st July 2017. The 2017 Air Quality Plan will show whether the UK Government has finally decided to address air pollution robustly.

Brexit will be another opportunity to see if the UK Government is serious about improving air pollution. The current Secretary of State, Andrea Leadsom, has promised that the Air Quality Directive will continue to apply after the UK leaves the EU. While the limit values may be kept, will all the duties in the legislation remain? The Governments may weaken the legislation by stealth, changing the detail while keeping the headline figures; it will be a case of watch this space! **ES**

This article was written before the 2017 draft Air Quality Plan was published.

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FEATURE

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Electric vehicles – are we nearly there yet?

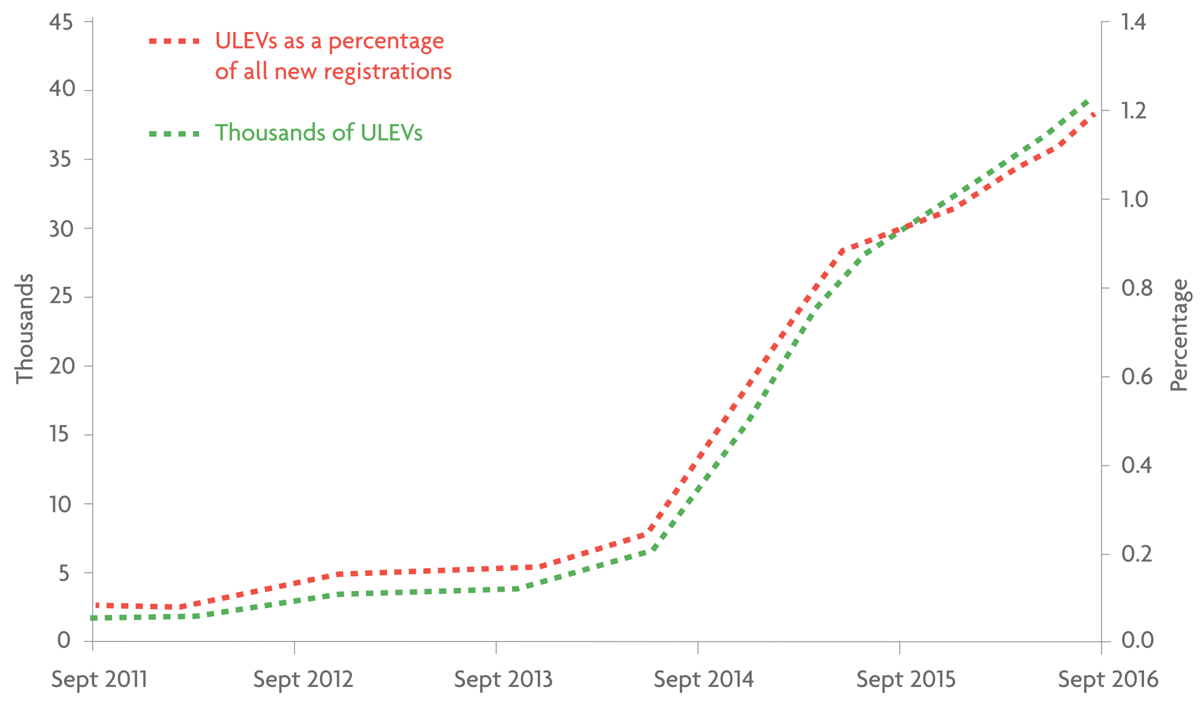
Roger Barrowcliffe explores the contribution electric vehicles make to society and the key they hold to improving local air quality.

Electric vehicles have been around for a very long time. Their origin and use on the road pre-dates that of the internal combustion engine (ICE), after the concept was invented in the mid-19th century. At the beginning of the 20th century, the electric motor was vying with steam and gasoline as a means of propulsion for cars. Then, in 1904, Henry Ford developed a range of low price, lightweight gasoline powered cars and the rest is history. From that point on the ICE became ever more refined and the development of the electric vehicle stagnated by comparison.

The advantages of the ICE, coupled with cheap oil, have made it the dominant form of propulsion for all road vehicles, and decades of development and investment have firmly entrenched its position. Price and the easy accessibility of fuelling infrastructure have preserved its dominance. For all of its practical and economic advantages, however, this form of transport has its environmental downsides. In contrast, the electric vehicle offers a means of reducing the use of fossil fuels and contributing to improved air quality. It is also close to competing with the ICE in the marketplace.

ELECTRIC VEHICLES IN USE TODAY

Sceptics may say that the proportion of electric vehicles (EVs) on the road today is small. This is undeniably true, but the recent trend is encouraging, with new sales showing a marked uptake. For 'ultra-low emission vehicles' (ULEVs) (defined as those emitting less than 75 g/km of carbon dioxide [CO_2], and which includes all electric and plug-in hybrid electric vehicles [PHEVs]),



▲ **Figure 1. New Ultra Low Emission Vehicle Registrations in the UK, 2011-2016. (Source: Department for Transport[1])**

there were 25,000 new registrations in 2015 compared with only 3,500 in 2013. Whilst the new registration of ULEVs is still less than 1 per cent of all new vehicles, this trend of increasing interest and activity suggests that the electric vehicle is reaching the point when it becomes more widely acceptable and commonplace. **Figure 1** shows clearly how 2014 may come to be seen as a turning point in the sales of new electric vehicles.

Of the new ULEVs entering the vehicle fleet, the largest fraction by far is made up of cars. There are few vans, and almost zero heavy goods vehicles (HGVs).

Table 1 shows the number of ULEVs licensed in the UK by categories of vehicle type and as a comparison between 2010 and September 2016. The stand out difference between the two years is the explosive growth in the number of new electric and plug-in hybrid cars. Of this population of 73,000, two models dominate: the Mitsubishi Outlander PHEV and the Nissan Leaf (**Figure 2**).

This story is therefore an encouraging one for privately-owned cars. It is clear from the data, however, that there is considerable scope for an increase in the

VEHICLE CATEGORY	2010 (YEAR END)	2016 (SEPTEMBER)
Plug-in grant eligible cars	134	73,274
Non-eligible cars	1,200	2,946
Plug-in grant eligible vans	0	2,636
Non-eligible vans	3,863	2,722
Heavy goods vehicles	967	416
Buses and coaches	79	233

▲ **Table 1. ULEVs licensed by category at year end in 2010 and September 2016. (Source: Department for Transport[2].)**

▲ **Figure 2. The Nissan Leaf. (© Roger Barrowcliffe)**

▲ **Figure 3. An electric lorry, manufactured by Magtec. (© Roger Barrowcliffe)**

purchase and use of electric vehicles for commercial use, either as vans or small HGVs. The market supply for the former is now quite healthy with models available from several major manufacturers, notably Mercedes, Nissan, Renault, Citroën and Peugeot. These vehicles are eligible for a plug-in grant of up to £8,000 from the Office of Low Emission Vehicles (OLEV) and an increasing number can be seen in use, especially in London where the Congestion Charging Zone and the impending Ultra Low Emission Zone increases their attractiveness. In contrast, there are very few new HGVs commercially available at present above 3.5 tonnes. Some niche companies, such as Magtec (**Figure 3**) and Tevva (**Figure 4**), will offer a service whereby old lorries are re-powered with electric or hybrid powertrains.

The major manufacturers are showing some caution about entering the market for vehicles of 7.5 tonnes and upwards. In part, this is because the battery technology is such that range is still limited, restricting the type of operations that can be undertaken. In addition, the payloads are also limited, relative to the diesel equivalent, because of the weight of the batteries required. Nevertheless, there are some signs that this may be about to change. Mercedes Benz has announced that it has built and tested an urban 'e-Truck' of 26 tonnes with a range of 200 km, but it will not be on the market until at least 2020. Some pockets of activity are present, often as demonstrator projects supported by governments or European funds. The FREVUE project (Freight Electric Vehicles in Urban Europe)[3] is supporting the use of electric lorries in various projects around Europe, including two in London. The courier company, UPS, has 16 retrofitted EVs operating its parcel services within London and in the other and Clipper Logistics has two 10 tonne Smith Edison electric lorries transporting goods from a consolidation centre in Enfield to retailers in Regent Street.

To stimulate activity further, OLEV announced in October 2016 that it would provide a grant of up to £20,000 for the first 200 new ultra low emission lorries purchased in the N2 (3.5-12 tonnes) and N3 (>12 tonnes) categories. The grant is specifically for new registrations, therefore excluding the repowering of existing vehicles, which is currently the main option open to potential users.

Electric buses are an increasingly prevalent option for bus companies, when supported by the local authority. Transport for London will, by the end of 2016, operate a fleet of 73 electric buses, making it the largest such fleet in Europe. Several other UK cities also now operate electric buses, with funds provided by the Department for Transport's Green Bus Fund, enabling a substantial reduction in nitrogen oxides (NO_X) on polluted routes.

The stop-start nature of city centre bus journeys, with low average speeds, are well suited to the performance offered by electric buses and, given sufficient financial support, could see their use increased. From the point of view of NO_X reduction, this represents a sound and targeted investment and the proposed Clean Air Zones in many cities may further encourage their use.

▲ **Figure 4. Hybrid electric 7.5 tonne lorry by Tevva Motors. (© Roger Barrowcliffe)**

OWNERSHIP AND DRIVING EXPERIENCE

The urban environment is the one that favours the electric vehicle most, where the total journey length in a day is within the range permitted by the battery size and the vehicle is not required to travel at high speeds for long periods. The driving experience in a modern electric car is one that is surprisingly pleasant to those unfamiliar with it. In particular, the acceleration of an electric car is such that it will easily out-perform even the most powerful car with an ICE over a short distance. The electric motor delivers instant and maximum torque from 0 rpm, meaning that the acceleration from a standing start is impressive. Coupled with a low centre of gravity (because of the battery weight) the electric car has high stability and good handling.

For commercial drivers, the experience at the wheel over the course of a working day is something that makes the electric vehicle superior to its diesel equivalent; it is much quieter, and the need to change gear constantly in urban settings vanishes. For the fleet manager, maintenance costs are much reduced; large parts of the conventional engine and powertrain are absent, eliminating many moving parts and oils. Regenerative braking is a common feature, reducing brake pad wear and a source of particles at the same time. It is often said that EVs are still pollutant emitters, because of the particles generated through tyre wear and resuspension; whilst these particle emissions remain, the elimination of particles generated by combustion is likely to be a significant improvement. Though it is not yet known which particle sizes and compositions are the most toxic for human health, it is a reasonable hypothesis that the ultrafine particles resulting from combustion are likely to be greater culprits than the larger re-suspended particles from road surfaces.

BARRIERS TO GREATER USE OF ELECTRIC VEHICLES

The fact that electric vehicles only represent a very small proportion of the overall fleet suggests that their attributes are not yet sufficient to persuade people to buy and use them as a matter of course.

The downsides are, for many people, fairly obvious: the limited range, the time taken to recharge the battery, the need to install a charging point, and most of all, the large initial cost. Most people do not make a vehicle purchase based on the total lifetime cost of a car; if this was the case then the electric car would be a much more attractive option, given that fuel costs are approximately 2 pence per mile and maintenance costs are very low. Instead, it is the list price that stands out and electric cars are expensive, even with the discount provided by the Government's plug-in grant of £4,500. It is estimated that the premium on the purchase price for a battery powered EV is 50 per cent. There are also some other negative financial aspects to running an electric car, such as the fact that insurance premiums are high and

SEGMENT	APPROXIMATE CURRENT MARKET SHARE	CHARACTERISTICS
Enthusiasts	15%	Positive – attracted to innovative technology.
Aspirers	15%	Interested but concerned by technical attributes.
Mass market	50%	Not interested and do not identify with benefits of EVs.
Resistors	20%	Strongly reject identity and symbolism of EVs.

▲ **Table 2. Consumer segments for purchasing electric vehicles (Source: ETI[2].)**

the second hand market is not yet established, meaning depreciation costs are high.

Aside from the affordability of electric vehicles, there are other attitudinal factors that influence purchasing decisions and which need to be understood. These aspects were explored in an insightful study undertaken by the Energy Technologies Institute (ETI)[4]. The authors note that there are three critical aspects for purchasers of a new car, after the constraint of disposable income. In order of decreasing significance, these are:

- Instrumental factors: Practical functionality aspects, such as whether it is large enough and whether it is perceived to be safe and of good quality.
- Symbolic factors: The expression a car makes about its owner in terms of social status, social conscience and personal values.
- Affective factors: Feelings evoked by owning and using the car.

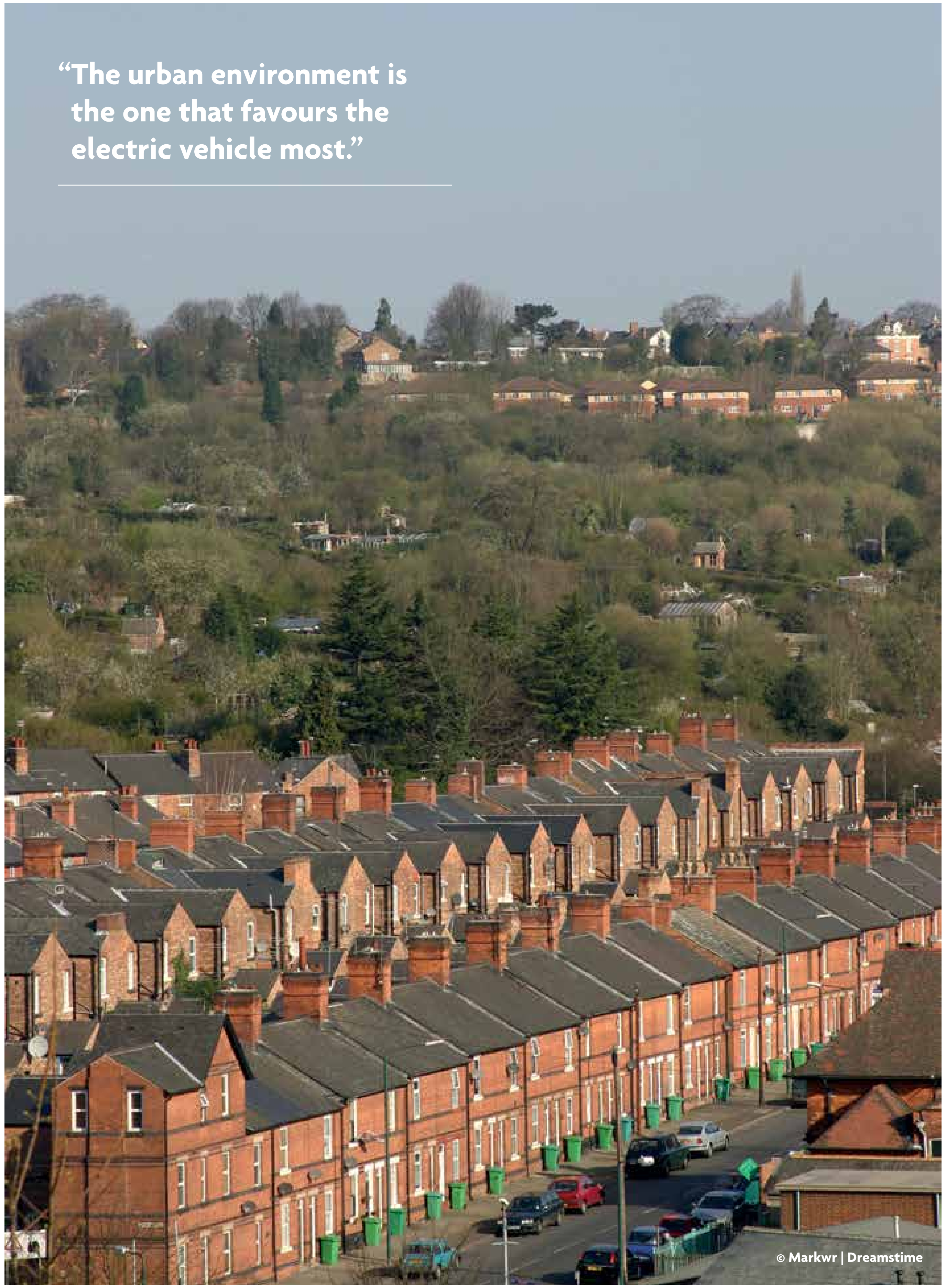
Additionally, the study conducted an in-depth survey of survey of consumers' attitudes, which revealed eight distinct segments. These can be simplified into four attitudinal groupings, as described in **Table 2**.

The decision to purchase an electric car is also dictated by the way the car will be used. An electric car is suited to daily journeys within an urban area and not so well suited for travelling longer distances on the motorway network. Another important factor is the ability to recharge the battery at home. A 7 kW dedicated supply is the most attractive option, which can be installed for less than £1,000. This option works best for owner-occupiers of properties with off street parking, which represents about half of all UK properties. Unfortunately, this proportion is substantially lower in city centres, where electric vehicles are most useful. For electric car owners who only have on-street parking, some form of local authority provision is required and, even in these circumstances, there are substantial practical hurdles to be overcome if such infrastructure is to be widely installed.

For commercial vehicles, some similar problems arise. If a company's premises are rented then there may be less autonomy over installing the supply. Often vehicles are parked overnight at the home of the driver, making the installation of a dedicated supply less likely. Even where a depot is owned by the company or organisation with an electric fleet, there could be a barrier in the form of a limit on the capacity of the local distribution system. UPS encountered such a problem in its participation in the FREVUE project; to recharge the 16 vehicles overnight simultaneously at its London depot, an upgrade to the local substation was required. The current structure of the electrical distribution system in the UK is such that any customer needing an enhanced supply is required to pay for the cost of the necessary upgrade. In this case, UPS decided to spend £600,000 on an upgrade that would allow for 68 vehicles to be charged overnight and the work took two years. For most companies this would be prohibitive and it is a problem that needs to be addressed by central government.

This aspect touches on another potential problem should the use of electric vehicles become more widespread. The likelihood is that most users will wish to recharge overnight, often choosing to connect to the electricity supply on returning home or to base in the evening, which is precisely when the peak demand occurs in the overall electricity supply system. If the Committee on Climate Change's (CCC's) ambition to have 60 per cent of new sales as electric vehicles by 2030 is to be realised, this nightly utility demand presents a major problem. Not only is the electrical distribution network badly

> **"The urban environment is the one that favours the electric vehicle most."**



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configured to deliver the necessary current in many urban areas, but there could be insufficient generating capacity to meet this peak demand. By 2050, the peak demand from the projected use of electric vehicles will exceed the current national generating capacity. The only way forward would be to persuade users to recharge at differing times of the day, to spread the load, or install some form of storage capacity to meet this peak evening demand.

PROSPECTS FOR THE NEXT DECADE AND BEYOND

It should be recognised that by far the greatest spur for the introduction of EVs to date has been the decarbonisation of the transport system, certainly insofar as the Government's interventions are concerned. The fact that EVs are also a useful means of reducing NO_x emissions is a happy coincidence, although of late, the Government and others have begun to promote EVs as a solution to the urban air quality problem in tandem with the long term reduction in greenhouse gases. As a consequence, a lot of the useful work on the projected uptake of EVs has been sponsored by the CCC and the Low Carbon Vehicle Partnership.

The prospects for a future market share of fully electric vehicles has been examined for CCC by Element Energy[5]. The CCC's target is for all vehicles to be zero emission by 2040, which requires a pathway of 60 per cent market share of PHEVs and EVs by 2030 and a 9 per cent share of these vehicles in 2020. This is a high uptake pathway, recognising that both awareness and acceptance by consumers have to increase considerably from their present levels, so that the EV becomes part of the mass market and attracts not just the enthusiasts. It would also require EVs to reach cost parity with conventional cars on a basis that makes sense to the consumer.

From the current position, this seems to be very ambitious and perhaps unrealistic. History tells us, however, that rapid transformations on this scale are actually quite normal. The ICE itself was once considered to be less attractive than equivalents powered by steam and early batteries, not to mention the horse. The recent rise in in the prevalence of the diesel engine for cars has also been rapid; in 1990 the share of the market for diesels was 5 per cent, rising to 15 per cent by 2000, but accelerating to nearly 50 per cent by 2010.

The longer term perspective is that plug-in electric cars are merely a bridge to a transport system using fuel cells powered by hydrogen. This would indeed bring many advantages, but the refuelling infrastructure requirements are a major barrier to rapid uptake from here. In the meantime, EVs are essentially a proven and viable zero emission alternative, for which there is a substantial market supply for cars and vans.

EVs are not the solution to the UK's air quality problems in UK towns and cities, although they are capable of making a helpful contribution. UK Government support is likely to be needed for at least another decade, however, to ensure that its targets are met. If the problem is one of compliance with the nitrogen dioxide (NO_2) limit value, then the timescale for the use of EVs to become widespread is roughly equivalent to that on which compliance is expected. With or without EVs, compliance will probably be achieved through the introduction of diesel vehicles that finally deliver on substantially lower NO_x emissions. If the EV 'revolution' had started 10 years earlier, then the story might have been a different one for air quality improvement. Nevertheless, the marked increase in the use of EVs is a welcome development for air quality management and manufacturers seem very eager to promote electric vehicles, which may even be a positive consequence of the Volkswagen's revelations in 2015.

Even if a sceptical view is taken on whether EVs are necessary to achieve compliance with the NO_2 limit value, the removal of combustion related pollutants from urban air is a positive step forward and, despite residual particle emissions from tyre wear and resuspension, the EV will play a greater part in a cleaner future for towns and cities. ES

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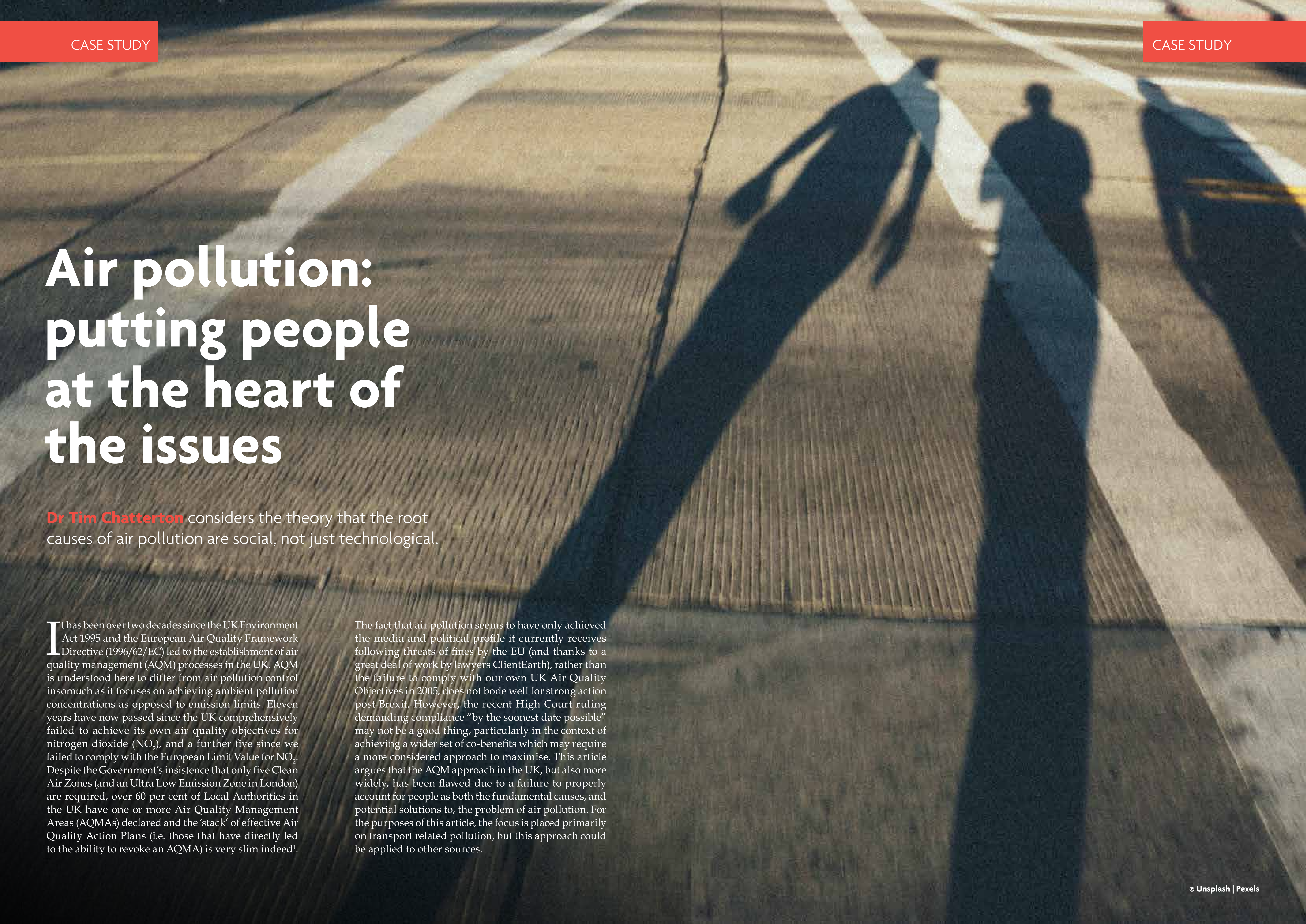
CASE STUDY

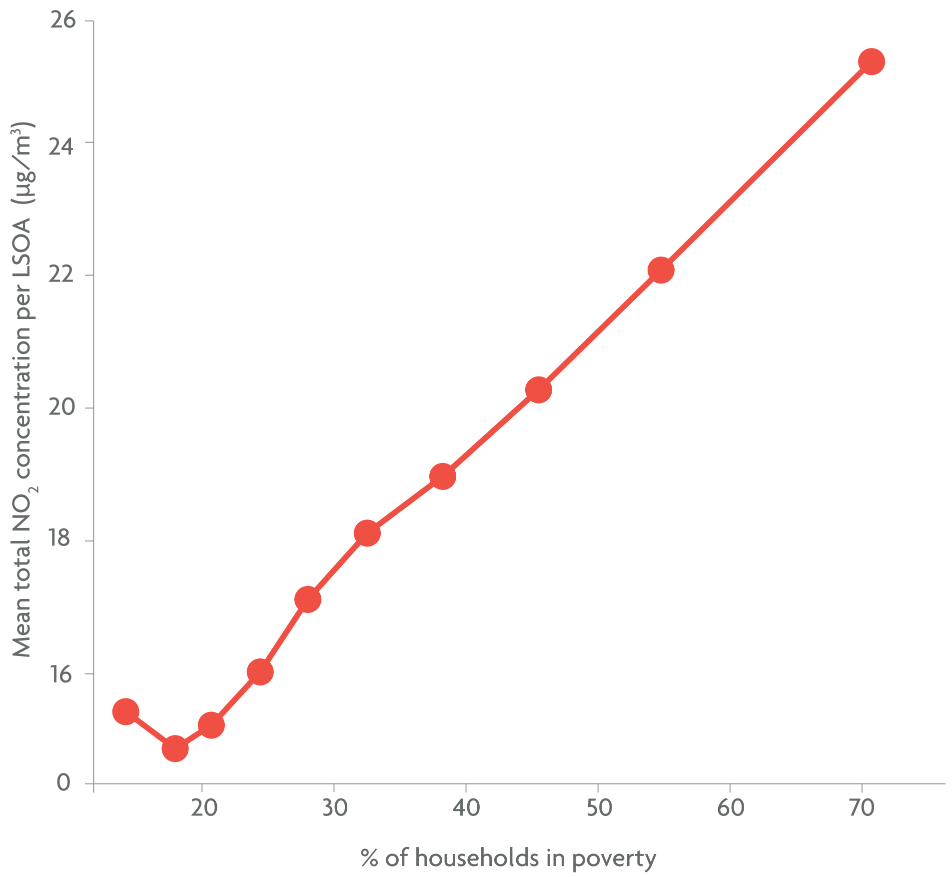


Air pollution: putting people at the heart of the issues

Dr Tim Chatterton considers the theory that the root causes of air pollution are social, not just technological.

It has been over two decades since the UK Environment Act 1995 and the European Air Quality Framework Directive (1996/62/EC) led to the establishment of air quality management (AQM) processes in the UK. AQM is understood here to differ from air pollution control insomuch as it focuses on achieving ambient pollution concentrations as opposed to emission limits. Eleven years have now passed since the UK comprehensively failed to achieve its own air quality objectives for nitrogen dioxide (NO_2), and a further five since we failed to comply with the European Limit Value for NO_2. Despite the Government's insistence that only five Clean Air Zones (and an Ultra Low Emission Zone in London) are required, over 60 per cent of Local Authorities in the UK have one or more Air Quality Management Areas (AQMAs) declared and the 'stack' of effective Air Quality Action Plans (i.e. those that have directly led to the ability to revoke an AQMA) is very slim indeed[1].

The fact that air pollution seems to have only achieved the media and political profile it currently receives following threats of fines by the EU (and thanks to a great deal of work by lawyers ClientEarth), rather than the failure to comply with our own UK Air Quality Objectives in 2005, does not bode well for strong action post-Brexit. However, the recent High Court ruling demanding compliance "by the soonest date possible" may not be a good thing, particularly in the context of achieving a wider set of co-benefits which may require a more considered approach to maximise. This article argues that the AQM approach in the UK, but also more widely, has been flawed due to a failure to properly account for people as both the fundamental causes, and potential solutions to, the problem of air pollution. For the purposes of this article, the focus is placed primarily on transport related pollution, but this approach could be applied to other sources.



▲ **Figure 1a. Exposure to NO_2 by level of poverty[5].**

IT'S NOT JUST ABOUT POLITICS

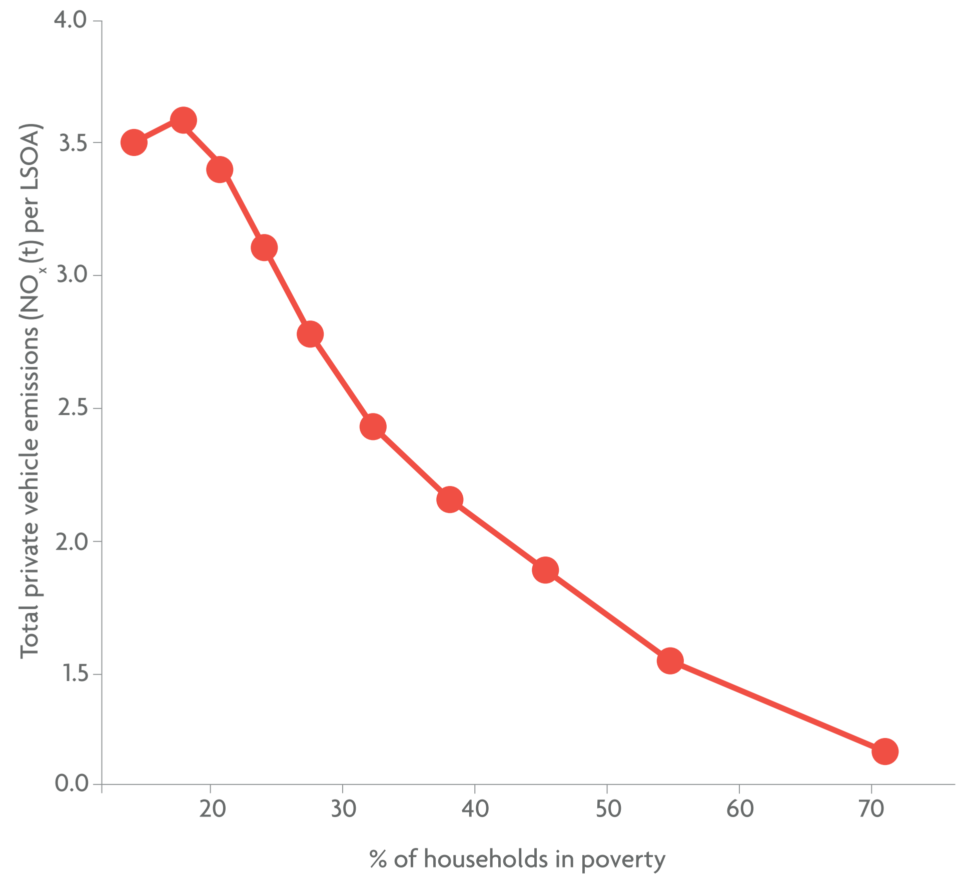
One of the key reasons why efforts to improve air quality have not been more successful across Europe has been the failure to elicit more political support for action at both national and local levels. This can be seen as being due, in no small part, to a failure to capture sufficient public engagement to create the democratic mandate for significant action on air pollution. The lack of public and political engagement is often cited as being caused by the 'invisibility' of current air pollution problems, although recent visible urban smog and 'Saharan Dust' events have captured some public interest. This issue of the tangibility of air pollution is worsened if we consider how visibility is linked to our political structures. Based on figures from the regular Census of Local Authority Councillors[2], in 2004 over 73 per cent of elected members had been alive during the time of the 1952 Great Smog; by 2013, this had only dropped to 60 per cent. It should be remembered that 'pea-soupers' were still occurring over a decade later[3] and so these decision-makers grew up in a world where air pollution literally meant not being able to see your hand in front of your face.

THE PROBLEM WITH NUMBERS

Within the wider public health community, air quality was often perceived (until recently) as a success story – having had both UK and EU legislation passed to enforce 'acceptable' levels of air pollution. However, although it is hard to argue that this legal recognition and definition is, in and of itself a problem, having a set of numeric µg/m^3 limit and target values, whilst being based on health evidence, has led to approaches to AQM that fixate on abstract numbers rather than real-world impacts. This in turn has led to technical approaches to solving the problem which allow the presentation of estimated figures that fit the numerical framing of the problem; a techno-centric policy approach to mitigation has developed as a result.

In terms of the conventional emissions equation, where emissions equal activity multiplied by emissions factor, we end up concentrating on controlling the emissions factor (e.g. by emphasising higher Euro standards) rather than addressing the activity. This is arguably not AQM, but is instead simply conventional air pollution control applied to numerous dispersed sources.

A second reason for low levels of civic engagement may lie in the absence of people in models and scenarios used to estimate and predict air pollution concentrations. For example, these models generally represent flows of cars or other vehicles along roads, and source apportionment concentrates on which types of vehicles are contributing to the problem (cars, vans, buses, trucks etc.). This



▲ **Figure 1b. Emissions from registered vehicles by level of poverty[5].**

approach can be considered as a 'Where and What' approach. It tends to focus only on where concentrations are above the limits, and on what vehicles (or other equipment) are emitting pollution. This approach has also supported a technocratic approach to solving air pollution problems, and having had at least twenty years to try and achieve its aims, it is time to reflect on this approach and to consider changing it.

The rest of this article will describe work that the Air Quality Management Resource Centre (AQMRC) at the University of the West of England, Bristol, is involved in, which is helping to develop a view of air pollution that puts people back into the picture. In doing so, work is outlined that moves away from the where and what, towards questions of 'who' – who is causing the pollution and being exposed to it, and 'why' they are causing the emissions. In putting these ideas forward, it is not intended that the air pollution control type approaches used to date are discarded, but it is argued that although they may be necessary, experience now suggests that they are far from sufficient.

LOOKING AT THE 'WHO?'

Within an Engineering and Physical Sciences Research Council (EPSRC)- funded project "Motoring and vehicle Ownership Trends in the UK"[4], AQMRC has been using new datasets from the Department for Transport to map emissions from road transport based not on the point of use, but on the location of the vehicles' registered keepers (as a proxy for drivers' homes). The core dataset extracted from the 'MOT' vehicle inspection records provides periodic odometer readings for every vehicle less than 3.5 tonnes in Britain. Then, using these to calculate estimates of annual mileage alongside emission profiles of the vehicles (using age or Euro standard, fuel type and engine size), emissions can be attributed to small areas (termed Lower-layer Super Output Areas, containing around 700 households) on the basis of the registered keeper. This allows a wide range of analyses to be carried out regarding patterns of car ownership and usage, but most relevant to the issue of air pollution is the ability to compare how these areas vary in terms of the amount of pollution they emit from driving, compared to the levels of pollution that those areas are exposed to in terms of concentrations. The results indicate that in general there is a strong inverse relationship between these, with areas where people are exposed to the highest concentrations being responsible for the lowest emissions and vice versa. However, when this is analysed in combination with levels of poverty, a stark picture of inequality emerges where those areas with the greatest poverty are responsible for emitting the least pollution, but are exposed to the highest concentrations (and the converse for least poor areas); see **Figure 1.**

CASE STUDY

LOOKING AT THE 'WHY?'

In another EPSRC funded project, "Disruption: Unlocking Low Carbon Mobility"[6,7], the problem of moving to more sustainable patterns of transport was looked at, not in terms of conventional views of travel being an individual 'choice', but instead by focusing on the activities (or in terms of social science, the 'practices'[8]) that travel is embedded within. Over three and a half years, the project undertook a wide range of research including following over thirty families in order to understand why people make the travel decisions they do. The findings showed that people do not, for the most part, make free choices about how they travel. Instead, people undertake and carry out a wide range of activities or practices, for example working, shopping, caring or learning, which often are felt to necessitate the use of a car. The way that we, as a society, have structured our transport system, our land-use planning and a range of other factors means that in order for most people to participate in these activities which constitute normal everyday life, an assumption is made about free and unlimited movement on the part of participants. This puts a burden of mobility on individuals which can often only be met through driving. It was surprisingly common in the research to encounter people who felt 'trapped' into driving because they felt expected to do certain things for which a car was the only practical option.

If we are really serious about tackling our transport problems and the air pollution that arises from this, we urgently need to move away from believing that decisions about how and when people travel are simply about personal choice. Instead we need to really consider how we can shape our societies in a way which reduces pressure on people to travel, not just by providing much greater support for non-car modes, but by looking at localising rather than centralising key services, ensuring that housing and land use policies minimise travel distances, by questioning social and economic drivers towards the need for dual income households, or even for some people to need to have more than one job.

LOOKING FORWARD

The full extent of the UK's air pollution problem is not going to be solved quickly even if, thanks to ClientEarth, the government is forced to "achieve compliance [with the EU Directive] by the soonest date possible". This means that there is good sense in aligning efforts to reduce air pollution emissions from transport alongside longer term efforts to reduce carbon emissions. The vast majority of work on future greenhouse gas emission reduction scenarios, however, suffer from the same problem outlined above with regard to AQM; they focus almost entirely on the deployment of new or cleaner technology, pay scant regard to individual behaviours, and almost never take a broad view of how society is organised. To address this point in particular, AQMRC is providing the technical/academic lead in a four year EU Horizon 2020 funded project called ClairCity[9] (Citizen-led air pollution reduction in cities). This project, involving ten research partners and six European city or regional governments, is developing a range of ways in which both citizen engagement and quantitative air pollution analysis and modelling can be recalibrated so as to put people (as citizens not as individuals) at the centre of plans for emission reduction. Through doing this we hope to both stimulate greater public engagement with air pollution issues and to allow the development of policies at a city scale, addressing the way in which air pollution results from day to day activities, not simply from exhaust pipes.

THE ONLY THING CONSTANT IS CHANGE

If society is to achieve significant, long-term and sustainable solutions to air pollution and other environmental challenges (including resource management with respect to new electric vehicles), we are going to have to go beyond technology substitution and change how society is organised. The good news is that despite discussions about 'behaviour change' often implying that people's habits are rigid, stubborn and difficult to shift, our research suggests that the opposite is true; people are generally highly flexible and adaptable. What makes them appear fixed is actually the structures imposed by their surroundings that force them into particular ways of acting. We have also shown that these structures can and do change, and they will continue to do so; however, we have to decide to make them change in the right direction. ES

Acknowledgements

I would like to acknowledge the contributions of my colleagues at AQMRC, University of the West of England. The work discussed here has been undertaken under EPSRC Grants EP/K000438/1 (MOT) and EP/J00460X/1 (Disruption) and has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement 689289 (ClairCity).

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Fact or fiction: The story of measuring NO_x emissions from modern diesel vehicles

Ben Marner discusses the tricky issue of accurately measuring diesel emissions using real-world tests.

ANALYSIS

In September 2015, news broke that Volkswagen (VW) had cheated in official emissions tests. Despite grabbing headlines, to many in the field this was largely a side issue to the failings in the emission tests themselves.

TIGHTENING EURO STANDARDS

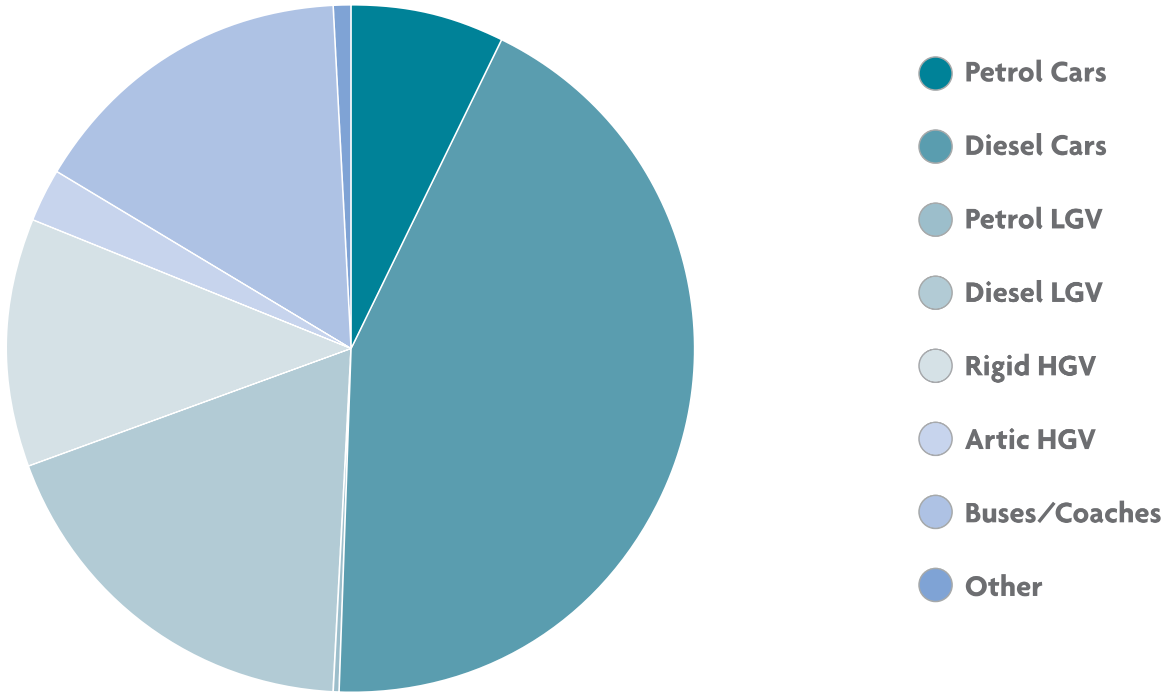
Road vehicles sold in the European Union (EU) have to meet EU Limit Values for their emissions, or as they are more commonly known, 'Euro Standards'. These cover a number of gaseous and particulate pollutants, with the current focus on nitrogen oxides (NO_x), which are essentially two gases, nitric oxide (NO) and nitrogen dioxide (NO_2). It is the NO_2 that affects human health and for which concentrations in the UK regularly breach the EU Limit Values. The NO emissions are not themselves benign, as reactions in the atmosphere convert the NO to NO_2. The Euro Standards have become progressively more stringent as time has gone on, leading to the expectation that traffic related NO_2 levels should have steadily reduced.

Between 1992 and 2003, NO_2 concentrations at most monitoring sites reduced appreciably, but around 2003 levels plateaued. Investigations have found that the principal reason for the disjoint between expected trends and reality relates to the on-road performance of modern diesel vehicles. Despite newer vehicles emitting less than earlier models within the laboratory emission tests, they often emitted the same, or even more, than earlier models when driven on 'real roads'.

The emission tests were historically carried out on rolling roads for cars and vans, and outside of the vehicle for Heavy Goods Vehicle (HGV) engines. The range of driving conditions simulated in this way was relatively small, and was well known by manufacturers. To borrow an analogy from education, where there is a fear that pupils are being "taught to the test", vehicles were being manufactured to pass the emission tests with little consideration of how they would perform under real-road conditions.

GAME CHANGE FOR EMISSION TESTING

In order to overcome these issues, a new test was introduced for HGVs in 2014, and from the summer of 2017, there will be a new test for cars and vans. These tests include more detailed laboratory test cycles, as well as Real Driving Emissions (RDE), which means testing during the driving of vehicles on real roads using portable measuring equipment. The specifics of the RDE tests, along with how the measurements are treated, mean that they're unlikely to be fully representative of UK driving conditions, but there is evidence that this regime has been effective in reducing HGV emissions and, to an extent, the same should hold true for cars and vans.



▲ Figure 1. Source-apportionment of NO_x emissions from a typical UK road (based on Defra's Emissions Factor Toolkit (EFT) V7.0, assuming 5 per cent Heavy Duty Vehicles on an urban road outside of London and at a speed of 50 kph).

Figure 1 shows how NO_x emissions on a typical UK road are made up, highlighting how significant diesel cars currently are. The latest Euro Standard for cars is Euro 6. In 2015, 11 per cent of the total number of kilometres driven in diesel cars were in Euro 6 vehicles; by 2025 this is expected to increase to 88 per cent. Understanding how these new Euro 6 vehicles will perform is thus crucial to understanding whether air quality is likely to improve in the near future.

The only Euro 6 diesel cars in use at present were approved under the old style of emission tests, and so there is a general expectation that later vehicles will perform better, but it is nevertheless helpful to look at how the existing Euro 6 vehicles have performed under 'real world' driving conditions.

A number of organisations have measured NO_x emissions from Euro 6 diesel cars, either on real roads or in a simulation of real world driving conditions on rolling roads. The results from some of these tests are summarised in **Figure 2.** Overall, these tests suggest that:

- On average, Euro 6 diesel cars emit significantly more than the emission standard.
- There is a great deal of variability between different vehicles. Some of this may relate to variations in the emission-control strategies used, but there sometimes seems to be little consistency for apparently quite similar vehicles.
- A small number of vehicles have very high NO_x emission rates and consequently are having a disproportionate effect on average emissions.
- There is no evidence that VW vehicles emit systematically more NO_x than other manufacturers.
- Emissions vary significantly according to driving conditions.
- Emissions can increase significantly at low ambient UK temperatures. This relates, at least in part, to a deliberate reduction or deactivation of emission controls in order to protect the vehicle.
- Despite emitting more than the emission standard, Euro 6 diesel cars produce, on average, significantly less NO_x than Euro 5 or Euro 4 diesel vehicles.

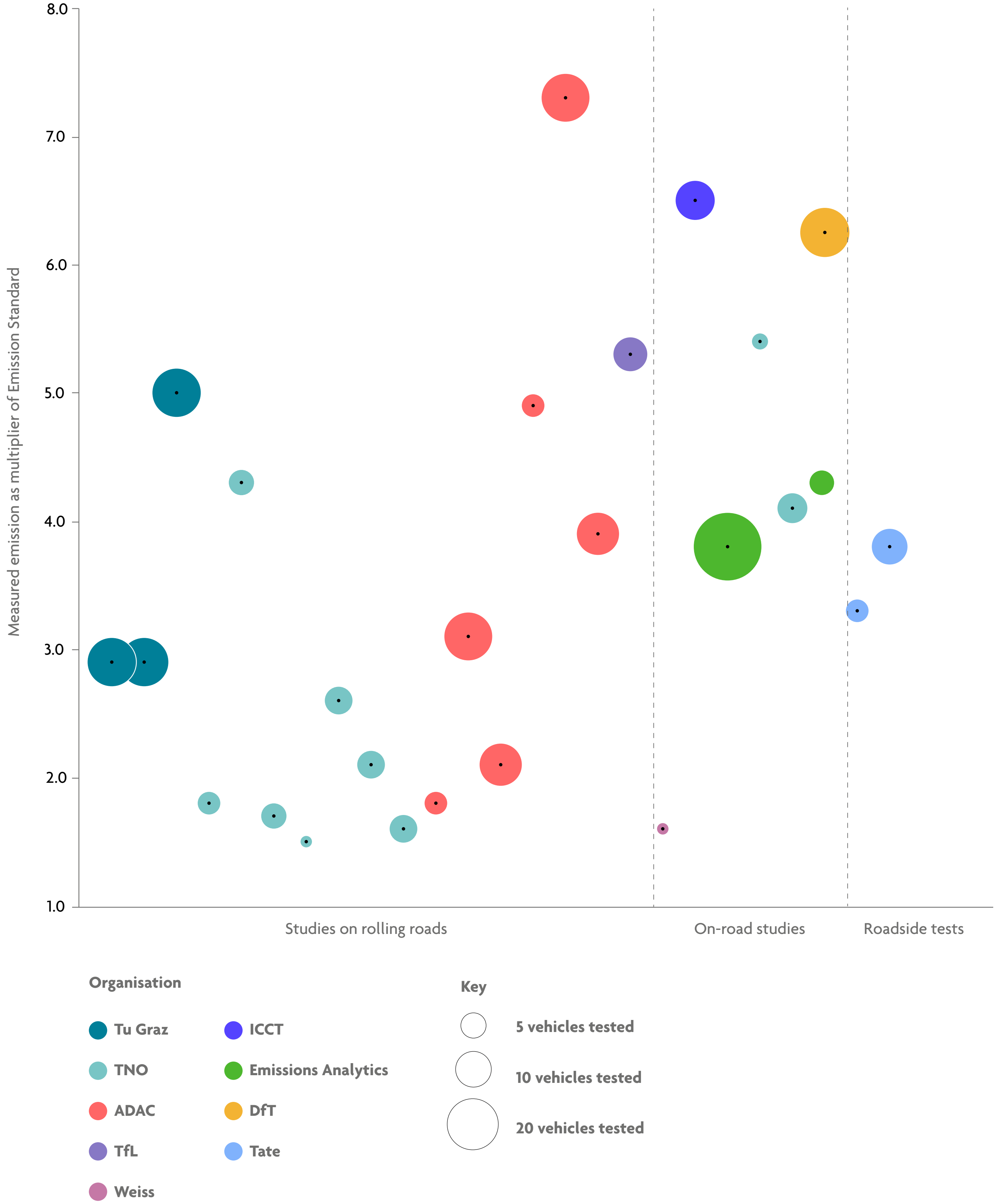
LINGERING ISSUES

In April 2016, when the DfT published the results from its own real-world emission tests (as seen in **Figure 2**), much of the UK press focused on the fact that the measured emissions breached the Euro Standard. In a way, this reporting has confused what the Euro Standard represents; they are not values that should never be exceeded and they represent the maximum allowable emission when averaged across the specific drive cycle of the test. During an emission test, there will be periods when all vehicles emit more than the standard, but this does not mean that the standard has not been met. For most air quality modellers in the UK, the key concern with the DfT's study and the other studies summarised in **Figure 2**, was not that the standards were exceeded, but the degree to which this was the case. This is because the measurements show that the assumptions used by the UK Government in its national air quality modelling, which are the same assumptions used by many air quality modellers in the UK, were unrealistic. The implication of this is that the UK Government's future year modelling, and any future year modelling which relies on the same emission factors, will be wrong.

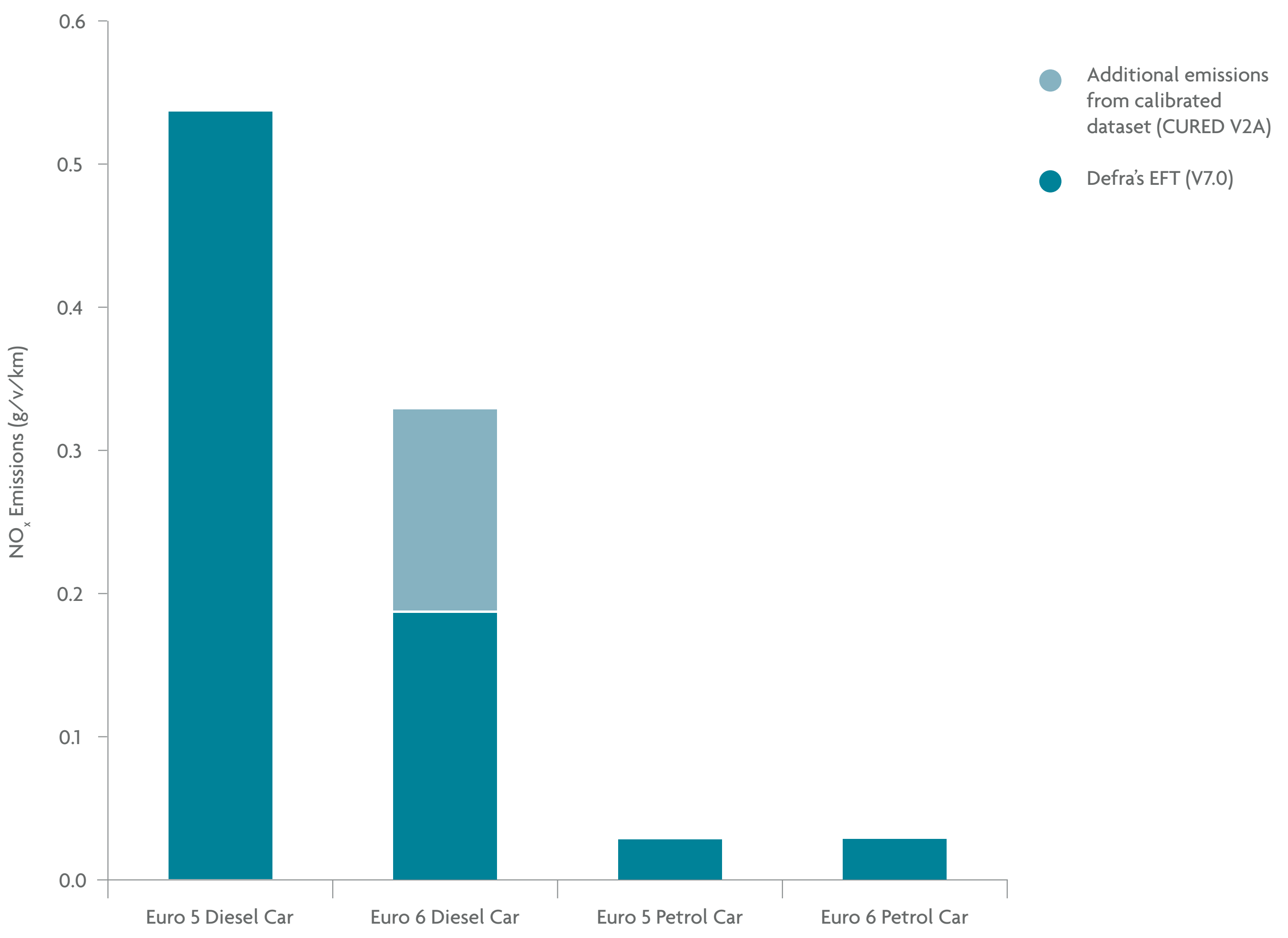
RECENT DEVELOPMENTS

There have been three pertinent recent developments in this field:

1. An alternative emissions model (the Calculator Using Realistic Emissions from Diesels [CURED]) has been published. This uses calibrated emission



▲ **Figure 2. Summary of some recent real-world NO_x emission tests of Euro 6 diesel cars. (Data source: Air Quality Consultants[1].)**



▲ **Figure 3. Comparative NO_x emission from Euro 5 and 6 Diesel Cars (at 50 kph). (Data source: Air Quality Consultants[2].)**

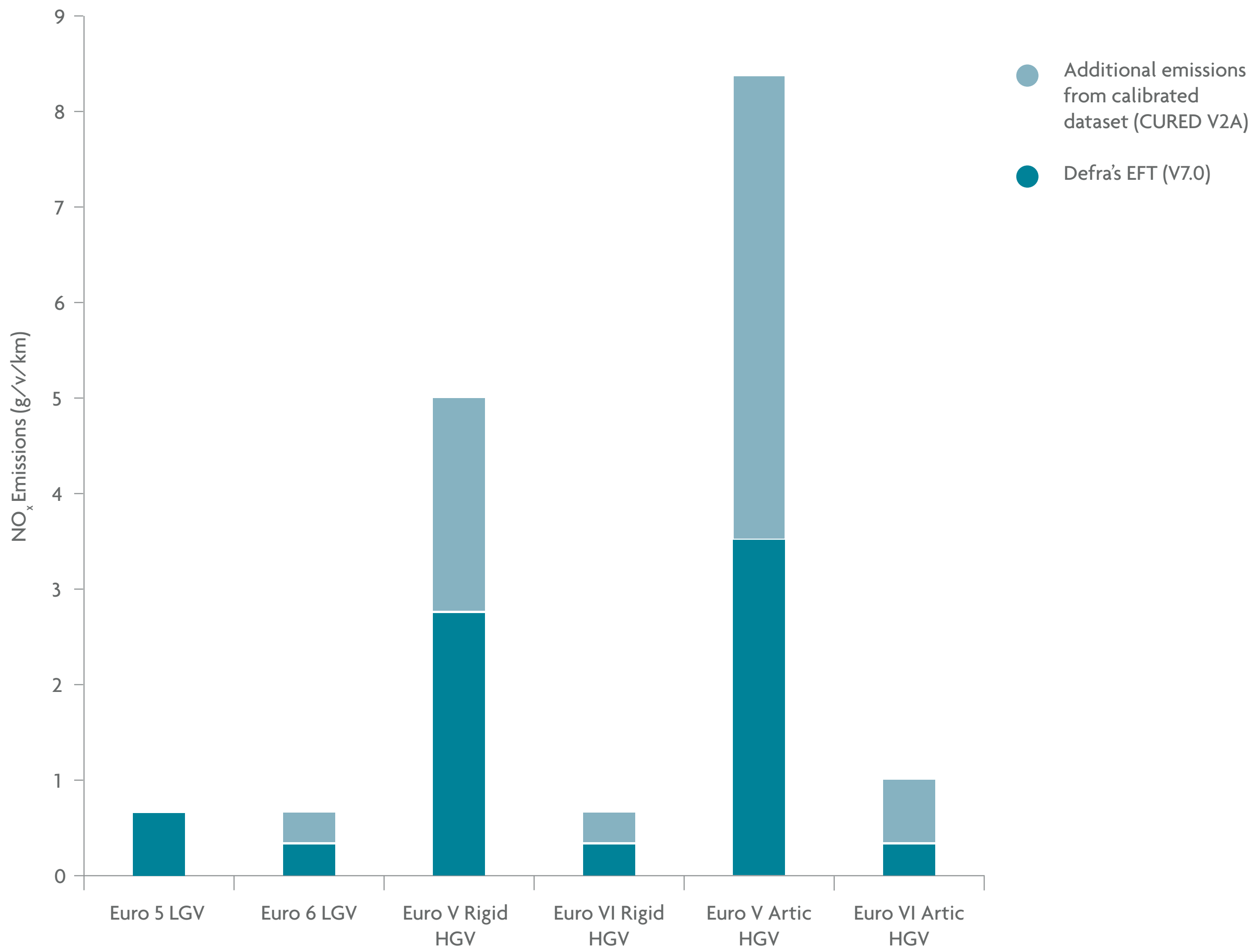
functions for Euro 6 diesel cars, along with other types of vehicle.

2. The European Environment Agency has updated its published emission functions for Euro 6 diesel cars, and these now predict higher emissions than the dataset previously used by the UK Government.

3. The pressure group, Client Earth, has successfully challenged the UK Government's national Air Quality Plan in the High Court. An important part of the argument that Client Earth put forward was that the UK Government's modelling had used improbably optimistic assumptions for emissions from future diesel cars.

Despite all of this uncertainty, the overwhelming message from real-world emission testing is that Euro 6 diesel cars emit lower levels of NO_x than older vehicles. This is highlighted in **Figure 3**, which shows how the emissions from modern cars compare with those from earlier models. **Figure 4** shows the equivalent picture for HGVs. The current emission test for HGVs already includes RDE, and there is evidence of quite startling benefits over earlier emission standards (**Figure 4**). The introduction of RDE testing for cars and vans, which will begin this year, should provide additional reductions for these vehicles, and a further adjustment in 2020 to the way the standards will be implemented, should make things better still. The position is not, therefore, that NO_x emissions are unlikely to fall; it is that they are unlikely to fall as quickly as the UK Government, and many air quality modellers, have been assuming.

Unfortunately, NO_x emissions are not the whole of this story. As previously noted, NO_x is the sum of NO and NO_2. NO has to react with ozone (O_3) before it can form NO_2, but the emitted NO_2 can have an immediate effect on ambient concentrations. This 'primary NO_2' thus has a disproportionate effect on ambient NO_2 concentrations near to roads, but these emissions are not regulated as part of the official tests. Systems designed to reduce the emission of fine particles and total NO_x can dramatically increase primary NO_2 emissions and, for this reason, ambient



▲ **Figure 4. Comparative NO_x emission from Euro 5 and 6 HGVs (at a speed of 50 kph in an urban area outside of London). (Data source: Air Quality Consultants[2].)**

NO_2 concentrations may not reduce in line with a reduction in NO_x emissions.

Despite this, with the current media attention focused on air quality, and the growing public recognition that petrol cars emit less NO_x and primary NO_2 than diesel cars, there are good reasons to be optimistic that NO_2 concentrations will fall in the future. Concentrations in many urban areas are, however, currently so high that it is likely to take quite some time before either the UK's domestic air quality objectives, or the European Limit Values for NO_2 are met. **ES**

This article was written in December 2016 and does not take account of developments since then.

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CASE STUDY

Enhancing Local Air Quality Management in Wales to maximise public health integration, collaboration and impact

Huw Brunt, Jo Barnes, James Longhurst, Gabriel Scally and **Enda Hayes** discuss their research on enhancing the LAQM regime in Wales to increase its focus on public health.

Air pollution exposure is a significant determinant of health[1,2]. It reduces life expectancy by increasing mortality and morbidity risks from heart disease and strokes, respiratory diseases, lung cancer and other conditions[3]. Air pollution exposure not only poses direct risks to individual and population health; its interaction with other health determinants can create disproportionate and strengthened disease risks and burdens, both between and within regions[4,5].

Although general air quality across the UK has improved considerably over the past 50 years or so, problems persist, especially at the local level. To continue to reduce air pollution, risks and inequalities, an effective air quality management framework is needed. Since 1997, the UK statutory Local Air Quality Management (LAQM) regime has served to support local government-led collaborative action to assess and manage air pollution problems. The primary intention of the prescribed LAQM approach is to protect and improve 'local' population health and wellbeing because it acknowledges that pollution sources are best managed at the lowest administrative level through proportionate, collaborative efforts which take account of the local context[6]. The regime is intended to complement national and international air quality management efforts.

Given the epidemiology of air pollution, effective LAQM processes must be informed by a good understanding of local air pollution problems and solutions in the broadest possible public health context[7]. It follows then that, if the regime is to protect and improve population health, LAQM should be fully integrated with wider public health policy and practice, and vice versa. This can ensure that Public Health bodies and specialists are not only able to help define problems, but also become part of the solution.

A RESEARCH CHALLENGE

Research to address these problems is now underway in Wales. A mixed methods approach is being used to support two complementary 'Research Strands'. The first is an ecological study linking local level health, air pollution and deprivation status data to quantitatively assess and describe the added value of extending the scope of LAQM; the second is a Delphi study (see **Box 1**) to achieve consensus on the role of Public Health bodies and specialists in LAQM and identify relevant development opportunities, barriers, solutions and added value.

Despite its intentions and underpinning principles, the public health aspects of, perspectives on, and integration and engagement in LAQM have received limited consideration prior to this research. A critique of available literature, as part of this research, revealed new knowledge and understanding of these aspects of LAQM; by assessing the regime's public health related strengths and limitations, and exploring how greater public health integration and collaboration in LAQM could add value to existing arrangements[8].

In summary, the literature review highlighted that LAQM is failing to achieve its full public health potential. It found that several 'structure' and 'process' weaknesses have contributed to the failure of LAQM to deliver effective 'outcomes' to protect and improve population health (see **Figure 1**).

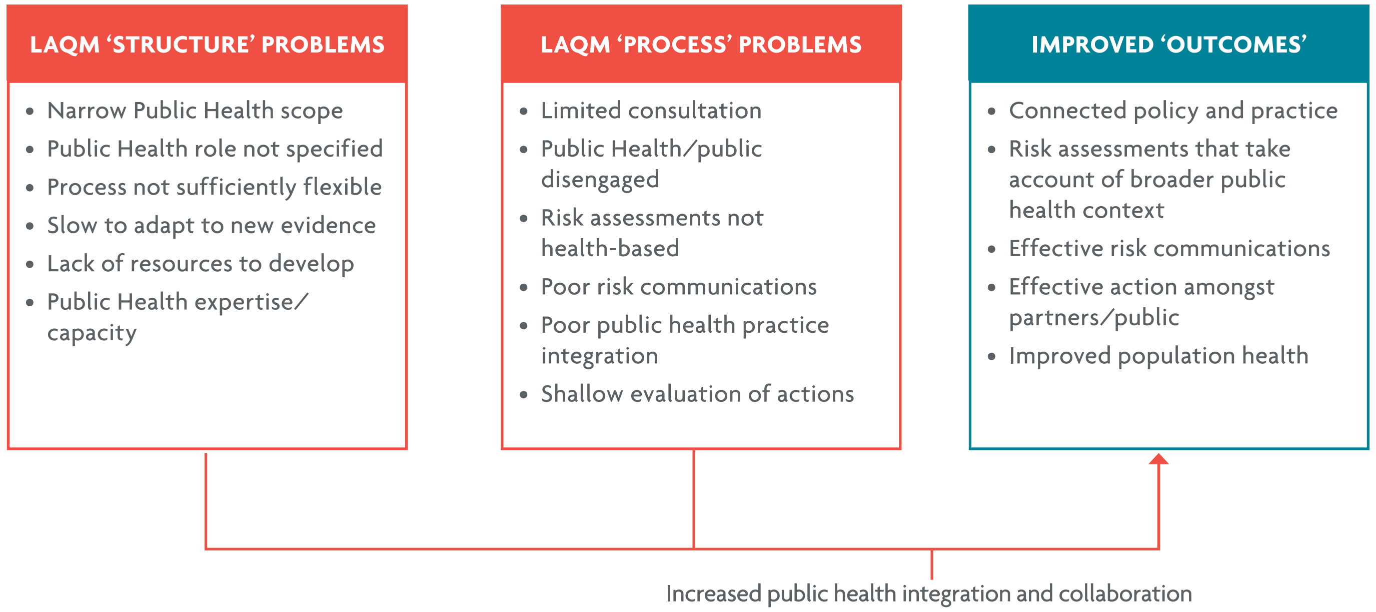
Problems identified, such as ineffective risk assessment, poor communication and disconnected LAQM and public health policy and practice, appear to stem from two main failings of the existing LAQM regime:

i. **The prescribed LAQM process is too narrow; air pollution problems and solutions are rarely considered in a broad public health context and action is restricted to small areas where there are actual or potential breaches of Air Quality Objectives**. Given the epidemiology, it is a mistake and a missed opportunity to ignore the complex interactions between air pollution and wider health determinants, and the influence that these associations can have on individual and population health. Further, because air pollutants hold non-threshold status where there is no 'safe' level of exposure, acting to reduce air pollution, risks and inequalities should not be restricted to localised pollution 'hotspot' areas.

ii. **Public Health bodies and specialists are disengaged from the LAQM process as their role has never been clearly defined.** The disconnect between LAQM and public health policy and practice is significant and growing. To date, reviews of LAQM related stakeholder collaboration have failed to reach out to Public Health bodies and specialists, and so it remains unclear why most do not support LAQM as much as they could and should. The added value of greater public health integration and collaboration in LAQM, and vice versa, has never been specified.

BOX 1: DELPHI STUDY DEFINITION

A Delphi study is a survey method used to determine multiple viewpoints on a particular subject and to achieve consensus on disputed topics. A panel of experts on the topic are purposefully selected and respond anonymously to a series of surveys interspersed with feedback on group opinions. Opinions proposed by participants are rated on so that consensus and responsibility can be assessed.



▲ **Figure 1. LAQM public health-related problems and improved outcomes.**

The literature review concluded that these two fundamental LAQM shortfalls have shaped an LAQM regime that is failing to adequately consider and act to protect and improve public health. Together, they have hindered the integration and collaboration of Public Health bodies and specialists in LAQM, and stunted the regime's reach, evolution and impact. The review recommended that, by further investigating and addressing these research problems, LAQM can be rendered public health driven rather than being merely public health-oriented.

ADDRESSING THE PROBLEM

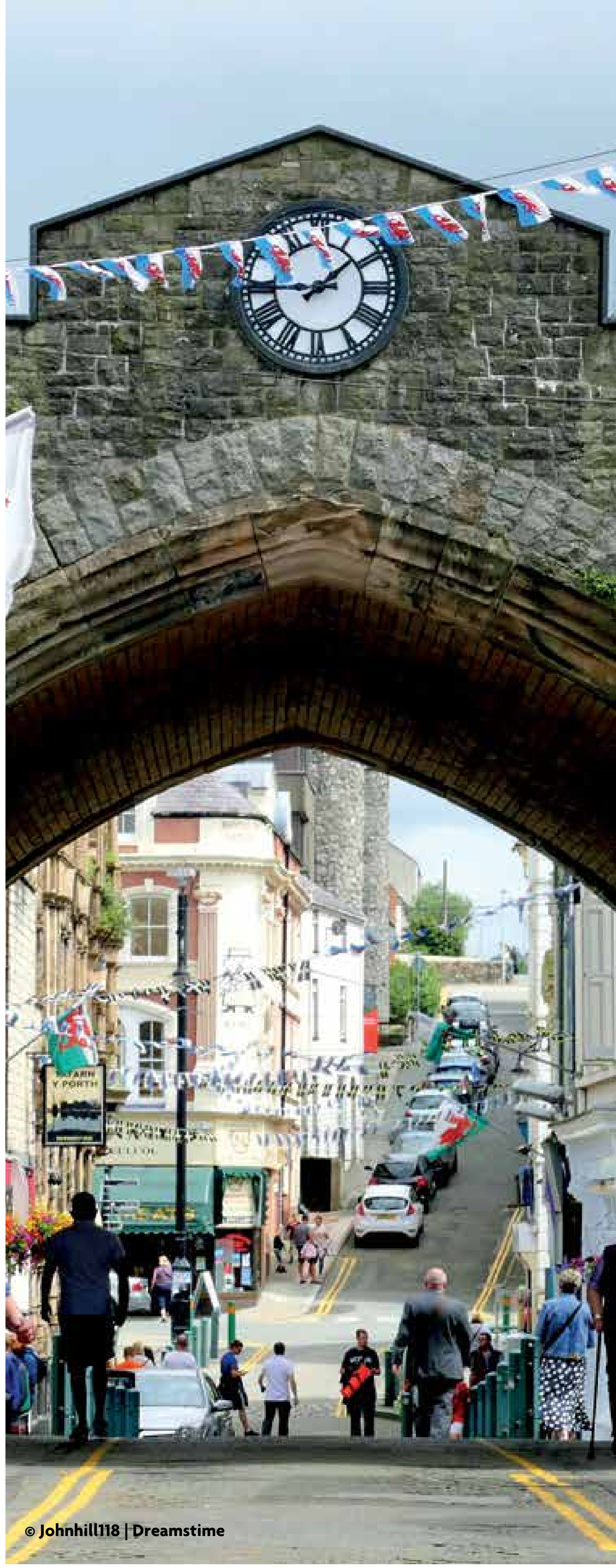
Work towards resolving this is now underway in Wales, framed in the broad context of the Wellbeing of Future Generations (Wales) Act 2015. This new legislation requires Public Bodies (which include Public Health bodies) to work together to improve the social, economic, environmental and cultural wellbeing of Wales[9]. The aims and objectives of this research project are specified in **Figure 2**. To maximise clarity and focus, and allow research to proceed without compromise or confusion, the overall research aim has been broken down into two distinct yet complementary Research Strands that run in parallel.

A mixed methods approach and study design has been adopted to take forward this research. Findings will be triangulated and validated by mixing and interpreting findings from 'Research Strand 1' (the epidemiological ecological data-linkage study) and 'Research Strand 2' (the Delphi consensus-forming study) in the context of the literature review. This approach should mean that the sum of the product of the research project as a whole is greater than its individual component parts.

FINDINGS TO DATE

The ecological study undertaken through Research Strand 1 linked local level air pollution, income deprivation (as a proxy for multiple deprivation), and health outcomes data[10]. It revealed that there is substantial small area variation in air pollution and deprivation status across Wales (**Figure 3**). Also, annual mean air pollution concentrations were found to be relatively high in both 'most' and 'least' deprived areas, but highest in the former where Wales' highest proportions of children and vulnerable people live[10]. This pattern was most pronounced for nitrogen dioxide (NO_2) air pollution.

When considered separately, income deprivation had a greater association with health than air pollution did. When considered simultaneously however, air pollution was found to interact with income deprivation status to create modified and strengthened associations with all cause and respiratory disease mortality. This was especially evident in the 'most' deprived areas. For example, respiratory mortality rates in 'low' polluted



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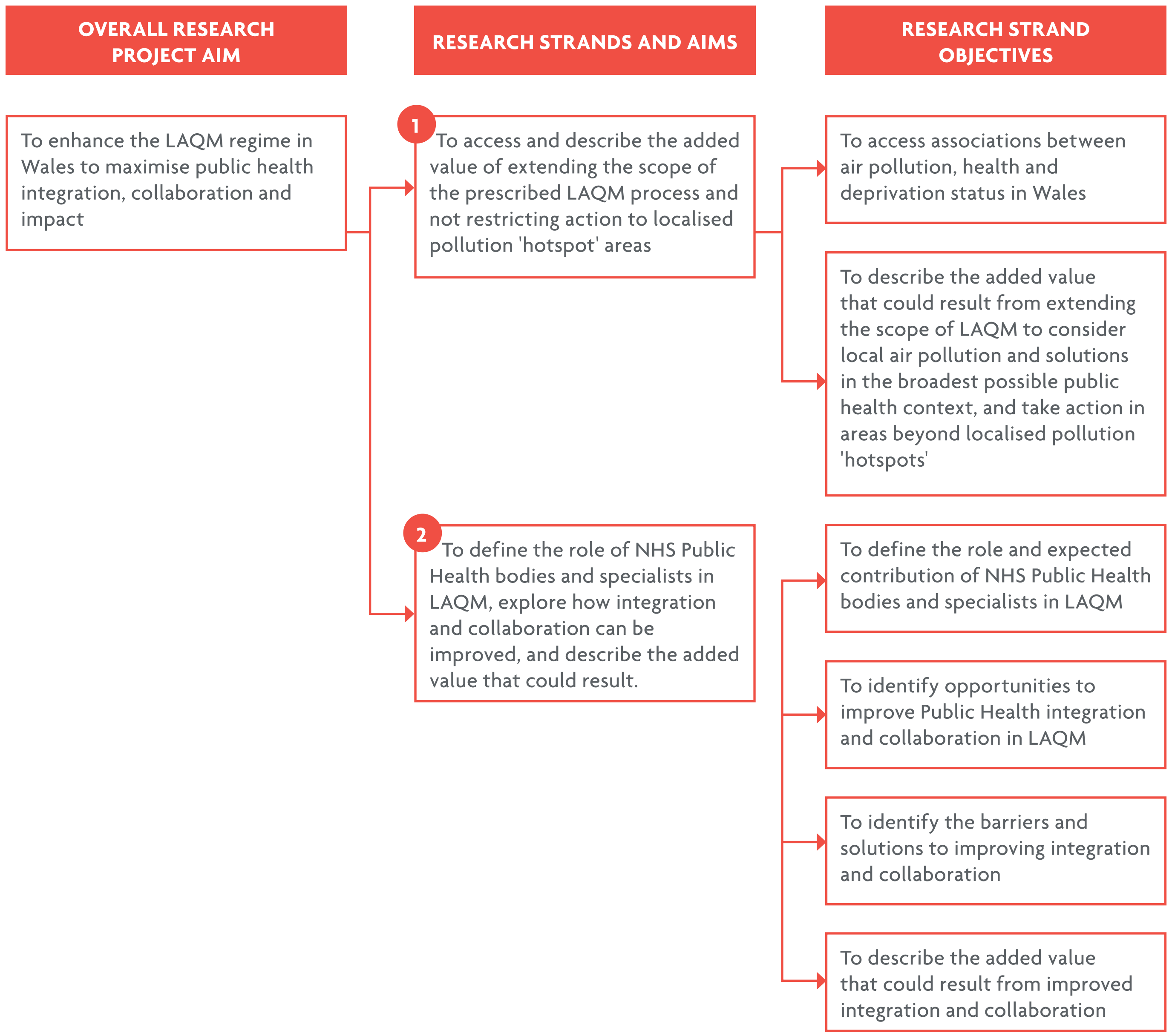


▲ **Figure 2. Overall research aim, and research aims and objectives of Research Strands 1 and 2.**

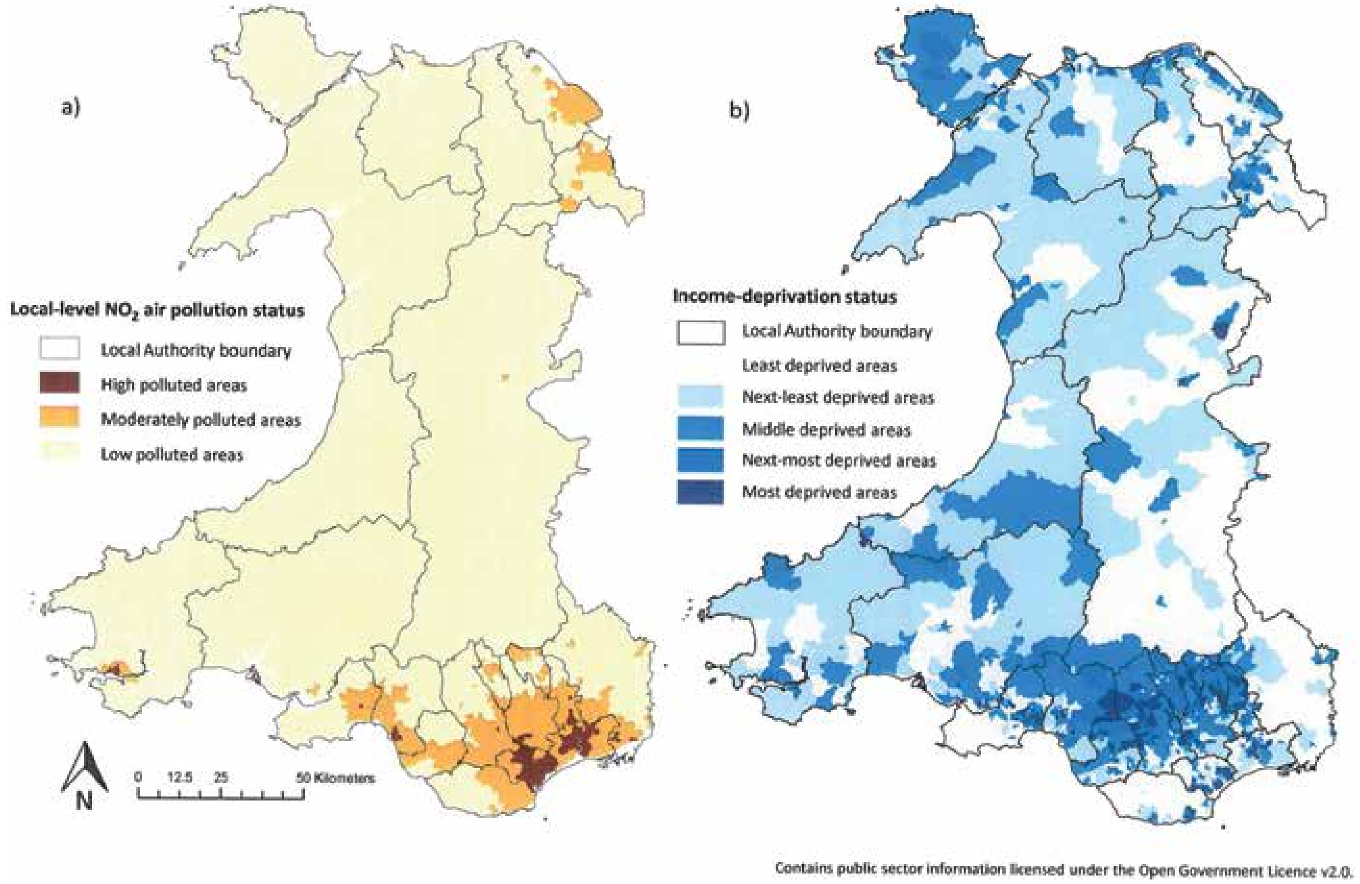
and 'most' deprived areas were around twice those in 'low' polluted and 'least' deprived areas, but increased to approximately 2.4 times higher in 'most' deprived and 'high' polluted areas[10].

Research Strand 2's Delphi study was completed in late 2017, and findings will be published shortly.

THE WAY FORWARD

The public health aspects of, perspectives on and integration in LAQM have received little attention to date. The literature review undertaken as part of this research project has moved understanding on by identifying a number of LAQM and public health related 'structure' and 'process' weaknesses that have contributed to preventing LAQM deliver effective 'outcomes'. It hypothesised that acting to bridge this growing disconnect can add value to existing arrangements (i.e. by expanding LAQM so air pollution problems and solutions are considered in a broad public health context, and defining the role and expected contribution of Public Health bodies and specialists in LAQM).

The ecological study that explored the first of these issues linked local level health, air pollution and income deprivation status data. The study confirmed that air pollution, deprivation and health are inextricably linked; interactions between air pollution and deprivation status modified and amplified already strong associations between deprivation and health outcomes, specifically all-cause, non-accidental and respiratory disease mortality, and especially in 'most' deprived areas. The findings suggest there is considerable merit in implementing measures to reduce air pollution risks at a population level, just as there is in tackling deprivation related risk factors. Further, if LAQM is extended so that local air pollution problems and solutions are considered in the context of wider health determinants, and air pollution mitigation and public health interventions are aligned and targeted in areas where health needs are highest, greater health



▲ **Figure 3. Map of Wales showing variations in local level. (a) NO_2 air pollution status, and (b) income deprivation status. (Source: Brunt et al.[10], by permission from the Journal of Public Health.)**

"There is considerable merit in implementing measures to reduce air pollution risks at a population level"

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CASE STUDY

gains (improved health, reduced risks, susceptibilities and inequalities) can be achieved.

To realise this, greater public health integration and engagement in LAQM policy and practice is needed. It is anticipated that the Delphi study will improve understanding around exactly what enhancements are needed and how these can be implemented. This study intends to develop expert consensus on the role of Public Health bodies and specialists in LAQM, as well as identify opportunities, barriers, solutions and the added value that could result from a more focused and supported air quality management process. When the study is complete, its findings will be mixed with and interpreted in the context of those from the linked ecological study and literature review.

Ultimately, the combined outcomes of this research should be used to inform evidence based enhancements to LAQM arrangements in Wales that introduce more effective, integrated and collaborative ways of working to maximise reductions in air pollution, risks and inequalities across Wales. Although contextualised to the situation in Wales, it is likely that research findings will be relevant to other parts of the UK and beyond. ES

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OPINION

Health and education versus economic development – are our children suffering in the crossfire?

Graham Harker compares UK and US policy on school and road building, and debates whether the health of children is being compromised by the race for economic development.

Children are particularly susceptible to the health effects of poor air quality as their response to atmospheric contaminants, both in the severity and the nature of the adverse effect, can differ significantly from adults. This can be for a number of reasons: children breathe more air per kilogram of body weight than adults, and as breathing increases significantly during periods of exercise, and children are generally more active than adults, their total air intake can be greater. In addition, when breathing solely through the mouth occurs, the process of deposition of pollutants in the upper respiratory tract is bypassed and

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OPINION

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direct deposition of the pollutant occurs into the lungs instead. The growth and development of children's lungs has found to be suppressed due to long term exposure to outdoor air pollution and this may, in the long term, speed up the decline of lung function through adulthood and into older age[1]. Children with chronic illnesses such as asthma are also likely to be more adversely affected during periods of poor air quality. The location of schools is therefore important when it comes to children's health, as they are the locations where large groups of vulnerable individuals are brought together for significant periods of time.

Over the past year in particular, air quality has risen up the public's agenda, and whilst progress is still slow, this is obviously welcome news. Significant publicity was generated in May 2016 by the news that a report into air quality and London schools commissioned by the Greater London Authority (GLA) in 2013 had not been published[2]. The report found that in 2010, 433 of the city's 1,777 primary schools (approximately 24 per cent) were in areas where annual mean nitrogen dioxide concentrations breached the EU Limit Value. Of those, 83 per cent were considered deprived schools, with more than 40 per cent of pupils on free school meals. This is important, as disadvantaged children may be more at risk from environmental hazards if other factors are present, such as poor nutrition, lack of access to healthcare provision and pre-existing health conditions.

So, we know that poor air quality is a particular problem for children and therefore it would be logical to suppose that this would be a subject that the government would be particularly interested in. Unfortunately, this does not appear to be the case as a search of government websites mostly draws a blank on the subject; the closest publication to any form of government opinion is a draft document on indoor air quality in schools[3] where guidance is provided on the design of mechanical ventilation systems to improve indoor air quality within school buildings. Interestingly it also refers to guidelines[4] suggesting that 'pollution-free' zones should be chosen as a preferential location for new schools. Whilst no major urban area in the UK is likely to be 'pollution-free', it is obvious that new schools are going to continue to be constructed in areas of poor air quality.

'ACROSS THE POND' – THE US REFLECTION

Within the United States the situation is different however, where the siting of schools seems to be taken more seriously. The Environmental Protection Agency (EPA) School Siting Guidelines[5] provides information and discussion of the issues surrounding the location of schools, and is meant to apply to the decisions about whether to renovate, relocate or replace a school on the same site. The guidance emphasises that the issues surrounding the siting of schools are complicated. Locating schools close to the catchments which they serve is potentially preferable to moving a school to a less polluted area, if it means that more pupils can walk or cycle to school (and not be transported by car). Moving a school to the edge of a community can also restrict public access to recreational or public facilities. The EPA guidance is not compulsory or retrospective, but does recommend that schools are periodically assessed to identify potential environmental health and safety risks. This would include the risk of poor air quality adversely affecting the health of the children attending the school.

In California, the South Coast Air Quality Management District (SCAQMD) have produced guidance on the siting of new schools[6]. The guidance recommends considering a general buffer zone of between 150 and 300 metres between the school site and major roadways, with new school sites no closer than 300 metres to other major mobile sources of pollution, such as busy distribution centres, rail yards or ports.

PREVENTION IS BETTER THAN CURE

As far as new schools are concerned in the UK, before they can be built they are the subject of an in-depth planning application process. The accompanying environmental assessment within this will almost certainly need to demonstrate that the site has acceptable air quality, and therefore this shouldn't be an issue for new schools. However, more importantly, the impact of poor air quality on the pupils of existing school sites should also be considered.

In Sheffield, partly due to concerns regarding high levels of pollution from the adjacent M1 motorway, the Tinsley infant and junior schools were moved to a location further from this busy road. Sheffield has historically been one of the few locations in the UK where air quality issues are high on the public's agenda and therefore the air quality concerns were sufficient to provoke the local education authority to act. Unfortunately, the Sheffield example is unique in that there is no national initiative to investigate the issue of poor air quality and the siting of schools. What is required is a mandatory review of the environmental and health risk of every school site in the UK, to identify where additional action is required to ensure an adequate air quality environment for our children (where they spend a large proportion of their early lives). As a minimum, children should not be exposed to air quality in breach of National Air Quality Objectives or EU Limit Values.

The review would need to ascertain where air quality at school sites was poor and expected to remain poor. Depending on the findings, it may be possible to mitigate the impacts sufficiently within the existing school site so as to avoid the need to move the school (assuming that an alternative acceptable location existed). For example, as distance from a pollution source is an important factor in reducing exposure, it may be possible to reconfigure the layout of car parks, access roads or playing fields to increase the distance between the source (most likely a main road) and the areas where children are present. With regards to the school buildings, alternative means of ventilation could be provided which draw less polluted air into the buildings, or use a filtration system to remove pollutants.

Doing something about poor air quality in schools is potentially expensive, but needs to be set against the potential costs of treating the adverse effects of poor

air quality in children in the long term. The health effects can potentially last a lifetime, and therefore a cost benefit analysis may show that it is beneficial, in financial terms, to take action sooner rather than later.

If we are to see a comprehensive review of air quality within schools and action taken to do something about it, it is likely to require overwhelming public pressure to force it through. This is not dissimilar to the whole air quality issue in the UK, and the response (or non-response up until recently) of the public to concerns about the adverse effects on health of poor air quality. What the issue has in its favour is that children's health concerns have greater traction with the general public than almost any other group. The political environment is also changing, with hardly a week going by now without an article in the press about air quality; this may be enough to see the government take the issue of poor air quality within schools seriously enough to do something about it, though some sort of kick start is likely to be required. Given the vulnerability of children to poor air quality, sorting out air quality within schools should be a higher priority than avoiding fines from Europe for breaching EU Limit Values, but that is the subject of a different article. **ES**

Graham Harker currently leads the air quality team at Peter Brett Associates LLP, where he provides air quality services for development projects. He started his career as a mechanical engineer in the oil industry, coming to air quality by way of the Environment Agency.

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Air quality drives down motorway speed limit

Fiona Prismall debates whether the negative reaction to the proposed lowering of the speed limit on the M1 is indicative of a failure to communicate effectively on air quality impacts.

In December 2016, Highways England wrote to MPs in and around Sheffield to inform them of its proposal to introduce a 60 miles per hour speed limit on the M1 between junctions 32 and 35a, from 07:00 to 09:00 and 15:00 to 19:00 on weekdays. This measure is being proposed as a means of reducing the predicted increase in air pollution when this section of 'smart motorway' becomes fully operational later this spring. A smart motorway uses active traffic management techniques to increase capacity by use of variable speed limits and hard shoulder running at busy times.

The history of the M1 project is complicated. In March 2014, a project to create a smart motorway, making the hard shoulder a permanent running lane, was commissioned for the M1 between junctions 28 and 31 and between junctions 32 and 35a. Works on the smart motorway between junctions 28 and 31 have already been completed and a smart motorway in this location has been operational since the 31st March 2016. Between junctions 32 and 35a, works began in February 2015, with a view to a smart motorway being operational in March 2017. However, an air quality related issue remains unresolved: the smart motorway scheme is expected to increase the number of vehicles using the motorway on a weekday from 120,000 to around 130,000 and the air quality impacts associated with the smart motorway operating with a 70 miles per hour speed limit are expected to be significant[1], potentially breaching EU Limit Values.

The potentially significant impacts for the M1 were identified during the environmental impact assessment undertaken when the smart motorway was originally proposed. At that time, mitigation was proposed in the form of a 60 mile per hour speed limit from 07:00 to 19:00, 7 days a week, between junctions 28 and 35a[2]. A public consultation was carried out between the 6th January 2014 and the 3rd March 2014. Of the 827 responses received, 92 per cent objected to the proposals[1] and the Secretary of State for the Environment at the time, Owen Paterson, rejected the proposal. Highways England reported that it would rigorously investigate alternative approaches to mitigate the air quality impacts over the 12-18 months following the consultation. The investigation would include reducing the periods for the lower speed limit and reducing the length of the M1 that would be affected. Nevertheless, there was no question that the smart motorway would still proceed to address worsening congestion and to facilitate economic growth.

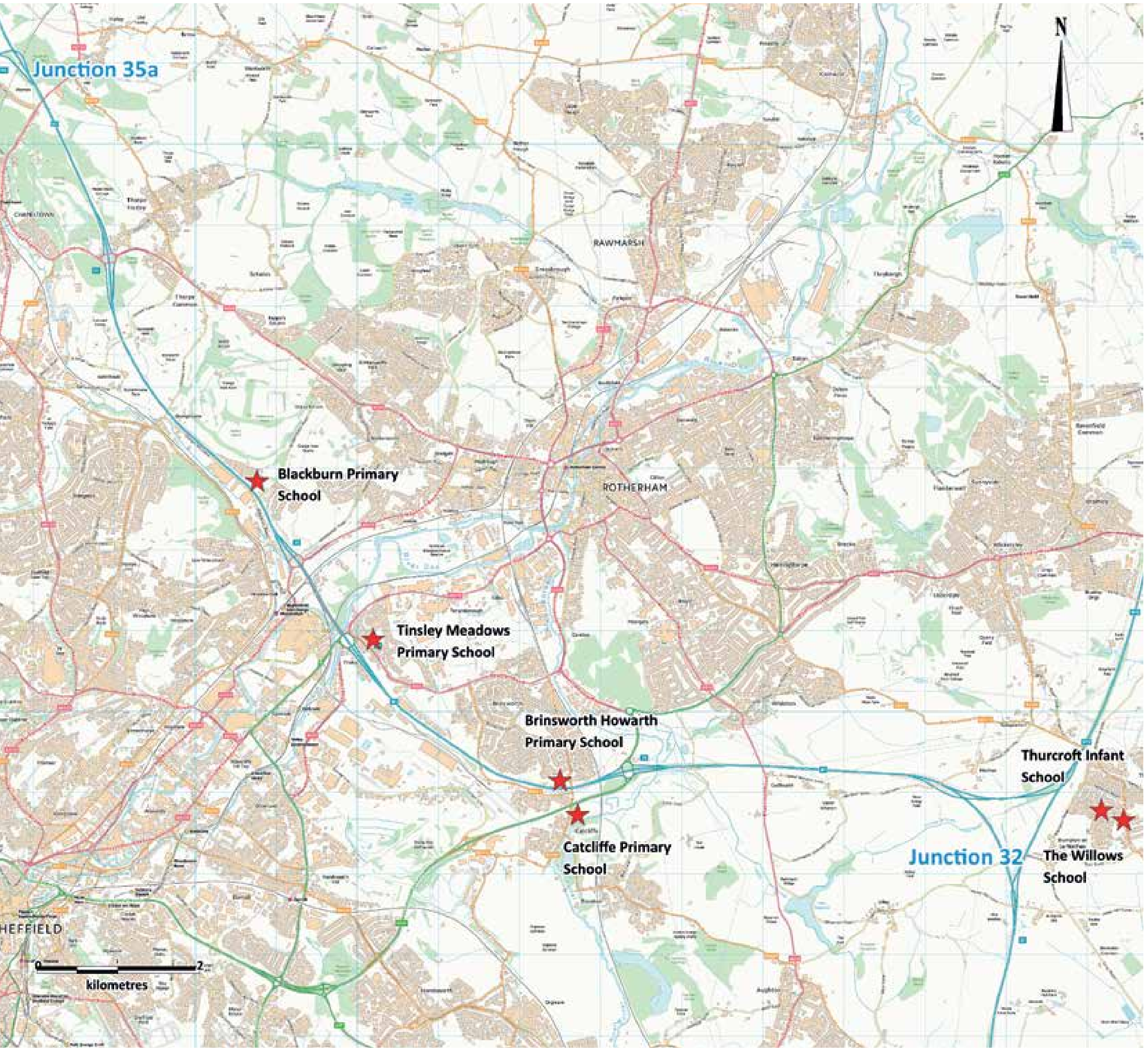
The investigation that followed focused on a speed restriction applying only to the stretch of the M1 between 32 and 35a and only on weekdays during the morning and evening rush hours; this part of the M1 is being specifically targeted due to its close proximity to schools and homes (**Figure 1**). The purpose of the reduction in the speed limit is purported to be the creation of smoother journeys, avoiding the need for the higher polluting acceleration and deceleration phases created by stop-start conditions. If the plan proceeds, this would be the first UK pollution linked speed limit (see **Box 1**).

ARE HEALTH CONCERNS LINKED TO SPEEDING CARS?

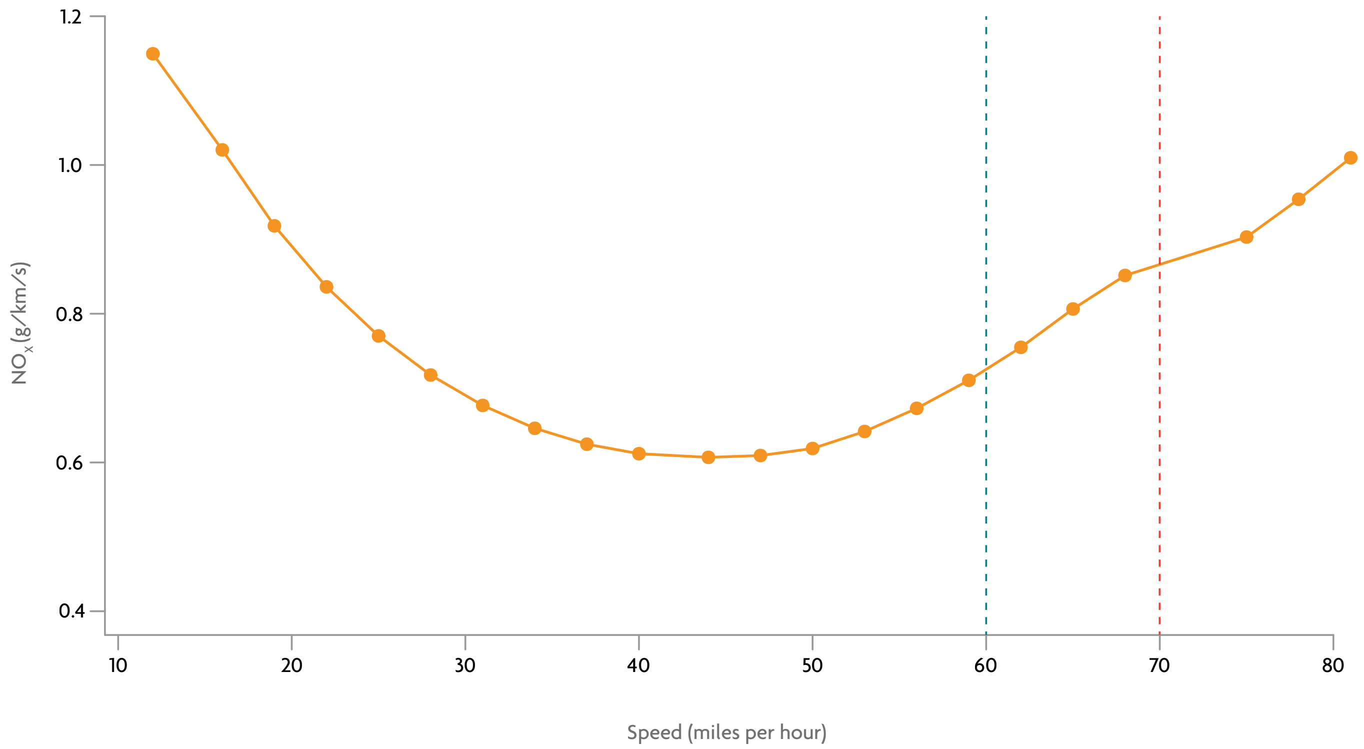
Each year in the UK, around 40,000 deaths are attributable to exposure to outdoor air pollution which has been linked to cancer, asthma, stroke and heart disease, diabetes, obesity, and changes linked to dementia. In February 2016, the Royal College of Physicians published a report[3] estimating that the costs of people who suffer from illness and premature death (to the NHS and to business) add up to more than £20 billion every year. Controlling speeds to mitigate air quality impacts is endorsed by the National Institute for Health and Care Excellence (NICE). In its draft guidance on outdoor air quality and health, issued for public consultation on the 1st December 2016, avoiding acceleration and deceleration underpins a large number of the proposed recommendations. The NICE draft guidance includes a recommendation for motorways to "Consider using variable speed limits and average speed technology on the roadside to promote a smoother driving style".

Air quality impacts at schools located in pollution hotspots were specifically raised as a concern in the Environmental Audit Committee's 2014 Action on Air Quality report[4], and this may have lent weight in determining the area requiring air quality mitigation on the M1.

FEATURE



▲ **Figure 1. Locations of schools in close proximity to the M1. (Contains public sector information licenses under the Open Government License v3.0).**



▲ **Figure 2. Graph showing variation in emissions of nitrogen oxides with different speeds. (Data source: Defra's Emissions Factor Toolkit.)**

MITIGATING THE IMPACTS – THE EVIDENCE

It is difficult to quantify the potential air quality benefits specifically associated with acceleration and deceleration, as the emission factors currently available for air modelling assume that vehicle emissions are speed related. In other words, pollutant concentrations can only be estimated on the assumption that a vehicle travels at a constant speed.

In October 2015[5], an air quality assessment report was published by Highways England setting out the results of the investigation into lower speed limit over varying time limits and reduced lengths of the smart motorway. The report does not suggest that any adjustments to emission factors have been made to allow for a reduction in acceleration and/or deceleration. Nevertheless, it is clear from the available emission factors that vehicles travelling at speeds between 30 and 60 miles per hour emit less harmful pollutants than vehicles travelling at speeds below 30 miles per hour. Similarly, the available emission factors show that vehicles travelling at speeds of 60 miles per hour emit less harmful pollutants than vehicles travelling at speeds at 70 miles per hour, as seen in **Figure 2**. If a reduced maximum speed means that more vehicles travel within the 30 and 60 miles per hour speed range for a greater proportion of the time, then there could be benefits. While the traffic data used in the assessment are not readily available, it is likely that the air quality modelling assumed a greater proportion of vehicles travelling within this speed range. There is therefore some merit in the pursuing the proposal to reduce the maximum speed.

Nick Harris, Operations Director at Highways England, wrote to MPs in December 2016 to set out its current proposal. Recognising the unpopularity of reducing the maximum speed, Highways England's letter to MPs in December states that "We are looking into initiatives that might avoid or reduce the need for these speed limits". It is understood that these initiatives include coating barriers with catalytic paints and putting out piles of 'mineral polymer' which could absorb vehicle-related pollutants. While the outcome of the consultation was a commitment to rigorously investigate options within 18 months, it seems that little progress has been made on investigating any options other than a reduction in the speed limit. It is curious that these novel options are apparently on the table now, but did not form a part of the rigorous investigation that followed the consultation.

A report published by the Department for Environment, Food and Rural Affairs' (Defra) Air Quality Expert Group in 2016[6], concluded that under laboratory conditions, photocatalytic surfaces are effective at reducing concentrations of the key traffic related pollutant, nitrogen dioxide. However, the group concluded that there is no such evidence that these coatings are effective at reducing pollutant concentrations from the atmosphere due to the large volume of the atmosphere compared to the coated surface area. More worryingly, the group also identified a risk that these materials produce other chemical compounds which in turn have adverse health impacts. This suggests that not only are these initiatives unproven in improving air quality but they could, in fact, make matters worse.

FEATURE

BOX 1: TIMELINE FOR THE EVOLUTION OF THE M1 'SMART' MOTORWAY.

- March 2014 – Highways Agency consults on an M1 smart motorway between J28 and 35a with a 60 mph speed limit. The reduced speed limit proposal is rejected, but Highways Agency commits to investigating options to mitigate air quality impacts over next 12 to 18 months.
- August 2014 – Highways Agency commences construction of M1 smart motorway between J28 and 31.
- October 2015 – Report investigating alternative maximum speed related options is published.
- March 2016 – M1 smart motorway between J28 and 31 is fully operational.
- December 2016 – NICE commences consultation on draft which includes recommendation to use speed limit as a means to promote smooth driving.
- December 2016 – Highways England writes to MPs proposing a reduced speed during a weekday rush hours on the M1 between J32 and J35a
- March 2017 – M1 smart motorway between J32 and J35a due to become fully operational.

UNPOPULAR CHOICES VERSUS EASY OPTIONS

The content of Highways England's letter has proved to be controversial and has been widely discussed by the media. The lack of popularity of the proposed 10 miles per hour decrease in the speed limit is interesting. While there have been no nationwide studies, 43 per cent of 1,015 parents of school age children in London polled by YouGov last year, ranked air pollution as the biggest health threat. It seems that a connection between driving style and health impacts is not being made by those responding to the M1 consultation. Turning back to the Environmental Audit Committee's 2014 Action on Air Quality report, the group stated that "The results of our own personal air quality monitoring suggested, perhaps surprisingly, that drivers and passengers in vehicles on congested roads are more at risk than people walking alongside busy traffic". This also tends to suggest that greater communication into air quality impacts may be required to allow informed decision making.

In the House of Commons, concern was raised that the smart motorway plans had proceeded before a robust plan to mitigate the air quality impacts had been identified, effectively prioritising easing congestion on our roads above health. Furthermore, one MP in the House of Commons derided the non-speed limit alternative options as "Mickey Mouse schemes".

With the final stretch of the M1 smart motorway due to commence operation in March 2017, a thorough consideration of alternative options seems to have been left too late. The only option remaining now appears to be the largely unpopular speed restriction between 32 and 35a and only on weekdays during the morning and evening rush hours. If the option does proceed, air quality would need to be monitored to demonstrate the efficacy of the mitigation. Extensive air quality monitoring was undertaken for the original Environmental Impact Assessment in 2012, so this will provide a useful comparison of the before and after situation. If the air quality impacts are found to be mitigated by the proposed speed limit restriction, this may provide some powerful evidence to include in communications for future similar proposals.

If the results of monitoring do not show an improvement in air quality or show that air quality has worsened, Highways England would either need to revisit its investigation into alternative mitigation options or revoke the smart motorway until an effective solution can be identified. ES

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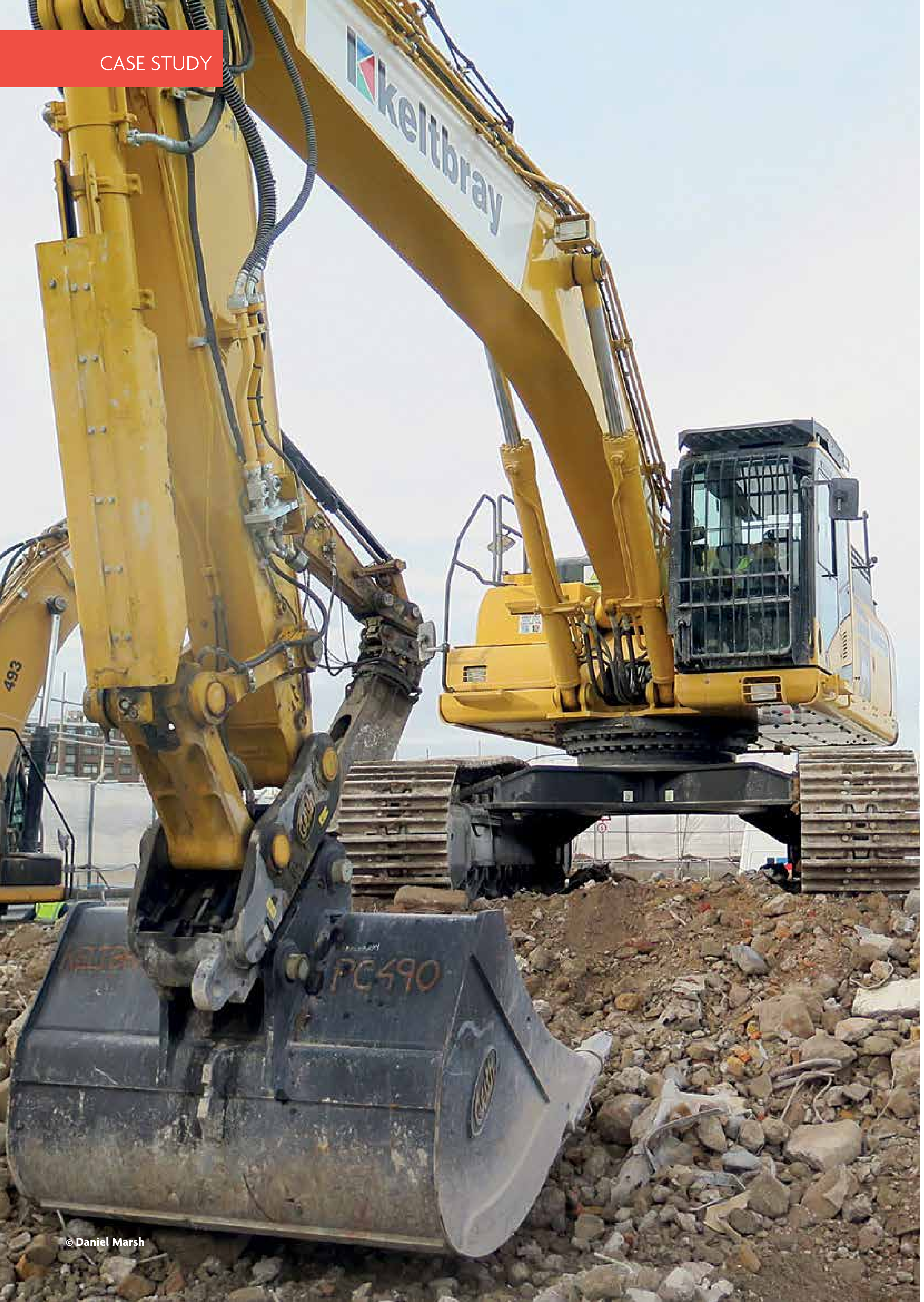

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CASE STUDY

Controlling non-road mobile machinery emissions in London

Daniel Marsh explains the impact of non-road mobile machinery on London's air quality and the legislation introduced to bring this not-so-obvious source of pollution under control.

Before getting involved in the finer detail of non-road mobile machinery (NRMM) policy and emission control measures that have been introduced in London, it's probably worth explaining what NRMM actually is. NRMM is defined as any mobile machine, item of transportable industrial equipment, or vehicle (with or without bodywork) that is not intended for carrying passengers or goods on the road and is installed with a combustion engine, either an internal spark ignition (SI) petrol engine, or a compression ignition diesel engine.

Examples of NRMM on construction sites may include, but are not limited to, excavators, dumpers, telehandlers, cranes, and piling rigs, but also includes generators, compressors and pumps which may not seem so obvious due to their apparent lack of self-mobility. Additionally, there are machines such as truck mounted cranes which have multiple engines, where the primary truck engine is affected by on-road regulation, but any secondary engine installed to power the crane is covered by the NRMM policy.

For many years, emissions from on-road vehicles have been controlled through European legislation (e.g. Euro 5 and 6). In London, the penetration of the lowest emitting commercial vehicles has been accelerated through the London Low Emission Zone (LEZ); this has been in operation since 2008 and requires increasingly higher European standard engines or the installation of retrofit technology for these vehicles. Until recently, however, there has been very little regulation of the machinery used in construction, and emission controls within this sector are now coming under closer scrutiny across the EU.

BOX 1: DEFINITION OF PARTICULATE MATTER

The term 'particulate matter' (PM) covers all particles suspended in the air, and is a complex mixture of extremely small particles and liquid droplets. PM can include both organic and inorganic particles such as dust, soot, smoke and pollen. Many of these particles are detrimental to health when inhaled. Two sizes of particle are commonly monitored:

PM_{10}: Particles with a diameter of 10 µm or less.

$PM_{2.5}$: Fine particles with a diameter of 2.5 µm or less.

HOW 'DIRTY' IS NRMM?

The London Atmospheric Emissions Inventory (LAEI) currently attributes 7 per cent of the nitrogen dioxide (NO_2), 8 per cent of PM_{10} and 14.5 per cent of the $PM_{2.5}$ levels (see **Box 1** for definitions) emitted into London's air as originating from the NRMM diesel engines used in the construction industry. As the emissions from road vehicles are to be further reduced through the introduction of the London Ultra Low Emission Zone (ULEZ) in 2019, other pollution sources such as NRMM, but also shipping, solid fuel burning etc., will increase in their percentage contribution and therefore also in importance.

WHAT CHANGED FOR NRMM?

In July 2014, the Mayor of London released a Supplementary Planning Guidance (SPG) for 'The Control of Dust and Emissions during Construction and Demolition'[1], based on an earlier best practice guidance document of the same name, as well as earlier guidance issued by the Institute of Air Quality Management[2]. The guidance aims to reduce emissions of particulate matter and nitrogen oxides (NO_X) as well as control fugitive dust from construction and demolition activities. The SPG also outlined the Mayor's policy to introduce 'Cleaner Machinery for London' through a low emission zone for NRMM. This came into effect on the 1st September 2015, making London the first city in the world to introduce such a scheme.

The policy splits London into zones requiring NRMM with different EU emission limit values: the Central Activity Zone (CAZ); Canary Wharf and Greater London. The CAZ and Canary Wharf have a tighter emission requirement of a minimum EU Stage IIIB[3] (see **Box 2**). They cover areas that are not only currently undergoing a huge amount of redevelopment, but are already some of the most polluted parts of the city while the rest of London is required to meet the Stage IIIA standard. From September 2020, NRMM used across both of these zones will need to meet the next respective EU emission stage.

BOX 2: EUROPEAN EMISSION STANDARDS

Introduction of the European Emission Standards for engines used in new non-road mobile machinery (NRMM) have significantly reduced gaseous emissions. The standards are split into categories for spark ignition (SI) and compression ignition (CI) engines and then further classified according to the engine power rating. These categories are then given limit values for specified gaseous outputs, more commonly known as the engines stage.

With so much new development taking place across the city involving a multitude of development companies, contractors and specialist suppliers, enforcing the policy is always going to present challenges for both the Greater London Authority (GLA) and the local planning authorities. In order to ensure that the site operators are complying with the NRMM policy, an online register has been developed. This is used to register the individual sites and record NRMM details, such as the manufacturer, model number, emission standards, and engine size, as well as some activity data. The information provided feeds back into the London Atmospheric Emissions Inventory (LAEI) and gives a greater understanding of the real contribution of NRMM to emissions in London.

To support the NRMM regulations, the Mayor's Air Quality Fund (MAQF) is funding a number of NRMM enforcement officers who will be auditing sites across the London boroughs to ensure that they understand, and are compliant with, the policy requirements. In the future, the GLA may bring action against companies that fail to meet the requirements of their planning conditions - but it is still early days.

THE AFTER EFFECTS OF 'DIESELGATE'

Of course, after September 2015 and the ongoing saga of 'Dieselgate', the question should quite rightfully be asked as to whether you can actually reduce emissions by simply introducing and enforcing a policy that requires tighter machinery emission standards. As with on-road vehicles, so many other factors influence the emissions, such as duration of use, fuel quality, service and maintenance schedules, as well as the type of activity being undertaken. Therefore, will the newer engines continue to deliver an emission reduction under 'real world' conditions?

This question is being addressed by the London Low Emission Construction Partnership (LLECP), a project funded by the Mayor of London and Transport for London in collaboration with several central London boroughs. The LLECP, in partnership with Emission Analytics Limited, is conducting a study to characterise NRMM diesel emissions through the use of a portable emissions measurement system (PEMS), the same technique which exposed the disparity between laboratory and real-world driving emissions for diesel vehicles. Taking it into the construction sector is a relatively new and exciting development.

The initial phases of this work focused on measuring emissions from diesel generators as virtually every development in London initially runs on off-grid power. Unlike other plants on the site, the power supply is required constantly so the generators are often left running overnight, not only emitting particles, NO_X and hydrocarbons, but also creating noise pollution that impacts on local residents.

It is necessary to understand not only the emission concentrations being produced, but also how the NRMM is being used in terms of both duration and load. Fortunately, much of the modern machinery is fitted with sophisticated sensor and telemetric systems that allow remote access to profile emissions against activity, as well as accessing additional information such as fuel consumption, even when after exhaust system regeneration events take place.

WHAT DOES THE FUTURE HOLD FOR NRMM?

Looking to the future, from 1st January 2017, revised EU NRMM regulation legislation (see **Box 2**) relating to gaseous and particulate emission limits, replaces the existing Emissions Directive 97/68/EC which was implemented in the UK by the Non-Road Mobile Machinery (Emission of Gaseous and Particulate Pollutants) Regulations 1999. This new legislation sets out the 'Stage V' limits[3] which continue to limit particulate matter and gaseous emission; it also introduces a limit on the particle number concentration emitted and widens the scope of the NRMM to compression ignition engines with a power below 19 kW and above 560 kW. It is therefore hoped that when Stage V machinery becomes widely available for London we will see a significant benefit in emission reductions. However, these engines will not be manufactured until 2019; this is still a long way off, and ultimately the industry needs to move away from diesel dependency and start to invest in innovative and 'clean' technology.

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CASE STUDY

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ANALYSIS

Will backup generators be the next 'Dieselgate' for the UK?

Kieran Laxen discusses whether the impact of backup diesel generators on local air quality is being overlooked by the UK Government.

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Are diesel generators the new 'Dieselgate'? There are currently hundreds, maybe thousands of diesel generators that have been installed or have permission from local authorities to be installed across the UK. To date, no public official log or database of these has been collected. These generators serve two principal purposes:

1. to provide backup power, whether for emergency provision or for power contingency in data centres or the like; and

2. to provide additional power to the national grid when the demand exceeds the supply – these are called Short-Term Operation Reserve (STOR) facilities.

Both purposes are largely unregulated in terms of air quality.

The idea behind STOR facilities is to top off the available power in the national grid at peak times, when the current infrastructure cannot cope with the demand. This extra power needs to be on tap and available very quickly, so the default in the energy market has been to use diesel generators for their quick start-up attributes. There have also been generous financial subsides for STOR sites available from the UK Government through the energy Capacity Market auctions, which have effectively meant that STOR sites are seen as financially beneficial for investors, with guaranteed returns. However, currently there are no regulations on emissions from stationary diesel generators and most standard diesel generators are seen as 'dirty' in terms of pollutant emissions.

The air quality impact from the operation of diesel generators have often been overlooked during the planning process for a number of reasons, including a lack of awareness of the potential impacts. As a result, there are many STOR facilities and backup generators located around the country that are having unknown impacts on air quality. In the case of STOR facilities, these are often near to suburban residential areas and have the potential to be very polluting; and many more are planned. Many air quality practitioners and members of the wider community are aware of the issues surrounding emissions from diesel road vehicles, but they seem to be overlooking emissions from diesel generators; this could well be a mistake.

There are two elements to consider when assessing the air quality impacts of short-term operating plant (STORs are one type of such an operating plant): the impact on the long-term or annual mean concentration, and the impact on short-term concentrations, for example, the one-hour nitrogen dioxide (NO_2) objective.

Both the long-term and short-term concentrations can be compared with national air quality standards. NO_2 is the main pollutant of concern, and this has an annual mean threshold of 40 µg/m^3, and a short-term threshold of 200 µg/m^3, measured over a period of one hour, which is not to be exceeded for more than 18 hours in a year.

SHORT-TERM OPERATION

There are a large number of developments, particularly in urban areas, where emergency generators are installed as routine for life safety purposes, or backup generators are installed for power continuity. Typically diesel generators, these are rarely considered in terms of air quality impacts. This is because, given that emergencies are rare, it is often assumed that there will be no significant impacts. However, many manufacturers recommend that generators are operated for a minimum of 2-3 hours per month under their maintenance schedules which are designed to ensure the engines are well lubricated, clear of dirt and the fuel hasn't degraded. So even before power cuts, which may for example, only be for only 1-2 hours per year on average in London, there is an annual usage of 24-36 hours for typical backup generator plant. Alternatively, some Energy from Waste (EfW) facilities for example (and other facilities where backup power is crucial to the safe operation of the facility), require backup generators to be tested weekly, typically for up to an hour, which equates to a total of 52 hours of operation per year. Then there are STOR facilities, which are expected to operate for 250-300 hours per year on average. So for both backup power and national grid reserve power, the generators are expected to operate for a relatively small number of hours per year. However, given that the one hour NO_2 concentration threshold can only be exceeded 18 times per year, these short-term operating plant could still potentially cause significant impact on local air quality. The actual impact will depend on how dirty (or clean) the plant is, how close the emitted pollutants are to receptors, the sensitivity of the receptors themselves, and the meteorological conditions.

EMISSION RATES

The Environment Agency (EA) has recently carried out dispersion modelling and air quality impact analysis for diesel generators as part of the Department of Environment, Food and Rural Affairs' (Defra's) current consultation[1] on the Medium Combustion Plant Directive (MCPD). For this modelling, the EA calculated the emission rates set out in **Table 1**.

The mass emission rates (g/s) were calculated using two emission factors: 12 g/kWh$_e$ and 19 g/kWh$_e$, hence the range for each generator size. The EA considered these to be typical emission rates of unregulated diesel generators. Plant with a thermal rated input below 20 MW$_{th}$ are not regulated, so there is no control on emissions from these. At the top end of the emission range is a plant that has an output of 8 MW$_e$, which is typical of some of the larger STOR facilities. Such a facility, when operating at full capacity, would emit the same rate of NO_x as a vehicle driving on a 30-50 km stretch of the M25 motorway.

MW$_{th}$ input	1.25	2.5	5.5	16.25	20[b]
MW$_e$ output (assumed 40 per cent efficiency)	0.5	1	2.2	6.5	8[b]
NO_x emission rate (g/s)	1.7-2.6	3.3-5.3	7.2-11.4	21.6-34.2	26.7-42.2[b]
M25 equivalent (km) 157,498 vehicles, consisting of 9.7 per cent HDVs travelling at 100 kph[c]	2-3	3.8-6.1	8.3-13.1	24.9-39.4	30.8-48.6

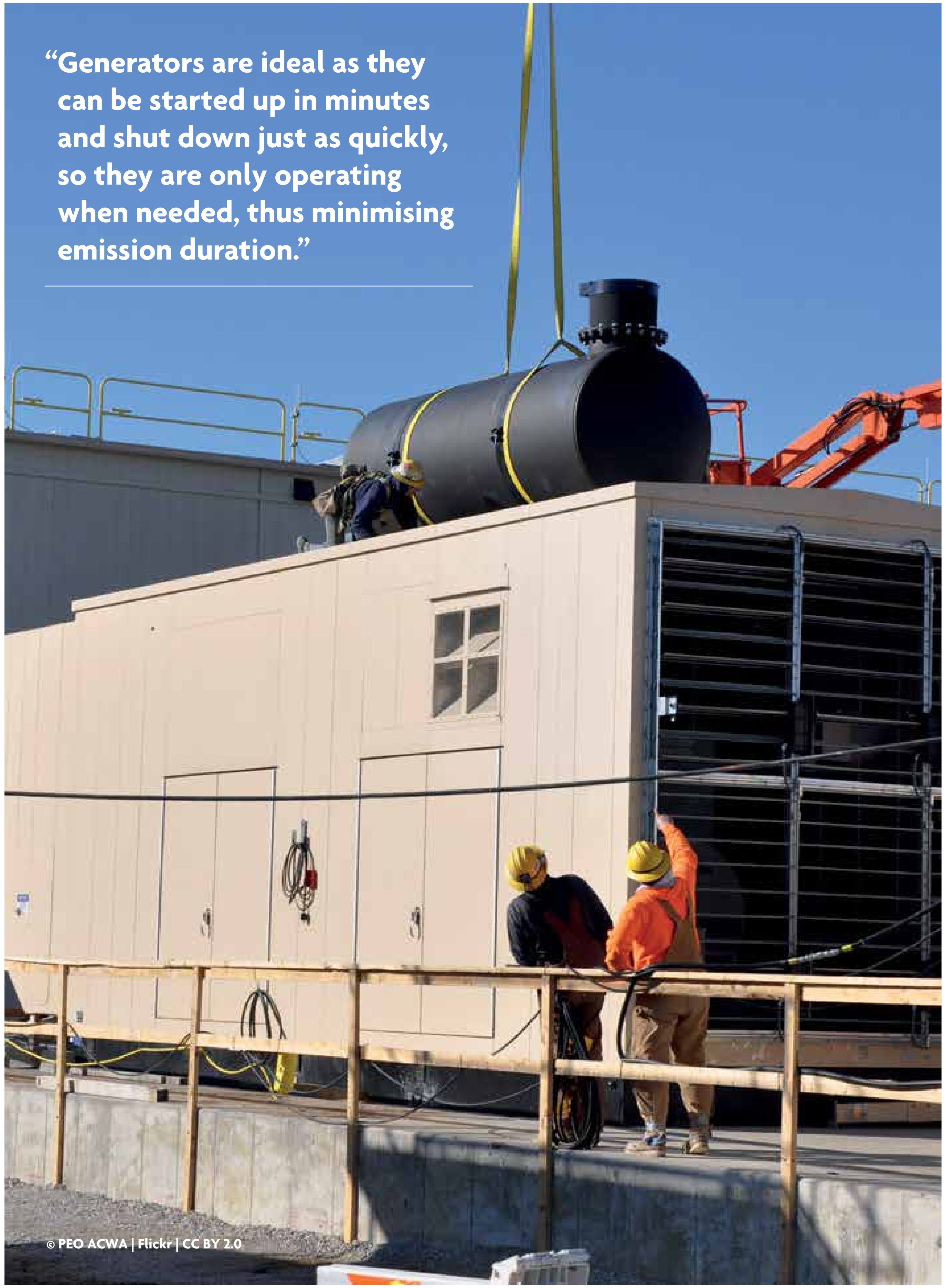
[a] Generator emissions taken from the EA report.
[b] Not provided within the report, however, it has been calculated following the same approach.
[c] Calculated by the author.
MW$_{th}$ = Megawatt thermal input
MW$_e$ = Megawatt electrical output
HDV = Heavy Duty Vehicles (Heavy Goods Vehicles + coaches and buses)

▲ **Table 1. Typical generator emissions of nitrogen oxides (NO_x) and equivalent lengths of the M25 motorway[a].**

LONG-TERM IMPACTS

Intuition would say that if a plant operates for only a few hours a year, then surely there is no long term impact when averaged over a year. As a consequence of this thinking, many air quality assessments of generators have simply concluded that the short-term operation of combustion plant will not have a significant impact on long-term mean pollutant concentrations because of the limited number of hours of operation per annum. This is assumed without any consideration of the generator emission rates or their proximity to sensitive receptors. Equally disturbing is that this simple statement has been accepted by many local authorities and even Defra, and many developments have been allowed to go ahead when perhaps they should not have been. Such a simplistic approach is not appropriate, as operating large diesel generator plant for a small number of hours can have significant adverse impacts on annual mean concentrations at nearby sensitive receptors, such as residential properties. Modelling carried out by Air Quality Consultants[2] has shown that generators operating for a small number of hours can give rise to an annual mean NO_2 contribution of several micrograms per cubic metre at sensitive nearby receptors. If the same change was predicted from road traffic then the conclusion could well be that the development is having a substantial adverse impact; however, because the pollution is from diesel generators it often seems not to be an issue. For instance, the consultation document published by Defra[3] within the last few months states that "*Generators with very high NO_x emissions can lead to exceedance of local hourly NO_2 limits but because they operate less than 500 hours/year their contribution to annual NO_2 concentrations is very small.*" Defra's definition of a "*very small*" is debatable. A bank of 10 generators operating on a single site, each with NO_x emission rates of say 4 g/s (giving a total of 40 g/s) and operating for 500 hours a year can easily result in annual mean concentration contribution of NO_2 of 4 µg/m^3. Given the annual mean threshold is 40 µg/m^3 and that the Institute of Air Quality Management (IAQM) and Environmental Protection UK (EPUK) planning guidance[4] considers a small impact to be 0.2-0.6 µg/m^3, it is surprising Defra is not worried about this. Obviously the total concentration is ultimately what is most important.

The IAQM/EPUK descriptors are based on both the magnitude of change and the sensitivity of the receptors, where the sensitivity is defined by the magnitude of the concentration at the receptor when the development



> "Generators are ideal as they can be started up in minutes and shut down just as quickly, so they are only operating when needed, thus minimising emission duration."

impact is included, relative to the air quality assessment limit. The matrix of descriptors within the IAQM/EPUK guidance suggests that, regardless of the total concentration, any change of 2.2-4.0 $\mu g/m^3$ is described as slight adverse and greater than 4.0 $\mu g/m^3$ is moderate adverse. This is significantly different to Defra's consideration of there being only a small impact.

Even when the annual mean impact is assessed, the total concentration is often simply calculated as the sum of the pollutant contribution from the generator plant, added to Defra's 'mapped' background concentration[5]. These maps are a publicly available database of average concentrations for a 1 km by 1 km grid across the whole of the country. These background concentrations do not necessarily represent "*the concentration of the substance that is already present in the environment*"[6]. For a roadside receptor or one affected by other emission sources, the concentration that is already present will include the effect of the emissions from these other sources. The baseline concentration at such receptors will therefore be higher than the background concentration. By adding the contribution from the generator to the background, the assessment will be underestimating the total concentration. You could, for example, have a total concentration at a receptor based on this simple approach of 30 $\mu g/m^3$ (26 $\mu g/m^3$ from the Defra 'mapped' backgrounds plus 4 $\mu g/m^3$ from the generators), which is significantly below the threshold of 40 $\mu g/m^3$. However, accounting for local sources, the baseline concentration could easily be much higher than the background concentration, say 30-36 $\mu g/m^3$ (or within an Air Quality Management Area [AQMA], above 40 $\mu g/m^3$). Taking into account the background concentration, local sources and the generator emissions, concentrations above the threshold could result. Air Quality Consultants is aware of many assessments that have not considered local road traffic sources, which, if correctly considered, may well not have passed through the planning system, and certainly not without mitigation.

It is important to note that the receptors nearest to the source may not be those worst affected, even if they are subject to the highest contribution from the generator. The question is why do air quality assessments frequently ignore an approach which is default for road traffic emission impacts, in favour of a black and white scenario, where, if the total concentration is below the threshold then the impact is considered to be insignificant without assessment of the magnitude of change and sensitivity of the receptor?

SHORT-TERM IMPACTS

The short-term threshold of 200 $\mu g/m^3$, measured over a period of one hour, is not to be exceeded for more than 18 hours in a year. This is often assessed by comparing the 99.78th percentile of one hour means (the 18 highest hours out of 8,760 hours in a year) to the threshold of 200 $\mu g/m^3$. Dispersion modelling is usually used to output a percentile concentration that represents the 'process' contribution, i.e. the contribution from the generator(s) only. The alternative of modelling hourly concentrations of the generator emissions, other local sources and background is not a practical option. The common practice is therefore to rely on a simplification to generate the total percentile concentration, whereby the process percentile concentration is added to twice the annual mean baseline concentration. As with the annual mean calculation, it is essential when doing this to take account of local sources when deriving the baseline and not to treat the Defra 'mapped' background as the baseline. For example, STOR developments typically operate between 16:00 and 19:00 when energy demand is high and as this is likely to coincide with the evening peak traffic flows, road traffic emissions should be included within the baseline concentration for receptors located near to roads. This is an aspect of short-term modelling that is rarely considered.

RESTRICTING OPERATIONAL HOURS

Practitioners and stakeholders involved in assessments of generator plant need to be aware that planned developments which include a short-term operating combustion plant (including backup power or national grid power provision) should have a limit applied to the maximum number of operating hours. This is particularly the case with the new STOR facilities, as without a limit on the operational hours, the plant could potentially be used continuously throughout the year if considered necessary. The limit should be based on the maximum number of operational hours used in the assessment, on the basis that this did not give rise to a significant impact. It is not just STOR facilities to which an operating limit should be applied, as there is already talk of the vast array of backup diesel generators within London being used to provide the extra power the national grid requires at peak times, and many of these generators will not have even had an initial air quality assessment.

WHAT INFLUENCE WILL THE MCPD HAVE?

The new EU MCPD limits are not yet in force. However, the MCPD must be transposed into UK law by December 2017. The emission limits for existing engines operating on diesel oil will be 190 mg/Nm^3 (normalised to 0 °C, 101.325 kPa, 15 per cent oxygen [O_2], dry). The emission limits will go some way towards preventing significant impacts, as they will require some form of emission control, but this will cost operators and developers significantly more in terms of control equipment. For investors in STOR facilities to see the expected returns on their investments, they will probably need to operate them for longer. Future energy demand is only going to go up, so the demand will be there, but with no operational limits there could be a big air quality issue which is not being properly considered. Also existing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plant (installed before 20th December 2018 or permitted before 19th December 2017) will not be required to comply with these new emission limits until 2024, so there could easily be several years of polluting plant impacting on suburban residential areas if the assessment has not been carried out correctly.

APPROPRIATELY SITED PLANT AND ALTERNATIVE FUELS

As previously mentioned, it is not just STOR sites that bring up these issues. Any generators, including generators in hospitals, as well as those for data centres and EfW plant which require guaranteed power, can have significant impacts especially given their frequent close proximity to sensitive receptors. For example, Air Quality Consultants is aware of an existing backup generator at a hospital, for which the generator emissions were pointing directly at the hospital's baby unit. Generators have their uses, but careful consideration should always be given to the siting of the plant, the location and direction of the release of the emissions, and to whether the fuel is diesel rather than cleaner natural gas.

ARE THEY ALL BAD?

It is appropriate to ask why diesel generators are a good option for our energy supply system. STOR facilities are being introduced to deal with the shortage of power at peak times. Generators are ideal as they can be started up in minutes and shut down just as quickly, so they are only operating when needed, thus minimising emission duration. They can also support green energy provision, as they can be used to provide input when solar and wind power generation is insufficient.

Generators clearly have an important role to play, but it is essential that the air quality impacts are assessed correctly. If significant impacts are identified then mitigation should be applied. The first mitigation measure to consider, certainly for STOR facilities, is to run the plant on gas rather than diesel, as this will lead to a substantial reduction in emissions. Air quality practitioners, together with local authority planners, should play a leading role in ensuring that these diesel generators do not become the next 'Dieselgate' scandal. ES

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A new Clean Air Act – what do we want?

Sarah Legge asks what major environmental organisations want from a new Clean Air Act to make it fit for purpose in modern times.

There have been many calls recently about the need for a new Clean Air Act (CAA), from a wide range of leading groups in the environment and public health fields. But are they all asking for the same thing? We asked them to outline why they thought it was important, what they considered to be priorities for new legislation, and their key concerns or opportunities for air quality legislation in light of the Brexit process. We therefore have contributions from the Institute of Air Quality Management, Clean Air Alliance UK and Environmental Protection UK, ClientEarth, the Royal College of Physicians, London Sustainability Exchange and Bright Blue for discussion within this article.

INSTITUTE OF AIR QUALITY MANAGEMENT[1]

The CAA was primarily designed for local authorities to control emissions from domestic and commercial coal burning. It does little to control air pollution from road traffic, the main source of air pollution in urban areas today, other than enabling fuel quality standards to be set in Regulation, or from decentralised energy plant and gas fired boilers.

The Act also does not address emerging issues, such as the emissions from power generation to meet peak demand for the national grid and to eliminate voltage fluctuations for data centres. The growing use of standby generators, installed for emergency use but used to provide electricity in period of peak demand, is a very recent concern. Therefore, a completely new Act is required to address these new air pollution sources.

It is also time for a new CAA to resolve the inconsistency over where the EU limit values and national air quality objectives apply. It is bizarre that there are two totally separate regimes, both aimed at reducing public exposure to poor air quality, but which come to different conclusions as to where there is an exceedance.

Part IV of the Environment Act 1995 (EA) should be replaced with consolidated Local Air Quality Management duties that combine the useful Local Authority powers from the CAA (such as controlling stack heights), the EA, and the EU Directive. In addition, the Secretary of State and the Devolved Administrations should be required to produce regular Air Quality Strategies (say five yearly). This should include a mandatory review of the air quality objectives based on up to date evidence of the health effects of key pollutants.

There may also be a need for a new duty on local authorities to ensure that air quality does not deteriorate. It may, however, be more appropriate to set a duty to reduce public exposure to air pollution, including vulnerable groups, such as children and older people, rather than focusing on pollution hotspots. The current government planning guidance provides little protection or direction, and strengthening this guidance may be more appropriate than including new duties in a CAA.

Brexit should not be used as an opportunity to water down any air quality legislation, including meeting the recently agreed obligations under the National Emissions

Ceiling Directive. In doing so there may be a need for a totally independent, statutory body to be established under a new CAA, similar to the Committee on Climate Change. Its purpose would be to advise national Government on air quality and report to Parliament annually on progress made in reducing public exposure.

EPUK AND CLEAN AIR ALLIANCE UK

The Clean Air Alliance UK (CAAUK)[2] was founded by Environmental Protection UK (EPUK)[3], and is a broad partnership of different interests, all with the common aim of improving air quality and working towards healthier air. It comprises of environmental interest groups, companies, public bodies and academic institutions.

The CAAUK and its founder have an additional take on the debate around a new CAA. While EPUK supports the need for a new CAA, especially in the light of Brexit, EPUK and the Alliance are also calling for more high level support and priority to successfully implement current and new legislation on the ground and deliver real health benefits to the public.

Many of the potential levers to improve air quality already exist, but are not used effectively because of split responsibilities between pollution sources and environmental health, both at local government level and national. Why aren't programmes which affect air quality, e.g. in energy efficiency, transport and ULEV, prioritised for areas with poor air? Air quality needs to be a priority for all bodies which influence it, and this needs high level political support.

The members of the Clean Air Alliance believe that the UK is currently at a tipping point where an acceleration of action on air quality is achievable and desirable, and could have major health, environmental, economic and business benefits. Our aim is to create a new momentum for the urgently needed action to tackle air pollution in our cities and countryside and to clean up the air we all breathe.

While the CAA and other air pollution legislation has been successful at reducing pollution from many sources and provides legal levers for others, it is no longer being implemented effectively. There are also new sources of pollution not covered by the current legislation, and the Brexit process is causing additional uncertainty. By pushing for better implementation, and increasing high level political support to ensure that clean air is a priority, the existing levers (and any new legislation) can be used far more effectively, to improve public health across the UK.

CLIENTEARTH[4]

The government has failed to get a grip with the invisible public health problem caused by

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air pollution that, according to latest estimates, results in the equivalent of 40,000 early deaths every year. Legal limits for nitrogen dioxide pollution, which were set in the late 1990s and that should have been met in 2010, are still being breached. Even in the case of particulate matter (PM) pollution, where legal limits are being met, we have a long way to go towards achieving much more stringent World Health Organisation (WHO) guideline levels.

Without the protection of EU laws, we would most likely revert to the ineffective 'rag-bag' of domestic laws which are, by the Government's own admission, not fit for purpose in their current form.

A new CAA is an opportunity to enshrine the right to breathe clean air in UK domestic law and set the ambition to meet safer WHO guideline levels. It would help drive action to tackle modern day sources and make the UK a world leader in clean technology and policy solutions.

A new CAA should preserve obligations currently enjoyed under EU law as a bare minimum, but also significantly improve on EU legislation. A new Act would:

1. Retain the objectives under the EU Ambient Air Quality Directive as a minimum safeguard on human health;

2. Adopt revised objectives based on WHO guidelines;

3. Guarantee the public the right to access the courts to enforce its provisions, in accordance with the Aarhus Convention –the procedure must be fast, affordable, allow for substantive review of air quality plans and policies, and provide effective judicial remedies, including fines;

4. Consolidate the complex and disparate body of domestic, EU and international air pollution laws into one coherent and effective piece of legislation;

5. Clarify the roles and responsibilities of national government, local authorities, the Mayor of London and the devolved administrations;

6. Lay down a national framework for effective Clean Air Zones (CAZ) which phase out diesel and accelerate the shift to zero emission transport;

7. Implement the UK's pollution reduction targets for 2020 and 2030 under the Gothenburg Protocol and the newly agreed EU National Emissions Ceiling (NEC) Directive, in order to tackle trans-boundary air pollution;

8. Ensure coherence with other relevant policies and legislation, particularly the Climate Change Act and planning guidance;

9. Require national, local and city authorities to collect adequate information on air pollution – including data from a minimum number of air quality monitoring stations – and proactively provide the public with that information, including smog warnings during high pollution episodes; and

10. Require national, local and city authorities to take measures to reduce exposure to air pollution – particularly for vulnerable groups, such as children, older people and those suffering from pre-existing health conditions.

Brexit has led to additional concerns for air quality legislation, and highlights the vital role of the current legislative framework governing air quality in enforcing the right to breathe clean air. In addition to developing and adopting a new CAA, it is vital to enforce the current legal obligations under the Air Quality Standards Regulations (AQSR), to ensure that the order of the High Court is complied with, and that a legally compliant air quality plan is adopted and measures included in it are put in place before 2019.

Another priority is to 'save' all air quality laws of EU origin. All relevant laws, including the AQSR, must be transferred to domestic legislation through the Repeal Bill. This would require that the Repeal Bill: transfers the directive and the AQSR into domestic law with no weakening amendments; provides that established EU case law applies in the interpretation and enforcement of these laws in the UK; provides for an alternative national equivalent of the European Commission for accountability and enforcement; and gives air quality laws the status of primary legislation so that any future changes to regulations such as the AQSR can only be made through primary legislation i.e. requiring full act of Parliament.

ROYAL COLLEGE OF PHYSICIANS

The intent of the proposed CAA is to provide local and national leaders with the tools and the public mandate to take immediate action on air pollution. The Royal College of Physicians (RCP)[5], along with many other health and environmental groups, will be asking the government to introduce a new CAA. This should aim to tackle the public health crisis of air pollution by consolidating all existing legislation, setting ambitious new emissions targets in line with WHO recommendations and laying out action to achieve those targets.

In particular, the Act should aim to:

- set a UK wide framework for CAZs in towns and cities to reduce emissions in the most polluted areas (including ships in dock, and airports centrally and regionally);

- introduce policies to disincentivise the use of diesel and incentivise low emission vehicles and active travel (e.g. walking and cycling, scrappage scheme for diesel vehicles, increased taxation on diesel fuel and other incentives);

- require local and national data collection on air pollution from a minimum number of air quality monitoring stations and publicly distribute this data through smog warnings and other methods;

- require national agencies and local authorities to reduce exposure to air pollution amongst vulnerable groups such as children, older people and those with pre-existing health conditions, through town and transport planning and the provision of health information; and

- align with the Climate Change Act to ensure joined up action.

OPINION

With regard to the challenges or opportunities posed by Brexit, the RCP believes that frameworks that underpin health protection must be replaced by equivalent or even stronger safeguards. The RCP has voiced particular concern to maintain strong EU air quality standards against pressure to weaken them. The EU has played a significant role in driving measures to control air pollutants and has provided a vital enforcement regime, allowing the UK to be held to account on meeting air quality targets. For example, the NEC Directive sets binding emission ceilings to be achieved by each member state and covers four air pollutants: sulphur dioxide, nitrogen oxides, non-methane volatile organic compounds and ammonia. Air pollution does not recognise national boundaries and given the important role that transboundary sources play in local air pollution, it is essential that the UK continues to work with the EU in responding to the challenges posed by air pollution.

LONDON SUSTAINABILITY EXCHANGE[6]

The great smog of 1952 led to the development of the 1956 CAA, which went on to save the lives of many people. Despite the uncertainty of Brexit, we see this as an exciting opportunity to bring in stronger and tighter air pollution standards, making the UK a


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leader in air quality legislation. The new CAA should take into consideration several aspects, such as the introduction of cleaner vehicles, whether by access restrictions or emission charges, and other effective measures, such as the introduction of CAZ. We want to find a consensus between all stakeholders to find solutions which will be mutually beneficial.

Opportunities that lie ahead for a new CAA:

- Establish air quality objectives that are compliant with the stronger WHO recommendations. Mandate local, city and national authorities to monitor pollution adequately.
- Regulate reliable tests for vehicle emission standards and test vehicles for other pollutants whilst they are on the road, using existent technology.
- Define effective interventions to tackle air pollution at local, city and national levels. Promote acceptance, understanding and confidence among the public opinion and coordinate actions.
- Introduce fiscal incentives to clean up polluting air, to phase out the most polluting vehicles and other sources of pollutants, and promote cleaner means of fuel and energy. Incentivise the adoption of sustainable transport infrastructure, such as cycling and walking.

▲ **Figure 1. Nelson's Column during the Great Smog of 1952. (© N T Stobbs | CC BY-SA 2.0)**

- Planning framework and guidance to include a duty to reduce pollution.
- Promote public information about pollution by text alert and other tools that help people to avoid pollution hotspots.

'Pollution busting' will require significant public engagement, to encourage attitudinal change, behavioural change and adaptation to minimise the health impacts of pollution.

BRIGHT BLUE[7]

The UK is currently failing to meet the legal limits for air pollution. Following a defeat at the High Court, the Government now has until April 2017 to produce a new draft plan. Supported by a range of organisations and the Chair of the Environment, Food and Rural Affairs Select Committee, Bright Blue has been campaigning for greater funding and powers to be devolved down to cities to enable them to set up their own low emission zones in pollution hotspots. This is urgently needed: our research has found that, last year, over 40 per cent of local authorities breached the legal limits. Yet, under the old plan, just five cities were mandated to set up CAZ.

Brexit creates the opportunity for the UK to be more ambitious on air quality. Forty thousand premature deaths per year are linked to air pollution. But this major public health problem will not be resolved solely by making the UK compliant with the EU limits; the WHO guidelines show these are not sufficient to prevent medical harm.

A new CAA should therefore enable local authorities to take bold action and be underpinned by the best scientific evidence for when pollution causes health problems. This approach would deliver multiple benefits for the UK. As well as improving public health and reducing costs for the NHS, it would provide a stimulus to the automotive sector. A strong air quality framework would incentivise owners of older, diesel vehicles to purchase new electric vehicles. Increasing domestic demand would help consolidate the UK's position as the largest market for electric vehicles in Europe. This would complement the forthcoming industrial strategy.

The first CAA in 1956 was passed by a Conservative Government. A new CAA would be an opportunity for this Conservative Government to demonstrate the UK's commitment to a stronger, healthier environment.

SUMMARY

There were clear areas of consensus around the need for legislation which reflected current sources of pollution, especially road transport and diesel, and new stationary sources of pollution, as well as continued protection for traditional industrial plants. Brexit is thought to pose a risk to environmental legislation, but it could also be seen as a potential opportunity to improve air quality laws, provided substantial safeguards are included, and key weaknesses to enforcement and the legal landscape are addressed. There was also a call by the Clean Air Alliance UK and Environmental Protection UK to consider how to make current and new legislation more effective, by identifying what more needs to be done, and who else needs to be involved, to ensure it has the high level political support and priority necessary to implement successfully on the ground and deliver real health benefits to the public.

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