A Breath of Fresh Air: A Holistic Approach to Reconcile Future Transport with Improved Air Quality

A Report on the Discussion Held at the TRL Academy Symposium in November 2016

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Foreword

Poor air quality poses a danger to public health as great as smoking and obesity. Medical research is revealing direct links between vehicle-generated pollutants and the triggering and exacerbation of respiratory, cardiac and neural conditions. Poor air quality could be contributing to thousands of early deaths every year in the United Kingdom, with a commensurate loss to the economy through lost days at work and increasing NHS expenditure.

Sources of the pollution in our atmosphere are both natural and anthropogenic, but we share our urban environments with increasing levels of road traffic, so it is in this sector that we can make a significant impact on the quality of the air we breathe.

The problem is current and we in the UK must take immediate, short term action to reduce pollutants but as the world’s urban population grows, we also need to be investigating longer term measures to reconcile transport demands with the need to sustain towns and cities as pleasant and healthy places in which we can live and work.

This white paper looks at the problem of poor air quality in our urban areas and the range of possible solutions that are currently being studied or trialled with the potential to reduce pollution levels. At TRL, we believe that the sheer scope of these approaches necessitates the involvement and cooperation of an equally wide range of key stakeholders in forging a holistic, multi-disciplinary approach to tackling the problem.

Professor Nick Reed
Director, TRL Academy
1. Introduction: The TRL Academy Symposium

1.1 The Aim
TRL (Transport Research Laboratory) is a global centre of excellence for research and innovation in surface transport. The TRL Academy is responsible for the strategy and coordination of scientific activities within TRL. Every year, the TRL Academy hosts a symposium to bring together a wide range of stakeholders from academia, public services and manufacturing to debate topical issues in a collaborative atmosphere. A mixture of presentations, debates and break-out periods are designed to stimulate discussion and develop visions for the future of transport.

The 2016 symposium, held at the headquarters of the Royal Society of Chemistry in London, was dedicated to the question of air quality, its impact on public health and how the transport sector can contribute to a cleaner and healthier future for our urban centres.

1.2 The Relevance
For more than a decade, the UK government incentivised vehicle drivers to switch to diesel as a more fuel-efficient alternative to petrol-fuelled vehicles. The revelation that Volkswagen attempted to circumvent US emission control tests for its diesel engines has cast into doubt the benefits of diesel and raised concern over the effects of that policy on our health.

The country’s own Supreme Court declared that air pollution limits for NO₂ were being exceeded in sixteen of the largest urban zones in the UK and planned improvements in air quality for London will not meet EU standards until 2025. This failure led to high profile legal action by the European Commission in 2014.

The question of air quality has not been so prominent in either the public or media consciousness for decades, so the time was right to hold this symposium to take stock of where we are and where we need to go.

1.3 The Audience
TRL undertakes research projects and trials with a wide range of research, legislative and industrial partners in the UK and beyond. We are able to use our extensive links in the transport sector and with leading universities to bring together these key stakeholders under one roof.

Speakers and guests at the 2016 symposium included representatives from the University of Cambridge, Imperial College London, King’s College, the vehicle manufacturing industry, Transport for London, the Department for Transport and the Department for the Environment, Food and Rural Affairs.
2. Poor Air Quality: The Scale of the Problem

Medical evidence is emerging to link transport-generated pollutants to serious health conditions. In 2015 the Committee on the Medical Effects of Air Pollutants (COMEAP), which advises the Chief Medical Officer of the Department of Health, reported that NO₂ had a directly adverse effect on health. The committee suggested that the gas cut short 23,500 lives each year in the UK.

It has been estimated that up to 30,000 premature deaths in the UK can be attributed to the effects of poor air quality (Public Health England, 2014). The Royal College of Physicians puts the figure closer to 40,000.

However, calculating attributable deaths is just the tip of the health crisis iceberg. How do we measure and value the effects of general poor health among the population associated with poor air quality? How much does the economy lose through increased instances of asthma attacks, self-medication, days lost from work or study, visits to the GP or increased hospital admissions?

"Around 90% of city dwellers in Europe are exposed to pollutants at concentrations higher than the air quality levels deemed harmful to health."

EEA report 2008

3. The Harm Pollutants Inflict on Human Health

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2 https://www.eea.europa.eu/themes/air/intro
3. The Harm Pollutants Inflict on Human Health

3.1 A Historical Overview

Ben Barratt of King’s College London and Rod Jones of the University of Cambridge cited the lethal effects of the smogs that once descended upon London until the first Clean Air Act was passed in 1956. It was estimated that the numbers of deaths from bronchitis rose nine-fold during the week-long “Great Smog” in December 1952, with significant increases in the number of deaths following the episode, particularly among children under the age of one and adults in the 45-64, 65-74 and 75+ age brackets (Bates, 1995). It was evident that there was a link between respiratory deaths and heavy smoke and smog, but once the Clean Air Acts removed the worst, and most visible, pollution from our air it seemed equally reasonable to assume that clearer air meant cleaner air in our urban centres.

However, transport trends over the intervening years, particularly an expansion of the number of diesel-fuelled vehicles on urban streets, have resulted in concentrations of pollutants such as NO$_2$ and particulate matter sufficient to cause alarm. The presence of these pollutants has been detected in the bloodstream, major or gans and even in unborn infants. The presence of these pollutants has been particularly an expansion of the number of diesel-fuelled vehicles on urban streets, have resulted in concentrations of pollutants such as NO$_2$ and particulate matter sufficient to cause alarm. The presence of these pollutants has been detected in the bloodstream, major or gans and even in unborn infants. Ultrafine PM has been detected in the brain, reproductive capabilities (Bates, 1995)

3.2 Particulate Matter

Particulate matter (PM) exists in solid or liquid form suspended in the air and is categorised by size; respirable particles have a diameter of less than 10µm and are known as PM$_{10}$. As their name suggests, these particles can be inhaled, penetrating deep into the lungs, and are linked to a range of respiratory and cardiovascular conditions.

Within this group of pollutants are also fine particles, with a diameter of less than 2.5 µm (PM$_{2.5}$) and ultrafine particles (PM$_{0.1}$) which are less than 0.1µm across. The finer the PM the more harmful it is considered to be because it remains in the atmosphere for longer and penetrates deeper into the body. Ultrafine PM has been detected in the brain, reproductive organs and in unborn infants.

A major source of PM$_{2.5}$, PM$_{10}$ and PM$_{0.1}$ is diesel combustion from road transport but tyre and brake wear and road surface abrasion can also generate PM$_{10}$. This is why Transport for London is delivering a package of local measures to reduce levels of PM$_{10}$ at a number of priority locations and hotspots within the capital.

Just a few hours of exposure to PM$_{10}$ levels over 35µg/m$^3$ causes irritation in the eyes, nose and throat, exacerbating breathing problems and triggering asthma attacks.

3.3 NO$_2$

Collectively known as NO$_x$, nitrogen monoxide (NO) and nitrogen dioxide (NO$_2$) are formed during fuel combustion. It has been difficult in the past to assess the direct effects of NO$_2$ because of its volatility and its nature as a precursor to some PM pollutants. However, evidence is emerging that exposure to NO$_2$ levels more than 200µg/m$^3$ irritates the eyes, nose and throat, causing breathing problems and asthma attacks among vulnerable people. NO$_2$ also increases the risk of other respiratory diseases and lung cancer.

3.4 Other Gases

A natural component of the air we breathe and typically at outdoor concentrations of up to 350 parts per million (ppm), Carbon dioxide (CO$_2$) is a direct product of fossil fuel combustion. Studies at the Harvard School of Public Health have shown that increases in CO$_2$ concentrations of more than 1200 ppm can reduce both cognitive and decision making capabilities (Allen et al, 2016). A greenhouse gas, CO$_2$ also contributes to increases in air temperature which may exacerbate the effects of pollution.

Asthma sufferers, children whose lungs are still developing, and the elderly are at risk from ozone, an irritant that causes muscles in the airways to constrict, trapping air in the lung’s alveoli. This leads to coughing, wheezing and shortness of breath it damages the airways, causing inflammation, an increased likelihood of infection and chronic obstructive pulmonary disease (COPD). It can also aggravate existing conditions such as bronchitis and emphysema.

A study of elderly residents in 10 Canadian cities found a link between ambient carbon monoxide levels and hospitalisations for congestive heart failure (Burnett et al, 1997). The same group also discovered that increases in ozone and sulphur dioxide corresponded to increases in daily hospitalisations for respiratory and cardiac diseases.

Low level PM$_{2.5}$ exposure over a few years can cause cardiovascular diseases such as strokes, heart attacks and the hardening of arteries. At higher concentrations, PM$_{2.5}$ exposure for just a few hours can bring on illness, strokes and heart attacks among vulnerable people. Ultrafine PM has also been associated with transient changes in heart rates and increases in plasma viscosity, contributing to thrombosis formation.

Magnetic mineral particles produced by vehicles engines and brakes, have also been found in brain tissue of Alzheimer’s disease sufferers.

“Physiological changes wrought by pollutant particles in the central nervous system have been linked to illnesses such as dementia.”

Notes:


4. How Much Does Transport Contribute to Pollution?

Pollutants in the air we breathe come from a multitude of sources. Industry, agriculture, all forms of transport, bonfires and domestic heating all contribute to pollution levels, while natural factors such as dust and sea salt may be exacerbating the problem.

Government policy promoting vehicles with low CO\textsubscript{2} emissions through road tax and company-car tax incentives has had an unfortunate effect – it has encouraged the use of diesel cars. These days, about half of all new cars are diesel. These can produce high emissions of NO\textsubscript{x} and particulate emissions, causing poor air quality in urban areas. In addition, diesel vehicles fitted with diesel particulate filters (DPFs) are not suited to slow, short journeys. They need periods of higher speeds to regenerate the filter (burn off the trapped carbon).

During the symposium Dr Iarla Kilbane-Dawe from the Office of the Chief Scientific Advisor at the Department for Transport (DfT) highlighted the role played by road and rail traffic in anthropogenic pollution, specifically resulting from fuel combustion (NO\textsubscript{x} and particulate matter) and brake, tyre and road wear (particulate matter).

This was also highlighted in the presentation given by Ricardo F Martinez-Botas from Imperial College. Ricardo included a review of the data from DfT’s diesel car emissions test programme (for which TRL performed the data analysis), showing that on-road NO\textsubscript{x} emissions were much higher on some vehicles than during the type approval test.

Transport for London (TfL), represented at the symposium by Glynn Barton, its Head of Road Space Management Outcomes Delivery, estimates that approximately 50% of NO\textsubscript{x} in Greater London is generated by general road traffic.
5. Current Approaches Towards Finding a Solution

Dealing with the effects of road transport on air quality is going to take a multi-agency approach. Central and local government, highways authorities and manufacturers all have a part to play, and public pressure is also playing an important role in applying pressure to those agencies.

5.1 Vehicle Technology

The power of market forces and the pressure of economic imperative are already driving the continued development of hybrid and electric vehicles. Initially treated as a curious experiment, the manufacturing sector now sees alternatively-fuelled vehicles as the inevitable successor to diesel and petrol driven vehicles, and the most promising and practical option for sustainable, motorised road transport in the future. As such, the efficiency, performance and desirability of hybrid and electric vehicles are steadily advancing.

5.2 Regulation

Regulation to limit pollutant emission has been successful in the past; the Clean Air Acts from the 1950s onward have led to a 97% reduction of PM in the atmosphere since the 1960s and ambient levels of particularly dangerous pollutants such as carbon monoxide, lead, sulphur dioxide and nitric acid have been cut to safe levels.

However, the revelation that VW attempted to cheat emissions testing based on the New European Driving Cycle testing regime has shaken public faith in current testing regimes and pollution measuring methods.

A reliance on laboratory-based testing is now being questioned, highlighting the importance of real-world, on-road trialling, and the EU is bringing in real driving emissions tests with on-road elements which herald a more realistic and practical approach towards emission control.

However, setting limits has its own limitations; NO₂ and PM levels, although much lower than 20 years ago, are still at harmful levels and the successive tightening of European and UK emission standards, which had previously made significant improvements to urban air quality, is seeing a diminished return.
Major urban centres must take radical legislative steps and adopt new approaches to achieve step changes in air quality.

The Mayor of London, working with TRL, plans to improve air quality in London by removing the most polluting vehicles from roads altogether, encouraging the use of ultra-low emission vehicles (ULEV), better traffic management and potentially deploying planning tools:

- An emissions surcharge within the congestion zone for vehicles that do not comply with emission standards.
- Bringing forward the implementation of an ultra-low emissions zone, with the possibility of extending it beyond central London.
- Age limits for taxis, removing dirtier, older vehicles from the road.
- Introducing a ULEV bus fleet that complies with stringent Euro Six emissions standards.
- Air quality audits for badly affected primary schools, which may lead to traffic control and planning measures.

Inducements from past governments have led to a tenfold increase in the number of diesel vehicles on the UK’s roads over the past decade. Now that the impact of that decision is being realised, a new policy may be required to remove the worst polluting vehicles while recognising the government’s responsibility towards diesel owners. There is speculation, encouraged by hints from the Prime Minister in April, that a scrappage scheme is being considered for diesel vehicles over ten years old which would compensate owners. A similar programme in France has proved successful.

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5.3 Monitoring

To understand the size of the problem and in order to assess the effectiveness of any solutions, then air quality monitoring needs to be in place. This could range from simple, cheap NOx/NO2 diffusion tubes to real time NOx and PM monitoring. Cheap, low precision devices could be used to check for any problems across an area. Once identified, more in-depth analysis can then be targeted to those areas.

For any scheme assessments, it’s important that sufficient base line data is collected before the scheme is implemented. Therefore this needs to be planned several months in advance of the scheme if there is no existing monitoring in place. It will then be possible to understand the influence and effectiveness of the applied strategy.

And to understand what is causing the problem, a detailed local fleet composition is needed. This can be derived through Automatic Number Plate Recognition (ANPR) studies together with DVLA data. Source apportionment can then be undertaken (together with dispersion modelling) to understand which vehicle categories need to be targeted.

6. Future Approaches
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There are generally three ways to reduce exhaust emissions and improve air quality:

1. Reduce vehicle activity – i.e. modal shift, reduce journeys (e.g. work from home); car share etc.
2. Use low emission vehicles – i.e. scrap old, polluting vehicles and replace with newer cleaner vehicles, ideally ULEVs.
3. Change the way in which vehicles are driven, through traffic management and/or driver training.

The key areas to drive the change towards cleaner transport and improve air quality:

- An increase in numbers of electric-powered vehicles on UK roads is likely to be the most noticeable and effective change towards a low-emission transport system that we will see. Electric vehicles make up 1% of current UK vehicle sales but, according to the Society of Motor Manufacturers and Traders, the number of electric vehicles registered in the UK has risen from fewer than 10,000 in the first quarter of 2014 to more than 90,000 in the same quarter of 2016. However, we are lagging behind the rest of Europe, where electric car sales make up a third of sales in some EU member states.

- Understanding this changing landscape and exploiting electrically-powered vehicle technology has become an increasingly important challenge for TRL, which has been pursuing a programme of research into ULEVs. Our goal has been to identify those technologies likely to provide the greatest benefits while understanding how the real-world use of these technologies may be affected by real-world conditions and user/consumer behaviour.

6.1 Technology

For drivers to be persuaded to switch to electric vehicles, a number of problems must be solved, not least the question of range and charging which will require investment in nationwide infrastructure, including service stations that will have to adapt for longer “refuelling” stops.

The UK’s power generation and distribution system will also have to be readyed for an increase in average demand as well as peak recharging periods. The Government-backed Go Ultra Low Campaign, which promotes electric vehicle use, predicts that half of new cars registered in the UK could be electric by 2027. More research is needed to forecast the growth in generating capacity required to keep up with demand, and to investigate likely charging habits of vehicle owners.

TRL, on behalf of Highways England, led a large consortium of international experts to determine the capabilities of DWPT technology, its possible applications and associated costs and benefits.

The study engaged a number of stakeholders, eliciting positive responses from the road haulage industry which can foresee potential fuel cost savings in a switch to electric HGVs. The study recommended a number of identified technologies to be trialled in the UK to understand better the performance, safety, road integration and grid connection issues before progressing to on-road trials.

Plug-in electric vehicles (PIVs) may prove to be an evolutionary dead-end as DWPT is developed. It could be possible to park vehicles overnight to top them up, or even to incorporate charging strips into lengths of road surface for drivers to manoeuvre onto and charge as they drive.

6.1.1 Electric Vehicle Charging

The number of electric vehicles registered in the UK has risen from fewer than 10,000 in the first quarter of 2014 to more than 90,000 in the same quarter of 2016.

6.1.2 Car Connect: Trialling the Impact of Plug-In Vehicles on the Electricity Grid

TRL is involved in the delivery of the pioneering Car Connect project, a trial by the power distribution industry to understand how vehicles can be charged at home, without the need for large-scale and expensive changes to the electricity grid. Set to be the largest project of its kind in the world, up to 700 drivers will be involved in the Car Connect trials.

TRL is overseeing technical and project management aspects of the study, on behalf of Western Power Distribution (WPD) which is based in Bristol.

The trials will run for three and a half years and allow WPD to develop an effective electricity network modelling tool to identify the impact of charging on the grid and to manage a mass-market customer trial to prove the technical and economic viability of PV demand control.

6.1.3 ZeEUS: Zero Emission Urban Bus System

TRL is leading the UK element of a Europe-wide trial to facilitate the introduction of electrically-powered buses by demonstrating a number of technological solutions in real-world conditions. Regular services will be run in Glasgow, in partnership with Alexander Dennis Ltd, and Strathclyde Partnership for Transport, and in London with TfL.

The buses being trialled in the UK will be the only demonstrators in the project using DWPT, allowing them to complete longer routes with higher frequencies compared to buses using other charging technologies.

We will analyse the results from Project ZeEUS to develop tools and guidelines for the vehicles’ widespread use.

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6.1.4 Advanced Monitoring

Traditional air quality monitoring relies on cheap, low precision diffusion tubes giving results for each two or four week period or expensive, bulky analysers typically giving 15 minute averages. There are a number of alternatives which include:

- Chemical cells which are relatively cheap and can give relatively fast responses. However, they are subject to cross sensitivity (e.g., the presence of ozone will affect the NOx response).
- Relatively low cost, portable particle counters can be used to map an area or provide personal exposure during a typical trip.
- Spectrometry can be used to detect various pollutants (CO, NO, NOx etc.) – both as a remote sensing device to determine tailpipe emissions from passing vehicles and also as a fast response roadside air quality monitor.

In addition to exhaust emissions, it is also important to consider non-exhaust particulate emissions – brake wear, tyre wear and road abrasion. With the latest emission regulations cleaning up the particulate emissions in exhaust, the non-exhaust particulate emissions are starting to become greater than the particulate emissions in the exhaust. However, there is very little data available on non-exhaust emissions compared to data on exhaust emissions. Monitoring needs to be put in place to develop a better understanding of non-exhaust emissions and also to be able to rank vehicles, with the possibility of future legislation limiting these emissions.

6.2 Traffic Management

6.2.2 Reduced traffic flows

Reducing the number of acceleration and deceleration events that occur will reduce the emissions from vehicles (both exhaust and non-exhaust), improving air quality. Interconnected traffic lights can be programmed to produce a green wave, allowing traffic through the network with little delay. In addition, it is possible to speed up an area, holding vehicles on the outskirts (where there are few people) to allow free-flow conditions in the town centre.

Speed enforcement through the use of speed cameras will reduce excess speeds, reducing emissions. However, isolated speed cameras might result in decelerations near the camera followed by accelerations after it. Average speed cameras should encourage steady speed along the entire section, though some drivers may need educating on what an average speed check means.

Traffic calming can improve safety on an urban or residential road, but can result in higher emissions (slowing down for a speed hump, followed by acceleration, fast acceleration through a chicane to get through before an approaching vehicle etc.). Therefore, traffic calming schemes that improve safety without being detrimental to air quality should be considered. These include schemes that effectively narrow the lane (physiologically through the use of road furniture and/or roadside parking or psychologically through the use of road markings) to reduce speeds without preventing their movement. Further research needs to be carried out in this area to determine the best schemes for both safety and air quality, especially as traffic calming might be used next to vulnerable people – outside schools, hospitals etc.

Traffic management covers both changing the fleet within an area and also affecting the way in which those vehicles are driven.

6.2.3 Networking

Closer interaction between connected vehicles and traffic lights has the potential to reduce congestion, by enabling junction control systems to predict lane demand and improve fuel efficiency, allowing vehicles to coast up to lights and pull away more smoothly. Although they represent small improvements for individual vehicles, the cumulative effect of millions of interactions per day could make a significant impact nationwide.

6.2.4 Inter-Vehicle Connectivity: HGV Platooning

In theory, running heavy vehicles in tightly integrated ‘platoons’ could improve road capacity and reduce congestion on inter-urban routes. Slipstreaming could also lead to significant efficiencies in fuel usage, with a resultant reduction in pollution.

The technology for platooning already exists, so TRL, in partnership with global engineering and environmental consultancy Ricardo, conducted a feasibility study for DfT in 2013-2014. We conducted a thorough technical review and held meetings with stakeholders to identify the key issues and risks. It was concluded that a trial of HGV platooning on public roads in the UK was the ideal way to measure potential benefits and identify challenges with this approach.

The resulting report detailed how a trial could be structured and identified the data that needed to be collected. It also provided technical roadmaps and outlined longer term issues over wider implementation and identified areas that required further analysis. The report provided DfT with clear guidance on how trials of this technology could be delivered.

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6.3 Societal Change

Another significant driver to improving air quality is to persuade the public and industry to reduce the use of polluting vehicles, reduce vehicle mileage and optimise the efficiency of their journeys through ride-sharing/consolidation of freight. This can be achieved by wielding the carrot and stick of regulatory measures, either by penalising adverse behaviours or incentivising positive behaviours, though achieving the right balance without causing undesirable and unexpected behavioural adaptations is challenging.

However, an educational approach may prove more effective, especially when equated with the rewards of reduced operating costs. Transport fleet operators, whether of buses or HGVs, have an important role to play ensuring and supporting best practice in driver behaviour while using available telematics and operating software to squeeze the maximum efficiency from their vehicle fleets.

Transport expectations for the future must also change; the road experience is likely to become less geared towards individual car ownership and solitary journeys and more about communal travel, vehicle-sharing, and central co-ordination of car use. This will very likely be facilitated by the use of automated vehicle services and mobility-as-a-service (MaaS) business models.

As urban centres grow, along with an ageing population less capable or willing to drive their own vehicles, more emphasis will also have to be placed on providing accessible, ultra-low emission public transport. Again, shared, automated, connected and electrically powered vehicles are expected to play a key role here.
6.3.1 Encouraging Active Travel

Not only do walking and cycling have obvious personal health benefits to the individual and contribute nothing to pollution levels, but active travel may also expose individuals to less pollution than sitting inside a vehicle. Work by Dr Barrett of King’s College, who addressed the symposium, indicates that vehicles provide no protection against pollution. In fact, passengers carrying individual air quality monitors were exposed to higher pollution levels as passengers than when walking or cycling beside a busy road.

TRL has been involved in a number of studies to investigate what motivates people to walk more and take up cycling, both for commuting and for short-distance journeys. These studies have included:

- A “manual for streets” to make residential roads more attractive for walkers and cyclists.
- Investigating cycling infrastructure, including a series of off-street trials for TfL.
- A study to assess the potential demand and enablers for cycling to railway stations.
- Packages of “smart travel” measures in London boroughs involving speed restrictions, better road crossings, cycle parking, signage for pedestrians and better marketing.
- Support for the European Commission’s FLOW project, to develop assessment tools allowing cities to evaluate the effects of walking and cycling measures on congestion.

6.3.2 Promoting Electrically-Assisted Bikes

The sale of electrically-assisted bikes (“pedelecs”) has increased 40% in seven years, although the UK is still an emerging market; sales in Europe reached 15 million in 2016.

Pedelecs give cyclists the option of choosing battery powered assistance when needed, such as on hills, or when travelling against wind resistance. This usually cuts out when the cyclist reaches a pre-determined speed limit. Although this is a compromise option in terms of exercise and emissions when compared to a traditional bicycle, pollution is insignificant when compared to motor travel. Pedelecs can also contribute to changing human behaviour by providing a healthier travel option to those who are less mobile because they are unfit or living with heart conditions or joint pain.

To test how consumers might react to, and use, pedelecs, the TRL Academy ran a trial, with 80 volunteers in Brighton who were loaned machines for six to eight weeks. The trial showed that three quarters of subjects used their bikes to ride 15-20 miles a week, with an average 20% reduction in car miles.

On completion of the trial, 70% of participants said they would be interested in using an electric bike in future. So far, the benefits of pedelecs are only theoretical, and real-world trialling still needs to be carried out on public roads before such technology can be fully exploited.

The trial was part of a project headed by the University of Brighton and funded by the UK Research Councils’ Digital Economy and Energy Programmes. The TRL Academy worked with other partner organisations including Raleigh, Bupa International, Brighton and Hove City Council and local bicycle shops.

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Conclusion
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The magnitude of the air quality problem in urban areas and the number of factors that influence it makes it highly unlikely that we will find a magic bullet to deal with the issue. Even while pursuing the most promising developments, such as electric cars, there are many different factors at play. Each factor has its own stakeholders who need to be coordinated or persuaded, not least the general public.

One of the chief concerns we have is how to ensure a coordinated approach in our search for ways to improve air quality. As we have discussed in this paper, a collective approach has developed which is making progress on many fronts in research and development.

However, with so many agencies involved, including national and local government, the academic community, vehicle manufacturers, road authorities, public transport operators, commercial fleet operators, and the general public, there is a risk that no one agency will take ownership of this problem to ensure time and resources are used as efficiently as possible.

The cumulative effect of numerous small improvements in technology, management and legislation will only come within a cross-agency, holistic framework. A strong, determined, but even-handed coordinator, most likely at national government level, is required to bring the different agencies together without necessarily backing a single champion solution because, as we have seen, this can lead to false starts and unintended consequences.

For this to happen, it is crucial, therefore, that there exists a source of independent, unbiased, evidence-based information taken from real-life environments on which to base decisions that will affect public behaviour, public services, the economy and the health of millions of people.

In the meantime TRL continues its work, bringing key stakeholders together and developing the necessary evidence base to inform decision makers on the most effective courses of action to win the biggest gains in the effort to improve air quality for the largest number of people.

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Through our innovation and development centre, the TRL Academy, we provide organisations with the evidence base needed to enable future innovation in transport.”