

## **Governing Urban Transformation**

**‘Are Low Emission Zones the route to cleaner air?’**

(Fuller, 2017)

**A report for Manchester City Council**

**12/05/17**

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## Author declaration

I 9459253 confirm that this report is based on my own work and that I am happy with both my own and my partner's 9474107 contribution to the final submitted version.

## Executive Summary

With an increasing number of deaths linked to air pollution, introducing Low Emission Zones (LEZ) offers a potential solution to reducing emissions. This report reviews the LEZ tool by assessing:

- potential barriers to implementation
- effectiveness in improving air quality
- how it might be introduced in Manchester

In the evaluation of LEZs, literature and policy documents are reviewed and an interview held with a Manchester City Council Policy Officer. Although LEZs are not unchallenged these zones can act as facilitators for change if not a perfect cure for air quality issues. Overall, LEZs in Europe have only led to modest air quality improvements but have been more successful in driving vehicle change. Despite London having the world's largest LEZ, it has not led to significant improvements in air quality. Air quality cannot improve without drastic action and considerable reduction in diesel vehicles. LEZs must have strict standards to ensure effectiveness as seen in Germany where many zones have led to improvements in public health and air quality. In Manchester city centre, urgent action is demanded to improve air quality. Geographically defined LEZs may not be as effective as in bigger cities such as London. Multiple zones may be necessary to prevent negative impacts of vehicles circumventing the LEZ. Private car use needs to be targeted but LEZs are better for facilitating an upgrade in vehicles rather than reducing numbers. LEZs may be controversial amongst the public due to the charging aspect, influence on daily life and exacerbate inequalities. The uncertainty of LEZs effectiveness creates challenges in gaining support from policy makers and the public but offers a way to potentially address these issues.

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## Introduction

The European Commission (EC) has issued the UK with a final warning after ‘persistent breaches’ of EU air quality limits (BBC, 2017). Air pollution significantly harms the environment, communities’ health and the economy (GMCA, 2017). In the UK, 40,000 premature deaths each year are linked to poor air quality (Roberts, 2016) which continues to worsen in cities. Low Emission Zones (LEZ) can be a vital tool to help authorities control emissions (Parliamentary, 2014). In this report, LEZs (also referred to as Clean Air Zones, CAZ) are defined as areas where most polluting vehicles, not meeting a minimum standard for emissions, are subject to either a charge for entering or a complete ban from the zone (Ellison et al., 2013; Holman et al., 2015). In the case of Manchester, they are considering an LEZ as part of their CAZ measures (TfGM and GMCA, 2016a).

This report has been produced to address the challenge set by Manchester City Council of improving air quality through the adoption of an LEZ. It will focus on reviewing the LEZ tool and assessing European case studies of how it works in practice. Among other examples, we will consider London’s approach as it faces the worst air pollution problems in the UK, and consequently the strategy they adopt is more advanced. The report will investigate the potential barriers to implementing the LEZ tool in Manchester and consider where the zone would be most appropriate. These aims will be explored through answering the following research questions:

- 1. What are the potential barriers to implementing an LEZ?**
- 2. How effective can the LEZ tool be in facilitating improvements in air quality?**
- 3. How might an LEZ be implemented in Manchester?**

## Context: LEZs and air quality in Europe

As many European cities are exceeding the EC air quality standards for PM<sub>10</sub> and NO<sub>2</sub>, LEZs have been introduced to meet the limit values (Cyrus et al., 2014). There are approximately 200 in operation in Europe (Fuller, 2017) with Stockholm implementing the first in 1996 (Holman et al., 2015). Whilst some countries, such as Sweden and Germany, have national frameworks for LEZs (ECORYS, 2014), others have municipalities which set their own criteria. This approach enables local air quality issues to be more specifically targeted (Holman et al., 2015). Ezeah et al. (2015) argue that LEZs in Europe have been effective in accelerating the switch to cleaner vehicles but show only a modest improvement in air quality. The effectiveness of LEZs in decreasing traffic-related exposures is heavily debated with particular regard to cost-benefit ratio (Morfeld et al., 2014).

Germany implemented a national LEZ framework in 2007 (Holman et al., 2015) and by 2014 it was operational in 78 cities (Wolff, 2014b). Despite concentrations of annual mean PM<sub>10</sub> and NO<sub>2</sub> having reduced in many German cities due to the zones, some have not experienced significant improvements (Holman et al., 2015). The effectiveness of German LEZs have been enhanced by the government's national scrappage scheme (Cyrus et al., 2014) and the provision of subsidies for vehicle filter retrofitting (CA and SFfC,nd). Studies have revealed that in some German LEZs, there is a correlation between the reduction in PM<sub>10</sub> and the reduction in mortality rates (Ezeah et al., 2015). These zones restrict cars, particularly diesel, and heavy goods vehicles (HGVs) which may explain why more air quality improvements have occurred than in other countries (Holman et al., 2015).

A study conducted into the implementation of two LEZs in Rome, concluded that this policy was effective in reducing traffic-related air pollution, however, well-off residents gained the greatest health improvements (Cesaroni et al., 2012). In contrast, LEZ research in Lisbon revealed no linked improvements in air quality (Ferreira et al., 2012). The limitations of LEZs was also highlighted by Boogard et al. (2012) who investigated LEZs in five Dutch cities and showed that traffic-related air pollution did not significantly decrease. The lack of effectiveness is reportedly due to the zones only banning the oldest lorries and applying to small areas within cities (Fuller, 2017).

In December, 2015, DEFRA announced that five English cities would receive funding to implement CAZs, by 2020, as part of their air quality action plan (Holder, 2016). Although LEZs have been in operation in London since 2008, few others have been introduced in the UK (Parliamentary, 2014). In Oxford, Brighton and Norwich LEZs have been implemented only for the purpose of ensuring cleaner

buses (DEFRA, 2015). However, DEFRA's plans did not comply with EU Directives and therefore new ones were required (TfGM and GMCA, 2016a). The Government appealed against this requirement due to the upcoming general election, but this was rejected and the new draft plans, criticised as 'woefully inadequate', have now been published (Carrington, 2017; DEFRA and DfT, 2017).

London has the world's most expansive LEZ which monitors compliance using cameras (Holman et al., 2015). Despite the LEZ covering a large area, minimal reductions in PM<sub>10</sub> and NO<sub>2</sub> emissions have occurred (Morfeld et al., 2014). Holman et al. (2015) stress that banning all vehicles pre-dating the year 2000 would increase the LEZ's effectiveness. However, restrictions on cars may be too challenging with many motorists being adversely affected. This could disproportionately impact any benefits.

Greater Manchester annually exceeds NO<sub>2</sub> limits so is branded one of the UK's 38 non-compliant zones (TfGM and GMCA, 2016a). Here, road transport is responsible for 79% of particulate emissions and 65% of nitrogen oxides (GMCA, 2017) with the congestion estimated to cost £1.3 billion per year (GMSF, 2016). Despite plans to improve air quality, Manchester is not predicted to meet EU limits until 2020 (TfGM and GMCA, 2016b). Therefore, without additional action, poor air quality will continue to present serious economic, environmental and health challenges (Holder, 2016).

## Methodology

First a literature review consolidated where LEZs have been implemented. Case studies were chosen to draw comparisons and reveal potential barriers to introducing LEZs. Reviewing the literature and policy documents, best practice was sought; where this tool has worked most effectively and to see what Manchester can learn.

Primary data was collected using a semi-structured interview with Manchester City Council's Policy Officer, Andrew Parkin, involved in the LEZ project. Given that no results of research on Manchester's potential LEZ plans have been published yet, the interview provided insight into general issues and barriers to consider before implementing an LEZ:

- spatial scope
- vehicle types
- charge levels
- operational costs
- direct/indirect economic and environmental costs/benefits
- monitoring arrangements

## Key findings: implementing LEZs in Manchester

There are many challenges when introducing an LEZ. Consequently, feasibility studies play a crucial role in considering whether it is a viable solution to deal with air pollution. To this end, Manchester is currently investigating the potential impacts of introducing an LEZ (TfGM and GMCA, 2016b).

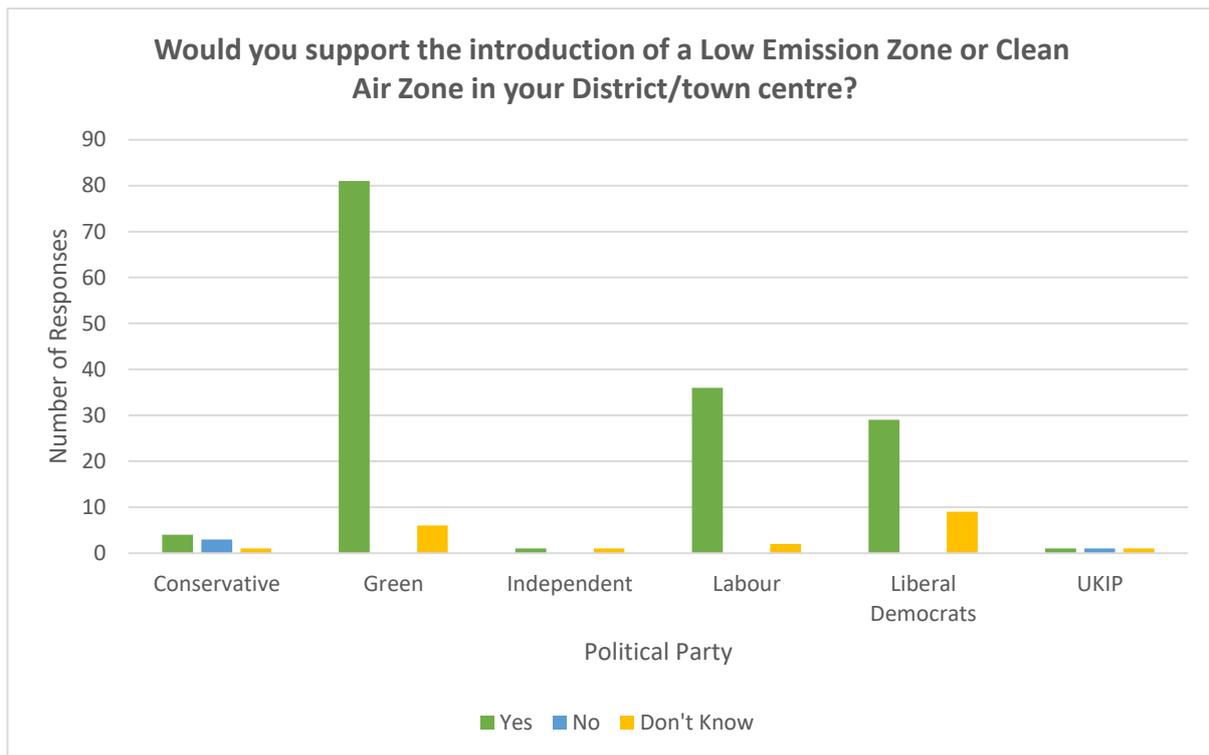
### 1. What are the potential barriers to implementing an LEZ?

A balance needs to be achieved between charging enough so that people change their behaviour whilst not adversely impacting those who regularly travel through the zone (Andrew). Lower-income groups are more likely to own older, more polluting vehicles and should not be disproportionately disadvantaged (Parliamentary, 2014).

The introduction of an LEZ also impacts the economy. Research in Germany found that businesses blamed LEZs for causing a decline in their sales (Ezeah et al., 2015). The estimated cost of setting up London's LEZ was nearly £10 million, with a yearly maintenance cost of £7 million (Ezeah et al., 2015). The improvement in air quality needs to justify the cost of implementing and operating the LEZ: London found that it is a net cost rather than a revenue-raiser (Parliamentary, 2014). However, according to Carrington (2017), increasing the number of planned CAZs from six to 27, would provide cost benefits of over £1 billion in the UK.

Enforcing an LEZ can be challenging. Whilst monitoring buses can be achieved through regulation or partnership working, monitoring cars involves the operational costs of cameras (Andrew). Controlling LEZs compliance is essential in ensuring that measures are effective (CA and SFFC,nd).

Ferreira et al. (2012) emphasise that emission reduction policies, such as LEZs, can be controversial as they could negatively impact resident's daily behaviours. Therefore, it is crucial to understand the public's opinion prior to implementation (ECORYS, 2014). Acceptability, perceived fairness and effectiveness are important determinants of future behavioural adaptations (Tretvik et al., 2014).



**Figure 1:** Graph showing support for the Manchester LEZ/CAZ, source: Adapted from FoEM, 2016

In 2008, Manchester tried to introduce the congestion charge, however, 79% of voters in a referendum rejected it (Sturcke, 2008), emphasising the need to provide evidence of how the LEZ can improve air quality and public health. Despite Manchester Friends of the Earth (FoE) supporting the LEZ proposals, they wanted even stricter approaches such as banning HGVs from centres. A local election survey discovered that the majority, from each political party, were in support of a potential LEZ (see Figure 1) (FoEM, 2016). However, this was not representative due to small number of responses.

Some argue that Manchester's LEZ plans are a 'congestion charge by another name which will make the air worse.' Furthermore, ensuring cleaner buses through regulations and a scrappage scheme may be more effective (Cox, 2017). Manchester's new mayor has played no part in the LEZ plans and rejects the idea of congestion charges for Manchester (Holland, 2017). This could further complicate the implementation of any charging LEZs.

## **2. How effective can the LEZ tool be in facilitating improvements in air quality?**

A recent study into London's LEZ revealed that it has not led to significant health benefits (O'Sullivan, 2015). Furthermore, they argue that merely restricting access for polluting vehicles is not enough to guarantee significant improvements in air quality (ibid).

In the past, government incentives have encouraged the purchase of diesel over petrol vehicles. However, increasingly these are recognised as main sources of air pollution in cities (Parliamentary, 2014). The Director of Clean Air (London) emphasised that traffic-related pollution cannot be reduced unless 'we get rid of diesel' (O'Sullivan, 2015). London's LEZ has increased the replacement rate for older vehicles (Ellison et al., 2013), but London is still breaching legal limits (TfL, 2015). From September 2020, an Ultra Low Emission Zone (ULEZ) will be introduced setting new emissions standards and daily non-compliance charges for all vehicles driving in central London (TfL, 2015). However, plans for charges to be levied on diesel vehicles are criticised, whilst others demand an outright ban on polluting vehicles (Parliamentary, 2014). Cities must learn from London's mistakes to address their own pollution problems (O'Sullivan, 2015). Paris has recently implemented an LEZ where vehicles over 3.5 tons are banned from entering the city between certain times and is proposing to eradicate all diesel vehicles by 2020. If successful, it will show that vehicle bans are more effective than fines and controls (ibid).

If the LEZ is going to be an effective tool for improving air quality 'you almost have to ratchet up what the levels are' as currently there are so few non-compliant vehicles (Andrew). Ellison et al. (2013) reiterate that emissions standards must regularly be updated. However, requirements that are too stringent may hinder political support by potentially prohibiting vehicles which are essential in maintaining local economies (Parliamentary, 2014).

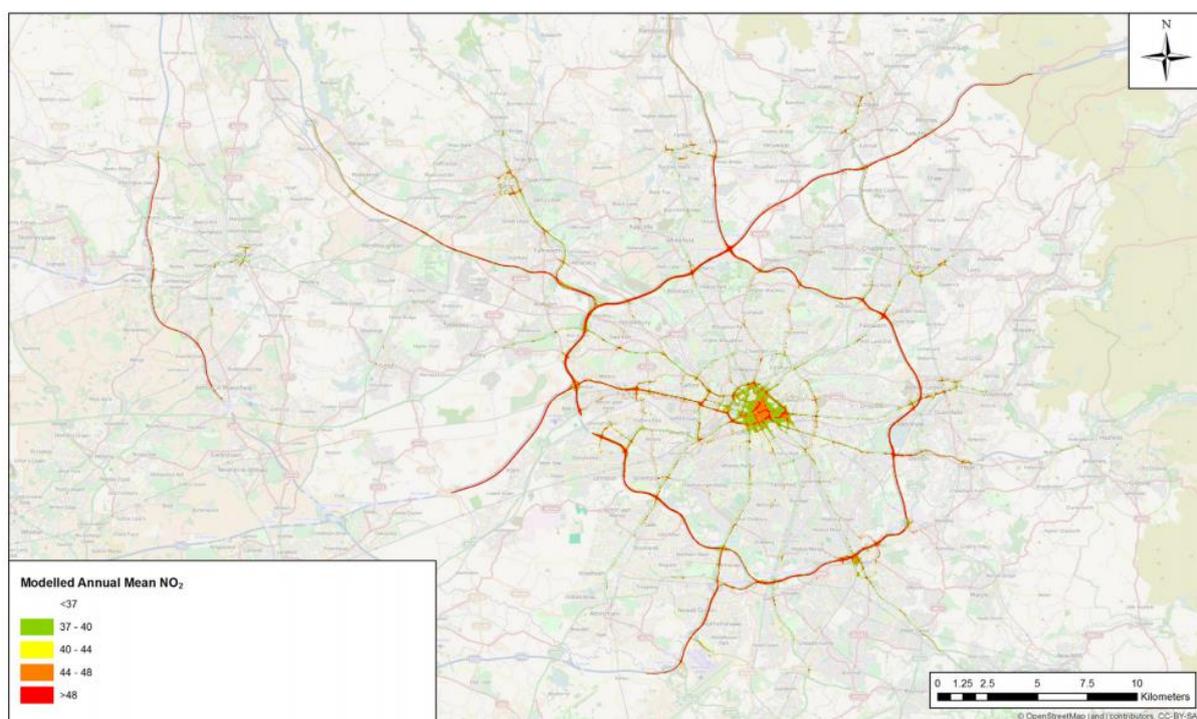
While LEZs have many advantages, alone they are unlikely to tackle air quality. Instead, they function as facilitators of change (CA and SffC,nd). Consequently, further action is needed, such as additional supplementary 'softer behavioural change' measures for example, encouraging more-efficient driving styles and promoting travelling at different times (MVA, 2013).

DEFRA's (2015) initial plans set out to provide a national framework for CAZs to ensure consistency between cities. This bottom-up localism approach provides local authorities with a toolkit for the development of LEZs (Parliamentary, 2014). This could help reduce the cost of implementing these zones and reduce the risk of heavily polluting vehicles being redeployed elsewhere (Parliamentary,

2014). The 'one size fits all' approach is criticised as each place is different (FoEM, 2016). A national framework needs to allow individual authorities to maintain a locally relevant balance in tackling air quality and protecting businesses (Parliamentary, 2014). However, the new plans do not specify cities/towns where polluting vehicles may face charges (Carrington, 2017).

Uncertainty about the effectiveness of LEZs presents challenges when making decisions among policy options and gaining support from the public and policy makers (Wolff, 2014a).

### 3. How might an LEZ be implemented in Manchester?



**Figure 2:** Greater Manchester's annual mean NO<sub>2</sub> concentrations, source: TfGM and GMCA, 2016a

The concentration of economic activity in Manchester's centre creates a major source of transport emissions. With increasing number of people expected to live in this area, more will be exposed to poor air quality (TfGM and GMCA, 2016c). The centre requires drastic action to improve air quality (Figure 2 showing its high NO<sub>2</sub> levels) but 'if you focus on the centre it might also have a bearing on other areas' (Andrew). Therefore, the presence of multiple LEZs rather than one central one may be more effective.

Consideration must also be given to the size of the LEZ, if too small it may not be as effective (CA and SFFC,nd). Areas surrounding London's LEZ have experienced an annual increase of PM<sub>10</sub> by an

average of 1.9% (Ezeah et al., 2015). Feasibility studies into the introduction of LEZs in Newcastle and Sheffield concluded that the costs of implementing geographically defined, enforced zones would offset the potential benefits (MVA, 2013).

Private cars need to be rapidly updated to cleaner vehicles to help achieve Manchester's 2020 target (TfGM and GMCA, 2016b). Manchester FoE argue that the Low Emission strategy in place is not tackling single-occupancy private car use for journeys within the city. Without measures to reduce this, legal air pollution limits will not be reached (FoEM, 2016). Furthermore, the switch to electric vehicles will not tackle congestion and potentially allows the public to continue with 'business as usual' (ibid).

In Greater Manchester every individual has a responsibility in tackling air pollution and therefore the population should be sufficiently educated to encourage this behaviour (FoEM, 2016). If the government creates a national policy, there will be an even greater willingness for people to accept it (Andrew). However, in Germany the national LEZ framework is controversial with a 2009 survey revealing that over 91% disapproved of LEZs, considering them too bureaucratic (Wolff, 2014b). Social equity issues must also be considered (ECORYS, 2014). To address unequal socio-economic impacts, Germany successfully provided financial assistance to those who need help updating their vehicles (ECORYS, 2014). They also allow exemptions on an individual case-by-case basis to try and deliver LEZs in a socially sensitive way (CA, 2014).

LEZs could specify vehicle types and standards to be achieved so vehicle selection could be responsive to traffic fleet analysis in each city (ECORYS, 2014). To allow citizens enough time to adjust, the LEZ needs to be phased in using a step-by-step approach. However, the stricter the standards the more likely the desired improvements will be achieved (CA and SFfC,nd). Furthermore, the Government needs to provide resources to facilitate the introduction of an effective CAZ in high air pollution areas (FoEM, 2016).

Finally, it is important to recognise that there is no universally agreed approach to building a successful LEZ (Fröhlich, 2014).

## Conclusion

The effectiveness of LEZs is debatable which makes it more difficult to show the importance of introducing them. However, drastic action needs to be taken. Existing evidence suggests that LEZs are more effective in changing the type of vehicle rather than reducing the number (UMS,nd). Germany successfully shows that it is vital to be strict but other initiatives have supplemented the LEZs effectiveness. In contrast, London shows that the absence of sufficiently stringent standards leads to little improvement. Feasibility studies and locally responsive developments are essential as different areas face different challenges. The effectiveness of the ULEZ will need to be monitored to further show the urgency for stricter enforcements and controls. Ultimately, diesel vehicles need to be phased out or there will be limited air quality improvements.

Manchester's LEZ plans are controversial and to minimise disproportionate disadvantages should be:

- Affordable and cost-effective
- Enforceable
- Effectively targeting highest polluting vehicles
- Deliverable in terms of ensuring public and political acceptability  
(MVA, 2013)

It would be advantageous to have a national LEZ framework. Germany's success is worthy of real investigation, particularly how to implement LEZs in a more socially sensitive way. This could prevent exacerbating social inequalities but would require extra funding. While the difficulties cannot be understated, LEZs offer a way forward from the present unacceptable situation facing the people of Manchester.

## References

BBC. (2017) *How can the UK reduce air pollution?* Available at: <http://www.bbc.co.uk/news/uk-38990192> (Accessed: 1/5/2017).

Boogaard, H., Janssen, N., Fischer, P., Kos, G., Weijers, E., Cassee, F., van der Zee, S., de Hartog, J., Meliefste, K., Wang, M. and Brunekreef, B. (2012) 'Impact of low emission zones and local traffic policies on ambient air pollution concentrations', *Science of the total environment*, 435, pp.132-140.

Carrington, D. (2017) *UK's new air pollution plan dismissed as 'weak' and 'woefully inadequate.'* Available at: <https://www.theguardian.com/environment/2017/may/05/government-fails-to-commit-to-diesel-scrappage-scheme-in-uk-clean-air-plan> (Accessed: 5/5/2017).

Cesaroni, G., Boogaard, H., Jonkers, S., Porta, D., Badaloni, C., Cattani, G., Forastiere, F. and Hoek, G. (2012) 'Health benefits of traffic-related air pollution reduction in different socioeconomic groups: the effect of low-emission zoning in Rome', *Occupational and environmental medicine*, 69(2), pp.133-139.

Clean Air (CA) and Soot Free for the Climate (SFfC). (nd) *Guideline: Low Emission Zones*. Available at: <http://sootfreecities.eu/download/best-practice/low-emission-zones.pdf> (Accessed: 4/5/2017).

Clean Air (CA). (2014) *LOW Emission Zones: Immediate Aid Paper for Municipalities*. Available at: [http://www.cleanair-europe.org/fileadmin/user\\_upload/redaktion/downloads/VCD/VCD\\_UWZ\\_soforthilfepapier\\_einzels-eiten\\_ENG\\_ONLINE.pdf](http://www.cleanair-europe.org/fileadmin/user_upload/redaktion/downloads/VCD/VCD_UWZ_soforthilfepapier_einzels-eiten_ENG_ONLINE.pdf) (Accessed: 4/5/2017).

Cox, C. (2017) *Proposed clean air plan slammed as 'congestion charge by another name.'* Available at: <http://www.manchestereveningnews.co.uk/news/greater-manchester-news/proposed-clean-air-plan-slammed-13010391> (Accessed: 9/5/2017).

Cyrys, J., Peters, A., Soentgen, J. and Wichmann, H. (2014) 'Low emission zones reduce PM10 mass concentrations and diesel soot in German cities', *Journal of the Air & Waste Management Association*, 64(4), pp.481-487.

Department for Environment Food & Rural Affairs (DEFRA). (2015) *Improving air quality in the UK Tackling nitrogen dioxide in our towns and cities: UK overview document*. Available at: [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/486636/aq-plan-2015-overview-document.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/486636/aq-plan-2015-overview-document.pdf) (Accessed: 25/4/2017).

Department for Environment Food & Rural Affairs (DEFRA) and Department for Transport (DfT). (2017) *Clean Air Zone Framework Principles for setting up Clean Air Zones in England*. Available at: [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/612592/clean-air-zone-framework.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/612592/clean-air-zone-framework.pdf) (Accessed: 11/5/2017).

ECORYS. (2014) 'FEASIBILITY STUDY: EUROPEAN CITY PASS FOR LOW EMISSION ZONES', urban access regulations. Available at: [http://urbanaccessregulations.eu/clars-members/images/stories/pdf\\_files/LEZ\\_Final\\_Report\\_Standards\\_and\\_Guidance\\_submitted.pdf](http://urbanaccessregulations.eu/clars-members/images/stories/pdf_files/LEZ_Final_Report_Standards_and_Guidance_submitted.pdf)

Ellison, R., Greaves, S. and Hensher, D. (2013) 'Five years of London's low emission zone: Effects on vehicle fleet composition and air quality', *Transportation Research Part D: Transport and Environment*, 23, pp.25-33.

Ezeah, C., Finney, K. and Nnajide, C. (2015) 'A Critical Review Of The Effectiveness Of Low Emission Zones (LEZ) As A Strategy For The Management Of Air Quality In Major European Cities', *Journal of Multidisciplinary Engineering Science and Technology*, 2(7), pp.1860-1868.

Ferreira, F., Gomes, P., Carvalho, A., Tente, H., Monjardino, J., Brás, H. and Pereira, P. (2012) 'Evaluation of the implementation of a low emission zone in lisbon', *Journal of Environmental Protection*, 3(09), p.1188.

Friends of the Earth Manchester (FoEM). (2016) *Response to Low-emission Strategy and Air Quality Action Plan*. Available at: <http://www.manchesterfoe.org.uk/wp-content/uploads/2016/04/Manchester-Friends-of-the-Earth-response-to-the-GM-Low-Emissions-Strategy-and-Air-Quality-Action-Plan-consultation-28th-April-2016-Final.pdf> (Accessed: 25/4/2017).

Fröhlich, M. (2014) *Low emission Zones (Umweltzone) in Germany*. Available at: <http://www.eltis.org/discover/case-studies/low-emission-zones-umweltzone-germany> (Accessed: 9/5/2017).

Fuller, G. (2017) *Are low emission zones the route to cleaner air?* Available at: <https://www.theguardian.com/environment/2017/may/07/air-pollution-low-emission-zones-pollutionwatch> (Accessed: 8/5/17).

Greater Manchester Combined Authority (GMCA). (2017) *GREATER MANCHESTER LOW-EMISSION STRATEGY AND AIR QUALITY ACTION PLAN*. Available at: [https://www.greatermanchester-ca.gov.uk/homepage/131/greater\\_manchester\\_low-emission\\_strategy\\_and\\_air\\_quality\\_action\\_plan](https://www.greatermanchester-ca.gov.uk/homepage/131/greater_manchester_low-emission_strategy_and_air_quality_action_plan) (Accessed: 29/4/2017).

Greater Manchester Combined Authority (GMCA). (2017) *GREATER MANCHESTER LOW-EMISSION STRATEGY AND AIR QUALITY ACTION PLAN*. Available at: [https://www.greatermanchester-ca.gov.uk/homepage/131/greater\\_manchester\\_low-emission\\_strategy\\_and\\_air\\_quality\\_action\\_plan](https://www.greatermanchester-ca.gov.uk/homepage/131/greater_manchester_low-emission_strategy_and_air_quality_action_plan) (Accessed: 29/4/2017).

Greater Manchester Spatial Framework (GMSF). (2016) *Draft GMSF October 2016 Consultation: Accessibility*. Available at: <http://gmsf-consult.objective.co.uk/portal/2016consultation/gmsfoct16?pointId=s1476450796172#section-s1476450796172> (Accessed: 5/5/2017).

Holland, D. (2017) *Clean air charge on St Peter's Way, Bolton, would be 'crazy idea', says council environmental chief Nick Peel*. Available at: [http://www.burytimes.co.uk/news/15275040.Clean\\_air\\_charge\\_on\\_major\\_road\\_would\\_be\\_\\_\\_39\\_crazy\\_idea\\_\\_\\_39\\_/](http://www.burytimes.co.uk/news/15275040.Clean_air_charge_on_major_road_would_be___39_crazy_idea___39_/) (Accessed: 10/5/2017).

Holder, M. (2016) *Manchester air quality and emissions strategy launched*. Available at: <http://www.airqualitynews.com/2016/03/04/manchester-air-quality-and-emissions-strategy-launched/> (Accessed: 26/4/2017).

Holman, C., Harrison, R. and Querol, X. (2015) 'Review of the efficacy of low emission zones to improve urban air quality in European cities', *Atmospheric Environment*, 111, pp.161-169.

Morfeld, P., Groneberg, D. and Spallek, M. (2014) 'Effectiveness of low emission zones: Large scale analysis of changes in environmental NO<sub>2</sub>, NO and NO<sub>x</sub> concentrations in 17 German cities', *PLoS one*, 9(8), pp. 1-18.

MVA. (2013) *LOW EMISSION ZONE (LEZ) FEASIBILITY STUDY Phase 2 – Final Report*. Available at: <http://democracy.sheffield.gov.uk/documents/s10802/Low%20Emission%20Zone%20Appendix%20A.pdf> (Accessed: 2/5/2017).

O'Sullivan, F. (2015) What Other Cities Can Learn From the Failure of London's Low Emission Zone. Available at: <http://www.citylab.com/cityfixer/2015/09/what-other-cities-can-learn-from-the-failure-of-londons-low-emission-zone/403504/> (Accessed: 25/4/2017).

Parliamentary. (2014) *Areas for Action*. Available at: <https://www.publications.parliament.uk/pa/cm201415/cmselect/cmenvaud/212/21206.htm> (Accessed: 2/5/2017).

Roberts, M. (2016) *UK air pollution 'linked to 40,000 early deaths a year'*. Available at: <http://www.bbc.co.uk/news/health-35629034> (Accessed: 3/5/2017).

Sturcke, J. (2008) *Manchester says no to congestion charging*. Available at: <https://www.theguardian.com/politics/2008/dec/12/congestioncharging-transport> (Accessed: 5/5/2017).

Transport for London (TfL). (2015) *Have your say on the Ultra Low Emission Zone*. Available at: <https://consultations.tfl.gov.uk/environment/ultra-low-emission-zone/> (Accessed: 7/5/2017).

Transport for Greater Manchester (TfGM) and Greater Manchester Combined Authority (GMCA). (2016a) *GREATER MANCHESTER AIR QUALITY ACTION PLAN 2016–2021*. Available at: [http://webcache.googleusercontent.com/search?q=cache:kHFsjQmd5AoJ:www.manchester.gov.uk/download/downloads/id/24676/greater\\_manchester\\_air\\_quality\\_action\\_plan\\_2016.pdf+%&cd=1&hl=en&ct=clnk&gl=uk](http://webcache.googleusercontent.com/search?q=cache:kHFsjQmd5AoJ:www.manchester.gov.uk/download/downloads/id/24676/greater_manchester_air_quality_action_plan_2016.pdf+%&cd=1&hl=en&ct=clnk&gl=uk) (Accessed: 28/4/2017).

Transport for Greater Manchester (TfGM) and Greater Manchester Combined Authority (GMCA). (2016b) *GREATER MANCHESTER LOW-EMISSION STRATEGY AND AIR QUALITY ACTION PLAN*. Available at: [https://webcache.googleusercontent.com/search?q=cache:hWLjRV\\_YIkUJ:https://www.greatermanchesterca.gov.uk/download/meetings/id/1317/download\\_the\\_reports+%&cd=3&hl=en&ct=clnk&gl=uk](https://webcache.googleusercontent.com/search?q=cache:hWLjRV_YIkUJ:https://www.greatermanchesterca.gov.uk/download/meetings/id/1317/download_the_reports+%&cd=3&hl=en&ct=clnk&gl=uk) (Accessed: 26/4/2017).

Transport for Greater Manchester (TfGM) and Greater Manchester Combined Authority (GMCA). (2016c) *GREATER MANCHESTER LOW-EMISSION STRATEGY AND AIR QUALITY ACTION PLAN PUBLIC CONSULTATION*. Available at: <http://www.tfgm.com/gmles/Documents/GM%20LES%20AQAP%20public%20consultation%20document.pdf> (Accessed: 25/4/2017).

Tretvik, T., Nordtømme, M., Bjerkan, K. and Kummeneje, A. (2014) 'Can low emission zones be managed more dynamically and effectively?', *Research in Transportation Business & Management*, 12, pp.3-10.

Urban Mobility Solutions (UMS). (nd) *Solutions Factsheet 3.2: Low Emission Zones*. Available at: [http://www.urban-mobility-solutions.eu/fileadmin/editor-content/Deliverables/Factsheets/Cluster\\_3\\_\\_City\\_logistics/SOLUTIONS-factsheet-3-2-low-emissions-zone.pdf](http://www.urban-mobility-solutions.eu/fileadmin/editor-content/Deliverables/Factsheets/Cluster_3__City_logistics/SOLUTIONS-factsheet-3-2-low-emissions-zone.pdf) (Accessed: 3/5/2017).

Wolff, H. (2014a) 'Keep Your Clunker in the Suburb: Low-emission Zones and Adoption of Green Vehicles', *The Economic Journal*, 124(578), pp. F481-F512.

Wolff, H. (2014b) '*LOW EMISSION ZONES*': *Incentives to switch to green vehicles produce big health benefits*. Available at: <http://www.res.org.uk/details/mediabrief/6514981/LOW-EMISSION-ZONES-Incentives-to-switch-to-green-vehicles-produce-big-health-ben.html> (Accessed: 9/5/2017).