How to get rid of *dirty* diesels on city roads

Analysis of diesel restriction measures in European cities to date[1]

March 2018

Summary

In response to congestion and high local pollution cities are increasingly using vehicle access restrictions to limit the number of cars on their roads and ensure those which grossly pollute are not allowed in. Following the dieselgate emissions scandal (that exposed the failure of modern diesel vehicles to adequately control toxic fumes when operated on the road), there is a new focus on deploying Low Emission Zones and Diesel Bans. Today there are around 40 million grossly polluting diesel cars and vans on the EU's roads but national vehicle approval authorities remain reluctant to mandate manufacturers to implement fixes. As a consequence cities have become the last line of defense in the battle to ensure the air is clean and to address the public health crisis that is causing around half a million premature deaths per year. London has recently announced a toxicity charge while Oslo, Paris, Madrid, Athens and lately Rome have pledged to ban diesel cars altogether in the years to come.

Germany's highest civil court has recently confirmed that German city councils have the right to ban dirty diesel cars from city centres to bring air pollution down to legally required limits. The Federal Administrative Court (BVG) said on 27 February that cities are entitled to ban the most polluting engines if there are no other effective measures to reduce pollution; in fact they must do so if that is the most effective measure to reduce pollutants, particularly nitrogen dioxide (NO2).

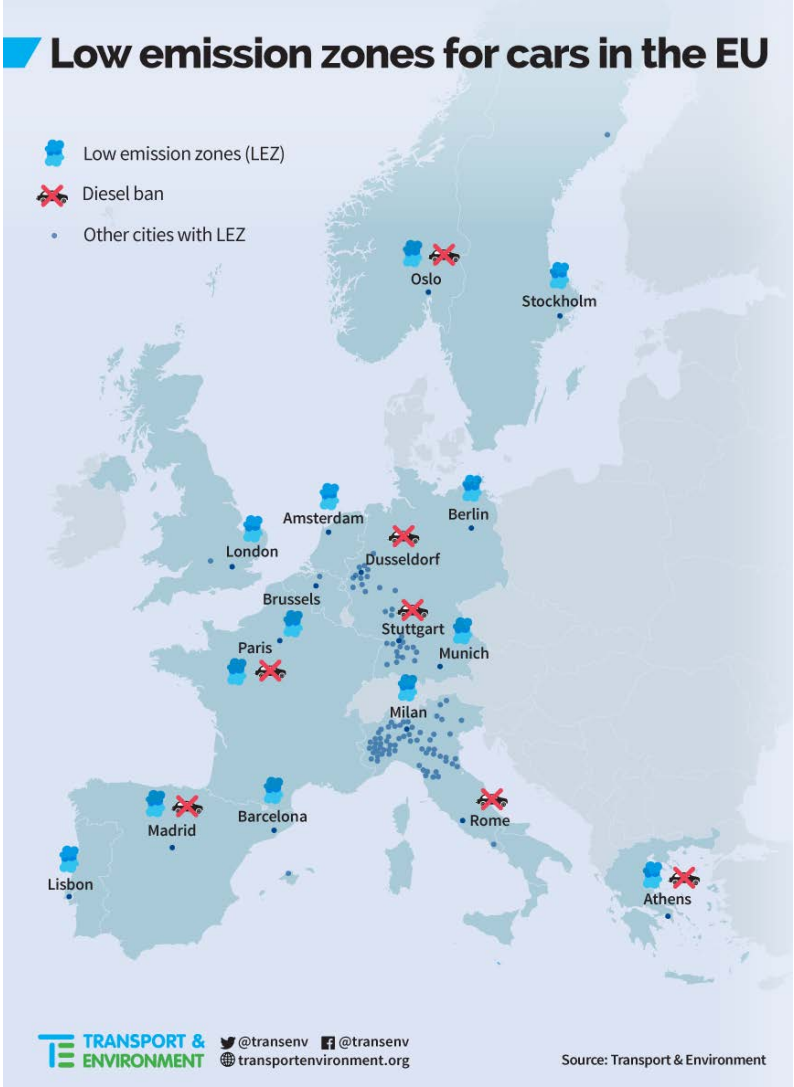
This paper analyses low emission zones and congestion charges in 11 European cities: Amsterdam, Athens, Berlin, Brussels, Lisbon, London, Madrid, Milan, Oslo, Paris and Stockholm. There are large differences in the environmental zones implemented so far. Some policies permanently exclude polluting vehicles and are intended to drive modal shift to cleaner transportation options. Others are of temporary nature in response to hazardous air pollution episodes.

One of the key weaknesses of measures introduced to date is the blanket exemption for Euro 6 vehicles. Less than 10% of new Euro 6 diesels on sale today meet the EU emission limits. Other 90% still exceed the nitrogen oxides limit by 4 to 5 times and some models up to 10 times, notably from carmakers such as Renault, Fiat and Opel. These diesels should either be upgraded to comply with the limits or not allowed in cities - only the vehicles that meet the pollution standards on the road should be exempted from bans.

Central and eastern European cities face a particularly acute situation. With many western cities considering outright diesel bans, it is very likely that the 40 million grossly polluting diesels – without adequate fixes - will end up on the roads of cities such as Warsaw, Prague and Sofia.

[1] This analysis was carried out by Petar Georgiev, T&E's research assistant between October 2017 – February 2018

a briefing by TRANSPORT & ENVIRONMENT



In order to ensure low emission zones and diesel bans are fully effective cities should:

- Avoid blanket exemptions of Euro 6 diesels and instead only allow vehicles that are clean in real-world driving, including those fixed. The inclusion/exclusion criteria should be based on vehicles' real-world emissions (RDE) that are now widely available.

- Use remote sensing linked to number plate recognition to police compliance, and identify individual grossly polluting models and ensure these are repaired or cannot enter the city.

- Provide high quality public transport as well as infrastructure for active, shared and zero emission transport modes.

Cities are now at the forefront of the fight to tackle urban air pollution and the legacy of dieselgate. Through better design of the local access restrictions they can succeed in removing polluting vehicles from city centers and encourage cleaner alternatives. As Madrid's "Plan A" low emission zone poignantly reminds us, there is no Plan B if we fail to make our cities livable and clean.

1. Introduction

Despite binding air quality standards that should have been met in 2010,[2] most member states still breach limits, especially in major urban areas. More than half of the EU countries are subject to a formal notice by the European Commission. Yet, European governments remain reluctant to tackle the main culprit; the high number of dirty diesel vehicles. It is two and a half years after the Dieselgate emissions scandal erupted exposing the widespread use of defeat devices to switch down or off exhaust treatment systems on the road. Yet there are still at least 37 million grossly polluting cars and vans are still on Europe's roads. National authorities have power to enforce or prosecute non-compliant vehicles and require software or hardware fixes but to date have done little due to their cosy relationships with the carmakers[3].

In the absence of national action, there is a growing pressure on city authorities to cut air pollution from diesel vehicles, or – where national legislation passes the responsibility to local levels of government – potentially face substantial fines for failing to meet air pollution standards. To date, the Commission has taken legal action against 16 Member States for excessive PM10 exceedances, and ongoing infringement cases regarding high NO2 levels involve 12 Member States.[4] In January 2018 European Environment Commissioner Vella summoned ministers from 9 Member States[5] to discuss what measures can be taken to achieve compliance as soon as possible, before referring the countries to the EU Court of Justice for infringing the air quality legislation. In most major cities, over 80% of the total nitrogen oxides emitted from transport comes from vehicles with diesel engines.[6] While diesel particles is less of a problem in Western Europe following the mandatory introduction of particle filters since 2011 (Euro 5), it remains a significant contributor to pollution in many Eastern and Central European cities due to high numbers of older (second-hand) diesel cars.

The European Environmental Agency estimates that 7% of EU urban citizens live in areas where NO_2 pollution is damaging their health, resulting 68,000 premature deaths annually EU-wide.[7] However, exceedances in urban areas are often outside of the direct control of cities, as vehicle standards are set at EU level while vehicle taxes and incentives are decided by national administrations. The only effective instrument cities have is to reduce the numbers of vehicles on the road. This has led to an increasing number of cities introducing vehicle access regulations in the form of low emission zones (LEZ). As of January 2018, Berlin, Brussels, Lisbon, London, Milan, Oslo, Paris and Amsterdam (only taxis) have an active LEZ. In addition congestion charges (CC) are in force in Athens, London, Milan, Stockholm and Oslo. In order to respond to the increasing air pollution from cars, most cities are also forced to implement short-term emergency measures when daily pollution levels exceed safe limits. Some have even announced an outright ban of diesel vehicles, with Oslo scheduling it as early as 2019, Paris in 2024, and Athens and Madrid in 2025.

This short report analyses the existing measures against polluting vehicles in cities and shows that limiting diesel access in large urban areas is the only effective policy to decrease pollution, given that the weak Euro 6 air pollution limits and distorted taxation favoring diesel that are widespread in Europe. Section 2 of the paper gives an overview of the vehicle restriction measures undertaken by several European cities. Section 3 describes these in more detail, while Section 4 consists of a thorough analysis of their effectiveness. Section 5 discusses key barriers for the successful implementation of the planned measures. Finally, Section 6 provides summary and recommendations on what an effective diesel restriction measure should look like in view of the best practice analysed in the report.

[2] EU Ambient Air Quality Directive, http://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX:32008L0050
[3] T&E, https://www.transportenvironment.org/sites/te/files/publications/2017_05_Fixing_Dieselgate_in_Europe.pdf
[4] http://europa.eu/rapid/press-release_IP-17-1046_en.htm
[5] the Czech Republic, Germany, Spain, France, Italy, Hungary, Romania, Slovakia and the United Kingdom
[6] http://europa.eu/rapid/press-release_IP-17-238_en.htm
[7] EEA, Air quality in Europe — 2016 report, https://www.eea.europa.eu/publications/air-quality-in-europe-2016

2. Cities at the forefront of action against air pollution

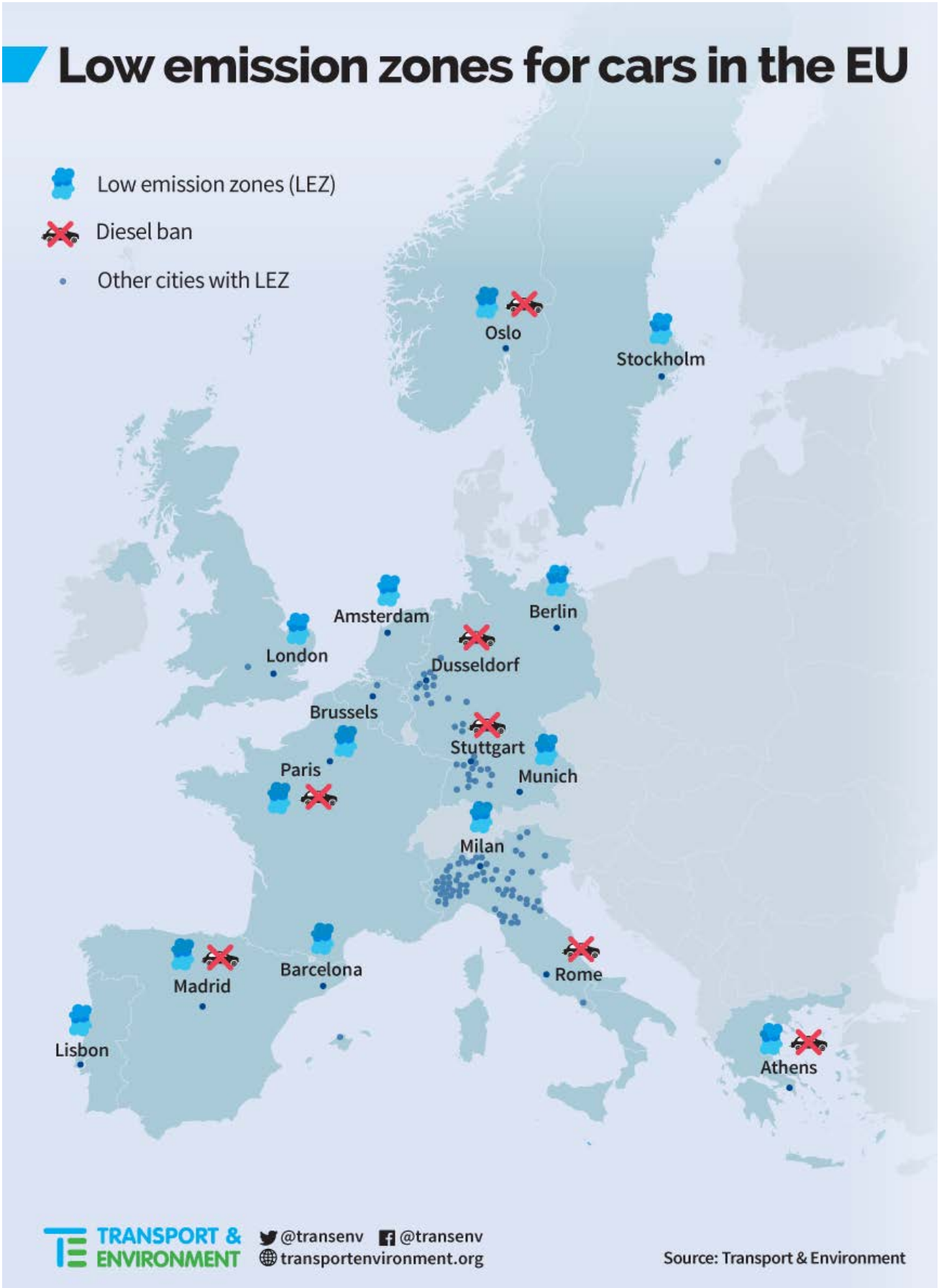
Most of the early actions taken by local authorities to limit vehicles have been aimed at reducing congestion. However, with rising awareness of the effects of high levels of road traffic pollution the focus has recently shifted to improving air quality to improve public health. The 2008 EU Ambient Air Quality Directive is the legal instrument regulating local air quality concentrations across EU cities and regions. Resulting from the obligations under this directive, Member States are required to prepare specific plans to reduce air pollution across their territory. While the EU adheres to the guidelines of the World Health Organisation (WHO) that define safe level of different pollutants (where no-effect thresholds exist). The EU limits for NO_2 and particulate matter (PM2.5 and PM10), the principal urban pollutants, are significantly higher that the WHO Guidelines. This report focuses on these pollutants that are the principal ones emitted by vehicles.

In response to repeated and or dangerous exceedances of pollution limits, many large European cities are now putting in place measures to regulate pollution from traffic as well as ease congestion including[8]:

City	Measure	Minimum standard allowed	Entry into force
Amsterdam	LEZ (taxis)	Euro 5	Jan 2018
Athens	odd-even rationing + LEZ aspect	Euro 5	May 2012
Berlin	LEZ	Euro 3 + DPF / Euro 4	Jan 2010
Brussels	LEZ	Euro 2	Jan 2018
Lisbon	LEZ (two sub-zones)	Euro 3 / Euro 2	Jan 2015
London	CC, T-charge / ULEZ	All vehicles*/Euro 6	Feb 2003 / April 2019
Madrid	parking LEZ	All vehicles	Mar 2012
Milan	CC, LEZ	Euro 4 + DPF	Oct 2017
Oslo	CC, LEZ	Electric vehicles	Oct 2017
Paris	LEZ	Euro 3	July 2017
Stockholm	CC	All vehicles	Aug 2007

The infographic below shows the European cities that have some low emission zones in places for light-duty vehicles/cars.

[8] Information updated as of 1.1.18


Low emission zones for cars in the EU
Low emission zones (LEZ)
Diesel ban
Other cities with LEZ
Oslo
Stockholm
Amsterdam
Berlin
London
Dusseldorf
Brussels
Stuttgart
Paris
Munich
Milan
Barcelona
Madrid
Rome
Lisbon
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2.1. Scope of existing measures

The example of Athens demonstrates a typical turn of events leading to air pollution measures in cities today. In **Athens**, urban vehicle access regulations were initially used only to tackle congestion or save fuel during the oil crisis in 1979. The scheme involved an odd-even number plate rationing scheme and became a permanent solution to control traffic congestion. Athens' zone was strengthened in 2012[9] and currently allows vehicles complying with Euro 5 standard or higher together with a minimum level of 140g CO2/km. Similar developments are seen around Europe since the early 2010s.

Most cities have a low emission zone and some a congestion charge to complement. **London** has additionally added a toxicity charge and plans to have it replaced by an Ultra Low Emission Zone (ULEZ) in 2019. The ambitious ULEZ will require all diesel vehicles to pay to enter the city centre apart from those meeting Euro 6 standards. **Oslo** incorporated a LEZ through an existing congestion charging scheme. The payable amount changes vary with the fuel type and time of day. For example, a petrol-fueled car will pay EUR 5.75 during rush hour, whereas a diesel has to pay EUR 6.29. A similar strategy is used in **Madrid**, where the LEZ is in fact a parking regulation with a base parking rate adjusted to the emissions of the vehicle and the parking location. Several cities with a LEZ, such as Paris, Milan and Brussels, have started policies with relatively low-ambition level but plan to gradually tighten them as the fleet is renewed.

Low emission zones differ as to how they treat vehicle retrofit programmes that upgrade the pollution controls on older cars so that they meet stricter emission limits (such as fitting diesel particle filters - DPF). **Berlin**'s LEZ, for example, allows DPF retrofits[10] for Euro 3 diesel vehicles, which has led to the retrofit of 60,000 diesel vehicles in order to be allowed into the city. Such upgrades are not only costly, but require a continuous compliance monitoring to make sure that they are effectively enforced on a wider scale. In **Milan**, Euro 4 diesels with a DPF filter are currently allowed, but as standards become more stringent retrofits will not be allowed after 1 October 2019. Conversely, Paris and Madrid do not allow any retrofitting.

Prior to the implementation of these measures, some local authorities have, in cooperation with other stakeholders, conducted extensive impact assessments in order to evaluate not just the technical and financial plausibility but the reductions in NOx and PM emissions. The City of **Berlin** projected a 20% reduction in NOx pollutant emissions levels annually after the LEZ's entry into force.[11] **Milan**'s Area C has is estimated to have resulted in a 19% PM10 tailpipe emissions reduction and 10% less NOx in the air. **London**'s ULEZ foresees a 49% reduction of NOx and a 48% decrease in tailpipe particle emissions within the zone one year after its implementation in 2019.[12] Out of the 200,000 estimated inhabitants of the ULEZ by the time of its entry into force, only 17% will be exposed to exceeding NO2 limits, whereas 63% would be exposed without the zone. The impact of London's ULEZ is also expected to reduce pollution levels beyond the zone with particle emissions levels reducing by 8% and NOx by 14%.

2.2. Coverage & timing

Vehicle restrictions usually include the inner part of cities, i.e. within the ring road that surrounds them, as is the case of Amsterdam, London, Paris, and Berlin. The **Lisbon** LEZ and **Athens** odd-even scheme have two sub-zones where a smaller, more central area has higher standards than the rest. The inclusion of the ring in itself is not a common practice. Certain strips or major roads are often excluded. Lisbon's Zone 1 features a few exempt strips, whereas **Stockholm** does not include the main bridges that traverse the city

[9] http://www.ypeka.gr/Default.aspx?tabid=822

[10] http://www.berlin.de/senuvk/umwelt/luftqualitaet/umweltzone/en/allgemeines.shtml

[11] https://www.connective-cities.net/fileStorage/Veranstaltungen/Projektwerkstatt_Thailand_092016/Martin_Lutz_final.pdf

[12] Table 4, https://consultations.tfl.gov.uk/environment/air-quality-consultation-phase-3a/user_uploads/consultation-information-document.pdf-1

and act as transit highways. Because of their pledges to have zero emission zones by 2025, **Oslo** and **Madrid** plan to have their centers car-free by 2019.

Overall, the overall size of restricted areas differs greatly with **Milan**'s LEZ just 8.2 km^2 whilst **Berlin**'s is 10 times bigger at 88km^2. **London**'s CC stands at 21km^2 and the upcoming ULEZ will have the same boundaries. The rationale behind defining a sufficiently large zone is clearly to avoid re-routing traffic to the neighbouring areas. The size of the population affected depends on density. With cities like Athens, London and Paris having population density over 15,000 inhabitants/km^2, it follows that restrictions in London benefit more citizens than that in Oslo. In 2015, more than 1.2 million inhabitants of **Paris** were affected by high levels of NO2, and another 100,000 by high concentrations of PM2.5 and PM10. [13]

Access restrictions also differ in terms of the period when they are in force. While restrictions in some cities, such as **Amsterdam**, **Berlin** and **Brussels**, apply permanently, others are active during specific periods only. One such zone is Lisbon, which is active on working days only – between 7AM and 9PM. Milan follows a similar design, which leaves the weekends and public holidays unregulated. The LEZ in Paris is active every day between 8AM and 8PM. Including a larger period of time, the scheme in Athens takes place between October – July with a slight deviation in dates from year to year.

Measures temporary by nature, or emergency measures, are a different type of restrictions and include speed restrictions, odd-even number plate rationing or car free days. These can address hazardous pollution episodes on specific days and are a last resort of local authorities where permanent measures are not sufficiently effective. **Oslo** for example has an emergency scheme which either temporarily bans of diesel-powered cars or enforces an odd-even vehicle number plate scheme both on top of its continuing measures.

3. LEZ design features

3.1. Long-term vs emergency measures

The purpose of a low emission zone or a congestion charge is to reduce car trips and to encourage the modernization of urban vehicle fleets in order to improve citizens' health and quality of life. These measures tend to be long-term and usually enter into force incrementally, which provides for time for drivers to adjust. These long-term solutions are, however, more sensitive to citizen criticism and have a high degree of politicization as they require change in commuters behaviour. This change has to be facilitated by offering adequate alternatives to the private car option, such as public transport, car sharing and ride hailing.

Another important issue to introducing long-term measures is cost. The 'merit or cash' decision is not easy to make on behalf of the legislators, and currently there are still some congestion charges, such as Athens, Madrid and Stockholm, allowing all vehicles to enter the regulated areas in exchange for a higher fee. The biggest reason is the difficulty to turnover the large existing stock of old diesel vehicles quickly.

Cities should be able to implement the necessary measures and charges without constraint, both on a permanent basis and temporarily when air pollution is too high. They should be able to react to sudden episodes of high pollution levels and rapidly put in place a temporary diesel or car bans and other traffic restriction for older or all vehicles. In January 2017, **Oslo** decided to temporarily ban all diesel vehicles from its city center after granting itself the possibility to do so in February 2016. The city can also choose to close municipal car parks as another emergency measure. **Paris** air quality monitoring agency, Airparif, showed that emergency measures can work when PM10 during rush hour on the ring road fell by 20%, whereas rush hour NOx levels were down by as much as 30% as a result from an odd-even rationing scheme.

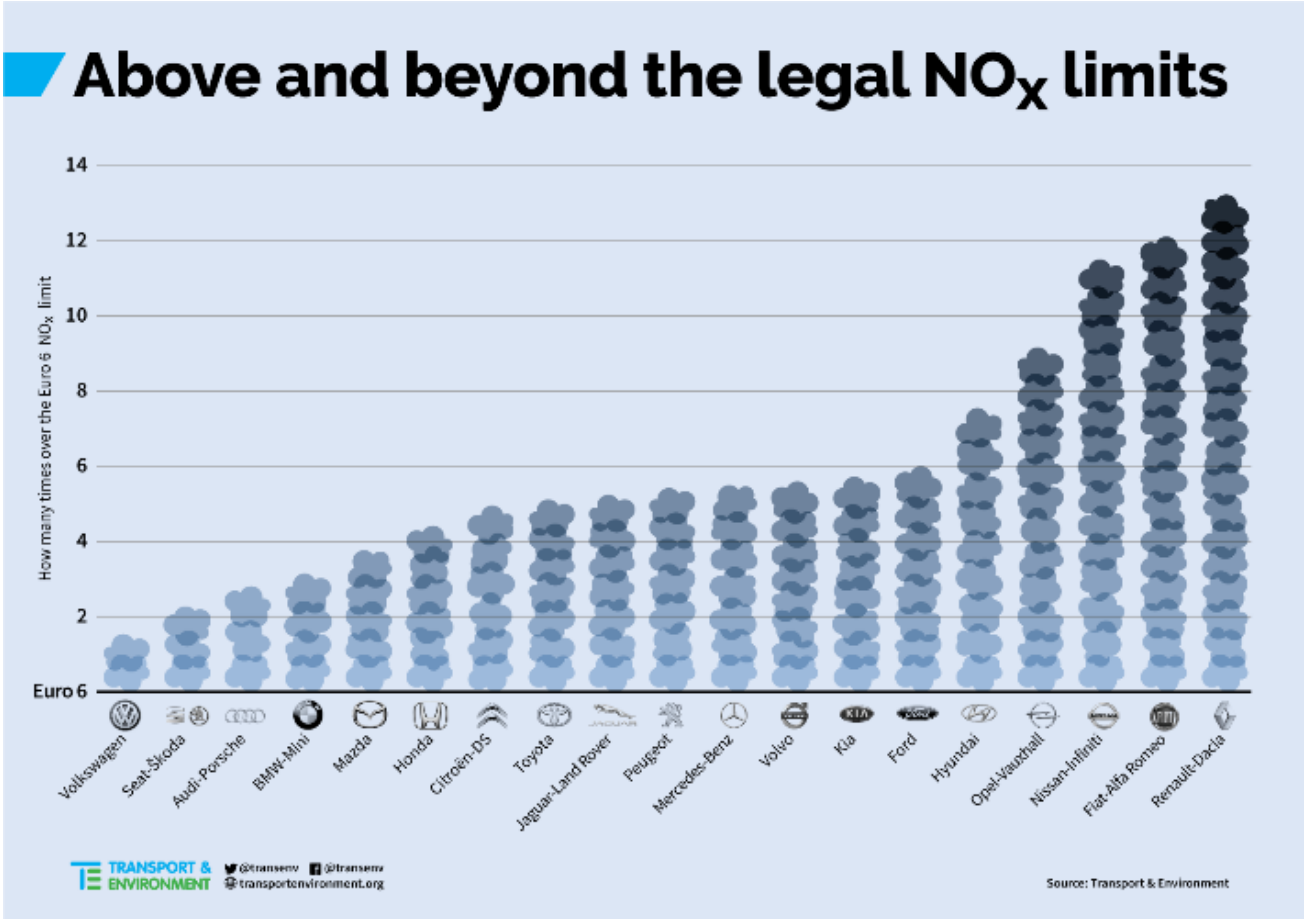
[13] https://api-site.paris.fr/images/87626 (pp.10-13)

3.2. The role of Euro standards in exempting vehicles

The Euro 1-6 standards define the limits for tailpipe emissions of particles, nitrogen oxides and carbon monoxide of diesel and petrol vehicles across in the EU. Standards are not consistent for petrol and diesel vehicles. For example; NOx emissions for petrol cars are 80/60/60 (mg/km) for Euro 4/5/6 respectively, whereas diesel is allowed to pollute far more 250/180/80. Such a wide gap between petrol and diesel limits is not technology neutral and constitutes a regulatory distortion providing preferential treatment for diesel. As a result most LEZs compensate for the lower diesel standards and require a higher Euro class for diesel cars. This is the case with the upcoming ULEZ in London (Euro 4 petrol and Euro 6 diesel), as well as with the already implemented LEZ in Berlin (Euro 1 petrol and Euro 3 + DPF or Euro 4 for diesel) and LEZ in Paris (Euro 2 petrol and Euro 3 diesel).

A key weakness with current LEZ's is the blanket exemptions given Euro 6 diesel. The Dieselgate emissions scandal shows Euro 5 and 6 diesel vehicles emit much more NOx in real world conditions compared to the official test results. On average Euro 6 diesel cars (on the road since 2014) emit 4 to 5 times more NOx than the regulated limit, with models by Renault, Fiat and Opel averaging as much as 10 times the limit[14]. The laboratory Euro 6 test and limit is not a robust basis to assess the level of pollution coming from the exhaust when the car is driven on the road. Some Euro 6 diesel vehicles emit more NOx in real world than Euro 5 or even Euro 4 vehicles. Only around 10% of the newest Euro 6 diesel passenger cars emit NOx within the legal limit.[15] This discrepancy greatly undermines the effectiveness of vehicle restriction policies. T&E estimates there are at least 37 million[16] grossly polluting cars and vans in EU roads as of last year, with most relatively new produced between 2011 and 2016. The image below summarises the average exceedance of the new Euro 6 vehicles by manufacturer:

[14] T&E Dieselgate report, 2016, https://www.transportenvironment.org/publications/dieselgate-who-what-how
[15] ICCT, https://www.theicct.org/news/road-tested-sep2017-press-release
[16] T&E Diesel report, https://www.transportenvironment.org/sites/te/files/2017_09_Diesel_report_final.pdf



Blanket Euro 6 bans will therefore undermine the desired emission reduction and also provoke citizen discontent when it becomes known some Euro 6 models are exempted although they emit more pollution than a Euro 5 model. Euro emission standard based LEVs are not delivering which is why increasingly cities are turning towards the measure of last resort; diesel car bans.

3.3. Facilitative measures

Facilitative measures, such as subsidies, tax reliefs, exemptions and parking or driving lane privileges can encourage drivers to switch to cleaner models and make the implementation of vehicle access restrictions more palatable for drivers and politically acceptable for politicians to support the case for an LEV. Substantial subsidies and support measures for zero emission vehicles in Norway and the Netherlands have resulted in a faster uptake of electric vehicles, putting them way ahead of the rest of Europe. Notably, the Netherlands have removed the purchase and annual ownership taxes for EVs. In a similar manner, the UK and Germany offer a one-time purchase grant of 4,500 pounds and 4,000 Euro, respectively, along with no ownership tax for electric vehicles.

While financial incentives are the prerogative of national governments, city authorities do usually manage parking and access to public transport lanes that can be used to encourage use of the cleanest vehicles. A good example is **Madrid**'s environmental parking differentiation that favors low and zero emission vehicles. City authorities can also allow ZEVs to use in bus lanes as **Oslo** has done. However such a measure can only apply for a short while to the very cleanest models if it is not to undermine public transport use.

In large metropolitan areas, most of the cars impacted by the LEV are registered outside the zone and impacts on those commuting within it. In **London**, for example, approximately 7,000 cars are affected daily

by the new T-charge, and yet only around 1,000 of these are owned by the residents living within the area.[17] It is important cities incentivize zero emission modes as well as demand-driven technologies and solutions, which also take into account a larger geographical scope and citizens' lifestyle and habits.

3.4. Enforcement

Enforcement mechanisms differ on a city to city basis. Sticker-based LEZs and congestion charging schemes are typically enforced manually by local police authorities. This occurs in Athens, Berlin, Lisbon, Madrid, Paris and Stockholm. Notably in **Lisbon**, the lack of inspection of taxis has exposed a significant failure in the implementation.[18] Therefore, manual police enforcement, despite having a lower cost, should be avoided due to the lower compliance levels and effectiveness.

Cameras are used to assist the monitoring of vehicle number plates in other cities such as Brussels, London, and Milan, but are costlier due to the required infrastructure investment. A 2003 estimate on the potential of a **London** LEZ compares a EUR 2.8 million set up price and EUR 4 million running costs per year for manual enforcement to a EUR 6-10 million set-up price and EUR 5-7 million running costs per year for automatic enforcement.[19] However, automatic enforcement ensures higher compliance and increases both the environmental and financial benefits from the restrictions. **Oslo** utilises a radio-frequency identification method at toll stations, referred to as AutoPASS[20], and compliance is established by Automatic Number Plate Recognition (ANPR) cameras. London's ANPR cameras further enhance the monitoring method by compiling a database with the aid of information from the Driver and Vehicle Standards Agency, vehicle manufacturers and operators registered with Transport for London.

Penalties for non-compliance vary across cities and start from around EUR 68 in Paris to up to EUR 200 in Athens and EUR 350 in Brussels. Milanese penalties differ in summer and winter between EUR 75 and EUR 450. However, certain provisions apply to different cities. The EUR 68 penalty in Paris becomes EUR 180 if not paid in the first 45 days. Conversely across the Channel, London's 130 pounds' penalty goes down to 65, if paid within the first two weeks. Brussels will not in fact fine drivers in the first nine months but simply issue warnings. Furthermore, the method of the Brussels' LEZ projects a maximum of one fine in a three-month period, while the penalty for foreign registered vehicles is only EUR 150. This type of differentiation trend between domestically registered vehicles and foreign ones is noticed in the entry charges of cities like Milan as well as the stickers for Berlin and other German cities, making enforcement practices extremely diverse around Europe.

4. Barriers & alternatives

4.1. National laws

While no EU-wide regulations for low emission zones exist, a few countries have adopted national LEZ legislation (France, Germany, Netherlands, Denmark, Sweden, and Czech Republic). Notably in France, the Grenelle II law envisaged reduction of road pollution by enabling French cities to institute a LEZ. However, cities are free to implement their own conditions and course of action, depending upon the local situation such as pollution levels, traffic congestion and topography. Italy has a harmonized criteria regarding LEZ on a regional level, particularly in the North. Greece's odd-even rationing scheme also has a basis in national legislation.

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[17] https://consultations.tfl.gov.uk/environment/air-quality-consultation-phase-3a/user_uploads/consultation-information-document.pdf-1 , p.42

[18] http://zero.ong/zero-quer-zona-de-emissoes-reduzidas-de-lisboa-com-fiscalizacao-maior-exigencia-e-medidas-complementares/

[19] LEZ feasibility study, London : http://content.tfl.gov.uk/phase-2-feasibility-summary.pdf

[20] http://www.autopass.no/en/payment/this-is-how-the-toll-stations-work

In some places national legislative obstacles prevent cities from taking action. In Germany, following a court ruling that air pollution should be reduced via introducing diesel driving bans, the cities of Stuttgart and Dusseldorf until recently faced a legal battle to implement a total diesel ban in their streets. This has been put to rest with the groundbreaking ruling, whereby Germany's highest civil court has confirmed that city councils have the right to ban dirty diesel cars from city centres to bring air pollution down to legally required limits. The Federal Administrative Court (BVG) said on 27 February that cities are entitled to ban the most polluting engines if there are no other effective measures to reduce pollution; in fact they must do so if that is the most effective measure to reduce pollutants, particularly nitrogen dioxide (NO2).

One of the most progressive cities on clean transport, **Copenhagen**, would like to impose a LEZ for passenger cars but this would require a national legislative amendment. Similarly, the City of **Amsterdam** has not implemented any pollution measures aimed at passenger cars, targeting vans and taxis only. In other cases, like in **Prague**, authorities were initially unable to act prior to the passing of national legislation[21] followed by a government decree. As a result Prague is now ready and expected to have a functioning LEZ in 2019. Taking it a step further, a legal action by the ECJ against Portugal was required in order for **Lisbon** to create its LEZ under an air quality plan without the existence of a national scheme.

Vehicle taxation can also act as a perverse incentive against cities policies to drive polluting diesels out. Most member states have CO2-based taxes. Such taxation tends to give a comparative advantage to diesel, which has advantage over petrol on a per km basis. This has created a heavy diesel bias[22] which greatly influences consumers, as it tips the balance in favor of owning a diesel car. In **Brussels**, the issue is further exacerbated due to the special incentives for company-provided cars. With taxation sitting with national authorities, cities are unable to influence the financial incentives and therefore the choice of vehicles that citizens purchase and drive on their roads. Until very recently over half of all new cars sold annually were powered by diesel with CO2 taxation failing to take account of their high NOx emissions.

4.2. Social acceptance

There is often widespread opposition to the implementation of LEZs and other forms of car restrictions in particular from motoring and retail organizations. The response of motoring organizations is understandable as they represent the group principally affected. However, motorists actually breathe some of the highest levels of pollution whilst driving their cars and are also citizens with families impacted by high pollution levels. Retailers frequently fear that traffic restriction will reduce footfall shops – although most of the evidence tends to point to the contrary with the busy Oxford Street a prime example. However, the fear that car restrictions will be politically unpopular is the primary reason relatively few are currently in place and such weak measures have been adopted to tackle urban air pollution in most cities.

LEVs are also opposed as being socially inequitable. However, this is often an unfair characterization as Euro 5 petrol cars (now up to 8 years old) are frequently permitted to enter the low emission zone. Recently there have been widespread calls for fiscal stimuli for replacement of old vehicles such as diesel scrappage schemes. However, these are generally poor value for money and simply bring forward purchases that would otherwise have been made at a later date. Drivers of old diesels also cannot afford to buy a new car even with a scrappage benefit – the scrappage scheme therefore tends to only benefit wealthier new car buyers. Finally encouraging car new purchase through public incentives is not consistent with the polluter pays principle and rewards carmakers for producing dirty diesels. Investment in expanding public transport and other mobility alternatives is the socially equitable way to respond to the implementation of an LEZ.

[21] § 14 of Law no. 201/2012 Coll.

[22] T&E Diesel report, https://www.transportenvironment.org/publications/diesel-true-dirty-story

In many cases, such as the recently-launched LEZ in **Brussels**, the adopted policy allows for a transition period. This is generally received positively by drivers but also slows down the implementation allowing high pollution levels to remain for much longer slows down the actual implementation.

Effective consultation and provision of adequate alternatives to car use are pre-requisites for a successfully LEZ. An example of an effective method for reaching out to the public is **London**'s recent public consultation. [23] The responses were collated and included in the consultation report prior to the introduction of London's congestion charge and ULEZ implementation. Achieving even greater reach and legitimacy, referendums have also been used to determine if citizens regard the planned pollution measures positively. A congestion charge was implemented in **Stockholm** after a 2006 referendum.[24] Similarly, **Milan** moved towards its Area C, combining a LEZ with congestion charge, as a result of a 2011 referendum.[25] However, measures are not always taken up the same way. The City of **Madrid** has run an extensive awareness campaign, and yet terms like "freedom of movement" or "mobility rights" are often used against any measures to minimize passenger car use in cities, despite the public health consequences of road traffic emissions.

4.3. Rules circumvention

Some cities saw citizens exploiting the loopholes of the local vehicle access restrictions. The odd-even number plate system in **Athens** is a good example that shows the inadequacy of congestion charge policy design. The efficiency of the policy is strongly undermined by an increase in double-car ownership, i.e. many families end up having two cars – one ending with an odd-numbered plate, and another one with an even. This is reflected in the growth of car ownership, which reached up to 1.16 cars per capita in 2001. Thus where a restriction is in force for a longer period, the odd-even rationing could be circumvented, as people or companies decide to make a long-term investment. Another facet of this is an increased car use on allowed days which undermines the very aim for the measure in the first place. However, in case of emergency measures, the odd-even number plate regulation could prove to be more efficient but by and large it does not provide for a permanent solution.

Another reason why the effectiveness of urban vehicle access regulations have proved of limited effectiveness results from overly-generous exemptions. Exemptions can prove tricky in mitigating environmental risks and have to be carefully assessed. In the particular case of **London**, historical vehicles will not be affected from the ULEZ which would allow the renowned London to Brighton car run to go on unaffected. However, looking at all case studies, exemptions mostly relate to people with impaired mobility, special vehicles (police, ambulance, and fire-brigade), mopeds or construction machinery. In most cases, foreign vehicles are also affected (apart from Athens and Madrid). However, it is the exemptions from restrictions for local citizens living within the LEZ that severely undermine the effectiveness of the regulatory measures in cities like Athens, Lisbon and Prague. While the afore-mentioned exemptions are justified to a great extent, generally letting the local population off the hook greatly reduces the number of vehicles affected within the environmental zones and thus its efficacy.

The effectiveness can also be hampered if the traffic shifts to roads outside of the LEZ area. Therefore, the LEZ should be large enough to prevent re-routing and moving the pollution problem from one place to another. Polluting vehicles that are banned from the city center cannot end up polluting the suburbs instead, which often are more densely populated than the LEZ area. **Berlin**'s LEZ has successfully tackled this challenge by encompassing a large enough area in what is one of the largest environmental zones in Europe.

[23] https://data.london.gov.uk/dataset/clean-air-consultation-july-2016
[24] www.transportportal.se/swopec/cts2014-7.pdf
[25] http://www.eltis.org/discover/case-studies/area-c-milan-pollution-charge-congestion-charge-italy

5. Provision of alternatives

5.1. Retrofits

One of the solutions to the millions of the grossly polluting diesel vehicles on city roads today would be to require carmakers – whose responsivity it is to put on the market vehicles that are compliant with EU emissions legislation – to upgrade the vehicle exhaust systems and ensure emission controls operate in most driving conditions and ambient temperatures. If done properly, this can help reduce NO2 emissions across cities but questions remain as to the cost and feasibility to effectively implement fixes on the hundreds of different models affected to equally high standard across Europe.

There is also a debate as to whether mere software fixes are enough or whether hardware upgrades are necessary to reduce the emission substantially. There has been a number of criticisms as to the effectiveness of the software upgrades carried out by VW to date, with drivers reporting [26] poorer performance and fuel consumption following the fixes. More systematic data would be needed to analyse this consistently, but it is clear that upgrading vehicles on a mass scale is not without its challenges. If retrofit programmes are to be rolled out, they must as a minimum:

- Reduce NOx emissions and effectively operate in most real-world driving conditions (and not only on a test bench)
- Ensure the fuel consumption and performance of the vehicles remains the same as prior to the upgrade
- Ensure durability to the driver in line with EU legislation

Only if adequately fixed at the cost and responsibility of the car manufacturer, can the "cleaned up" diesel vehicles that meet the emission limits on the road enter city centers.

5.2. Public transport, shared mobility and reallocation of public space

Alongside vehicle access restriction measures, improving public transport is essential to get citizens to switch to lower emission transport modes are provide an alternative form of mobility. Most of the cities examined in this paper significantly improved public transport provision as part the in the implementation of vehicle access restrictions. **London** has been a leader in terms of bus fleet improvements including widespread adoption of hybrid buses and some provision of full electric models.[27] Interestingly, in the case of London public buses have higher emission standards than the LEZ because of progressive public procurement rules by Transport for London. One of the more comprehensive economic frameworks for measures to improve public transport can be seen in **Oslo** with the adoption of the EUR 10 billion package called Oslopakke 3 in 2016[28]. It aims to remove cars from the city center altogether by 2019 covers the period between 2017 and 2036.

The increasing uptake of shared mobility, such as ride hailing and car pooling, as an alternative to conventional transportation in urban areas will also play an important role in the transformation of public transport. Zero emission vehicles such as EVs can go hand in hand with shared mobility services since these vehicles have low operating costs. Compiling such innovative services into one has provided for the so-called Mobility as a Service integration, where customers' demand is the main driver for different transport options. Similarly, projects for cycling highways have grown in number, and **Amsterdam** is a great example where more than 40% of the trips are taken by bike. In order to accommodate demand, on-demand shared bike services are becoming more popular in many big European cities too like Paris, London, and Brussels to just name a few.

[26] The Guardian, https://www.theguardian.com/money/2017/jul/12/drivers-loss-of-power-vw-emissions-fix-class-action
[27] https://tfl.gov.uk/corporate/about-tfl/improving-air-quality?cid=transport-emissions
[28] **https://www.vegvesen.no/vegprosjekter/oslopakke3**

The subsequent promotion of such type of modal shift goes hand by hand with public space reallocation. Since April 2017 no new parking permits are issued to old diesel cars in **Amsterdam**[29], whereas priority is given to electric drivers. Relocation of public space in **Oslo** is happening by removing on-street parking spaces and creating more roads for cycling. Targeting a similar objective, **Madrid**'s Plan A projects to redesign main roads and green streets in order to give more space to public transport and active modes of transportation, such as cycling and walking.

5.3. Zero emission vehicle infrastructure & other support measures

In addition to tax and purchasing incentives for zero emission vehicles in countries such as Norway, France, the UK and the Netherlands, it is cities that make a step further in promoting zero emission mobility and a transition away from conventional diesels. Particularly in **Norway**, which is the largest mass market and leader in terms of EVs, incentives have played a key role including tax and toll exemptions. Norway also involves stakeholders at different levels to agree a very comprehensive and market-friendly policy.[30] These measures, including preferential access for EVs to bus lanes in Oslo, supplement the plan of the Norwegian government to have only zero emission vehicles sold after 2025.

The creation of LEZs and congestion charges can be an important driver for the uptake of zero emission vehicles (ZEVs). **London**'s congestion charge is a good example of an incentivizing scheme, where EVs receive a 100% discount. Important parts of the urban fleet such as taxis can also be high emitters, and are for this reason regulated under **Amsterdam**'s LEZ. While the legislation entered into force on January 1, 2018 and concerned diesel engine taxis (hybrids included), the City of Amsterdam also planned the creation of cooperative agreements with taxi companies on emission-free taxis. Until December 2018, the City of Amsterdam will provide a subsidy of 5,000 EUR per every electric vehicle purchased by taxi companies.[31]

There is also a strong need for supporting infrastructure in order to increase uptake of electric cars, vans and buses across cities and alleviate public concerns regarding access to recharging points. EV drivers in **Amsterdam** can request online a new charging point to be built in their region following the purchase of an electric vehicle, if no public charging infrastructure is available in a 300-meter radius. After obtaining the permission of the city council, a contractor requests connection to the grid and installs a charging point.[32] This demand-driven approach has resulted in substantial growth of public charging points and an overall behavioral change. This exemplar approach is now replicated in other Dutch cities.

Installation of charging hubs at parking lots and in shopping centers also improves the overall accessibility for EV drivers and at the same time increases the appeal for clean vehicles. Cities like Oslo, Madrid, London are also working in this direction, in line with their push to phase out diesel vehicles post-2025. **London**, in particular, has initiated a GBP 18 million scheme to install 75 rapid charging stations which can recharge vehicles in 30 minutes.

Apart from public charging points, a lot can be done in terms of bolstering charging infrastructure in homes and workplaces. In particular, there is a legislative requirement for EV infrastructure resulting from the obligation of Member States under the Directive on energy performance of buildings (EPBD)[33] requires the pre-equipping of residential buildings with EV charging infrastructure. Directive 2014/94/EU on deployment of alternative fuels infrastructure (AFI).[34] Mandates a minimum publicly accessible charging points

[29] https://www.amsterdam.nl/parkeren-verkeer/parkeervergunning/schoner-parkeren/

[30] https://www.oslo.kommune.no/english/politics-and-administration/green-oslo/best-practices/the-electric-vehicle-capital-of-the-world/#gref

[31] https://www.amsterdam.nl/veelgevraagd/?productid=%7bBCA74071-7A96-4F67-9A75-088F4E819F79%7d

[32] Bart Vertelman and Doede Bardak, Amsterdam's demand-driven charging infrastructure, 2016.

[33] http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014L0094

[34] http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1515752299107&uri=CELEX:32014L0094

nationally. Such developments will raise public awareness, remove current barriers to wider market uptake of EVs and thus allow for their greater market penetration.

Conclusion

High levels of road traffic and dirty diesels that emit many times legal pollution limits when driven on the road are the biggest cause of Europe's urban air pollution crisis and major contributor to the nearly half a million premature deaths annually. Demands are now being made that cities tackle high local levels of pollution. Cities are being forced to act having been failed by:

1. European Commission that allowed the effective application of Euro 6 vehicle pollution limits (RDE) to be delayed;
2. Carmakers, that widely circumvented the legislation;
3. National Type Approval Authorities – that weakly enforced the rules on turning down exhaust treatment systems and defeat devices; and
4. National Governments that have failed to establish national plans to deliver ambient air pollution limits or require carmakers to fix non-compliant diesel vehicles.

Consequently, a plethora of large European cities have now instituted vehicle access restrictions to improve air quality and tackle congestion levels.

However, many proposed measures risk failure because of the erroneous assumption that Euro standards provide a sound regulatory basis upon which to judge the emissions from vehicles. In particular the assumption that latest Euro 6 standard are clean and excluded from LEZ restrictions is wrong. The Dieselgate scandal has exposed that fumes produced by most of the new diesels on sale remain many times the test limits, with emission control often switched off when in real-world driving conditions.

To ensure LEZs are fully effective, Transport & Environment suggests cities adopt the following recommendations for **LEZs and Diesel Bans**:

1. **No blank exemption to Euro 6** vehicles. Instead, access should be based on real-world NOx and PN emissions of new diesel vehicles, available since last year via the new real-world driving emissions test provisions, or RDE. Such restrictions should apply to all vehicles on all city roads consistently (e.g. no even-odd numbering) to avoid perverse incentives and rules circumvention.
2. The vehicles with emissions above the EU limits should either be **adequately fixed**, at the expense and responsibility of the car manufacturer, **or not allowed in** city centres. Unaltered performance and fuel consumption should be guaranteed to drivers.

3. Cities with large exports of **second-hand vehicles**, i.e. in central and eastern Europe, should evaluate which **restrictions on the number of dirty diesels that can enter into circulation** are legally possible. Notably, Euro 5 & 6 vehicles subject to mandatory or voluntary recalls in another European country (e.g. VW, Renault, Daimler, Fiat, Opel, etc) **should only be registered if they have undergone the required software or hardware upgrades before they will be accepted for import**.

4. Cities should investigate and where possible install **remote vehicle emissions sensing**. This can help identify grossly polluting cars that can be specifically excluded for failing to comply with the necessary standard on the road.[35] In this way vehicles that can legally enter the zones but produce high emissions due to tampering, poor maintenance or other faults can be identified and repaired or excluded where linked to **automatic number plate recognition (ANPR) technology**.

[35] The new True Real Urban Emissions (TRUE) project, which brings together the mayors of London and Paris, as well as the C40 cities alliance, is currently putting together such a database in order to measure real-world emissions.

5. **Cities should have powers to put in place permanent vehicle restriction policies** to help them achieve local air pollution limits as well as **emergency measures when daily concentrations reach dangerous levels**. Where national legislation specifically prevents cities acting these should be revised accordingly.

6. Adequate **investment into public transport**, **incentives to reduce vehicle ownership** as well as **infrastructure for zero emission vehicles, shared and active mobility (e.g. cycling lanes)** should be implemented to help secure public acceptance and local buy-in.

7. There should be **consistency between all levels of government and EU, national and local policies** to help reduce pollution and make cities clean and livable. At EU level, **emission limits should not be favouring diesel** but instead follow the principles of technology and fuel neutrality. At national level **vehicle taxation should include an air quality increment** not to skew the market in favour of efficient diesels.

Cities have become the first line of defense in the battle to tackle urban air pollution. But local measures will only succeed if these are well designed and succeed in removing polluting vehicles from city centers. As Madrid's "Plan A" low emission zone poignantly reminds us, there is no Plan B if we fail to make our cities livable and clean.