

# Low-Emission Zones are a success - but they must now move to zero-emission mobility

Evidence shows well-designed Low-Emission Zones reduce toxic air pollution. But EU air quality and climate targets require shifting up a gear.

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## Summary

In reaction to the looming air pollution crisis and the Dieselgate scandal cities across Europe have introduced or tightened Low-Emission Zones (LEZ). More than 250 EU cities have already taken such measures. This briefing reviews the evidence available on the justification and effectiveness of LEZ and recommends the way forward. It finds that more than 70,000 scientific publications provide strong health and social equity arguments. Toxic air is estimated to decrease life expectancy of every European by an average of almost 1 year. Poorer neighbourhoods suffer disproportionately, with NO<sub>2</sub> concentrations being up to 50% higher than in wealthy areas, although they own less cars themselves. A survey shows 67% of interviewees either 'strongly' or 'somewhat' support the introduction of LEZ.

A review of the available evidence shows that existing LEZ already reduce air pollution. The highest reduction observed is a decrease of the NO<sub>2</sub> concentration in Madrid by 32%. The evidence also indicates that the design is critical for the effectiveness. Moreover, exemptions and financial support schemes should be targeted at low-income households and SMEs that absolutely need to use their vehicles in cities and otherwise could not afford a switch to clean alternatives. Looking ahead, it is time to shift up a gear given that the improvements in air quality are real but often limited. LEZ should be gradually turned into zero-emission mobility zones (ZEZ) and complement policies promoting a switch to clean alternatives, such as walking and cycling, the electrification of all modes including public transport, taxis, shared and private vehicles as well as delivery vans. This transition is also required by climate targets that imply a complete phase-out of internal combustion engines by the mid-2030's, starting earlier in cities. Some of Europe's largest cities have set course towards such a phase-out and should serve as a model for others.

### Low-Emission Zones work, but are not enough



67% of Europeans surveyed support Low-Emission Zones

LEZ work & achieve reductions of up to



for NO<sub>2</sub>



>250 European cities have a Low-Emission Zone

London  
Amsterdam  
Madrid  
Paris  
Brussels



European capitals have started moving towards Zero-Emission Zones

# 1. Introduction: LEZ are introduced in reaction to the looming air quality crisis

Air pollution has been high on the European agenda in the past years as air pollution in many cities and regions across Europe still exceed the limits set at EU level back in 2008. Moreover, the Dieselgate scandal revealed that these exceedances were often due to wrongdoing in the car industry which means that the massive damage to public health was and is avoidable. Although Europe has seen undeniable progress in improving air quality progress has however been slow<sup>1</sup> and official data show that up to 95% of the EU population are still exposed to levels of air pollution the WHO considers dangerous.<sup>2</sup> Infringement procedures against 15 Member States are currently ongoing because they remain in breach of the Ambient Air Quality Directive (AAQD).<sup>3</sup> And road transport remains one of the main sources of dangerous levels of air pollution, namely in cities. The German Environment Agency, for example, estimates that road transport alone is responsible for 60% of NO<sub>2</sub> concentration in cities.<sup>4</sup> In Paris, transport accounts for 65% of NO<sub>x</sub> emissions and 36% of PM10.<sup>5</sup>

## Low-Emission Zones as the primary tool to address local toxic air pollution

Given this looming air quality crisis and the important contribution of road transport it is coherent that cities have taken measures to tackle air pollution from road transport. Low-Emission Zones (LEZ) – “areas where access is restricted due to the emissions of certain road vehicles”<sup>6</sup> – were first used in Swedish cities in the 1990s<sup>7</sup>, then slowly spread across certain parts of Europe and recently got new impetus through the Dieselgate scandal. There are now more than 250 cities in the EU that restrict access for polluting passenger cars, a recent T&E analysis showed.<sup>8</sup> The importance of LEZ has also been recognised at EU level by their inclusion in the newest draft guidelines for “Sustainable Urban Mobility Plans”<sup>9</sup>, which are not only a widely used planning tool but also a precondition for access to certain EU funding programmes.

But despite long-standing practice and official recognition, LEZ have been attacked by interest groups. These attacks questioned the scientific foundation of public health evidence on air pollution. In early 2019 a group of around 100 German doctors and engineers, some of whom were found to have ties with the car industry<sup>10</sup>, signed a letter questioning the EU limit values for NO<sub>2</sub> concentration. The German Transport Minister echoed this message in a letter sent to the European Commission in which he pled for a review of pollution limits.<sup>11</sup> Although these claims were rapidly rebutted by the World Health Organisation (WHO) on the basis of a comprehensive body of evidence<sup>12</sup> and also rejected by the European Commission<sup>13</sup>, there are still lobby voices that use false arguments to question the need and the effectiveness of LEZ. This briefing reviews the arguments, evidence and need for future developments in view of Europe’s air quality and climate targets.

## 2. Public health and social equity: a very strong case for LEZ

Evidence on the dangerous effects of air pollution on public health has expanded massively over the past decades.<sup>14</sup> There are now more than 70,000 relevant studies available<sup>15</sup> and the World Health Organisation underlines that for particulate matter (PM) no threshold has been identified below which no damage to health is observed<sup>16</sup>. A recent global review also indicates that air pollution may harm every organ in the human body.<sup>17</sup> EU legislation recognises the adverse effects of air pollution on public health but EU limits on the concentration of pollutants in the ambient air are not consistently set in line with the WHO guidelines. Air pollution is estimated to decrease life expectancy of every person in Europe by an average of almost 1 year.<sup>18</sup> In the most polluted European cities, life expectancy could be increased by almost 2 years if the air was clean.<sup>19</sup> European citizens consider it the second most important environmental concern after

climate change according to a Eurobarometer poll from 2017.<sup>20</sup> The health costs and the contribution of road transport have also been quantified. A study commissioned by the European Public Health Alliance estimates that the indirect health costs of road air pollution amount to between 67 billion and 80 billion euros (depending on whether real-world NO<sub>x</sub> emissions are accounted for) annually in the EU.<sup>21</sup> An estimated 75% of these costs are linked to diesel cars, and are primarily borne by taxpayers and insurances. These costs can be significantly reduced by up to 70% by 2030 if appropriate measures are taken, such as low emission zones, the study finds.<sup>22</sup>

The health damage caused by road transport has recently been shown to be much higher than initially thought with the Dieselgate scandal revealing the extent of widespread manipulation of car emission limits. Many of the recent cars approved under Euro 6 rules were found to emit up to 13 times the current NO<sub>x</sub> legal limit when driven on the road.<sup>23</sup> Given this air pollution crisis and the strong contribution of road transport cities have taken a series of measures to protect public health, with LEZ as a last resort measure which in many cases has been required by court rulings. LEZ were not only considered as the most effective measure in this regard but were also mandated by cost-benefit analyses.

## The social case for Low-Emission Zones

The case for LEZ is even stronger when one takes into account that certain parts of the population are exposed to particularly high levels of air pollution. Evidence shows that poor people are disproportionately affected by air pollution. Conversely, they are the least likely to own a car themselves and thus contribute less to the pollution problem. A study by Austrian environmental group VCÖ<sup>24</sup> shows that among the lowest income quartile, 44% of people don't own a car and that this same part of the population tends to be exposed to higher than average pollutant levels. A recent study in the UK confirmed these findings and showed that poorer households are generally exposed to higher levels of NO<sub>2</sub>.<sup>25</sup> Areas with the highest percentage of households in poverty show NO<sub>2</sub> concentrations that are 50% higher than areas with the lowest percentage of households in poverty. Researchers conclude that there are 'significant environmental justice issues with regards to generation of traffic pollution.' Recent research also suggests that air pollution has twice the impact on lung function for members of lower-income households according to UK data.<sup>26</sup> The European Environment Agency found that this is also true at the European scale, with the continent's poorer regions, namely Central and Eastern Europe, being hit harder by air pollution.<sup>27</sup>

While it is true that poorer residents are often disproportionately affected there have also been concerns that these parts of the population will find it more difficult to comply with the policies put in place by LEZ, namely when it comes to purchasing cleaner vehicles. It is not only important to bear in mind that these groups own less cars than the rest of the population as shown above but also that the proper design of a LEZ can address social concerns. Box 1 contains examples of good practice for these considerations.

### BOX 1: Design matters – How LEZ can drive a fair transition

**Provide incentives to use other forms of mobility:** It is essential to offer good alternatives to using cars in city centres. Promoting clean and healthy alternatives such as walking, cycling, new forms of micromobility and public transport help reduce pollution, congestion, noise and accidents. Given that 75% of trips in the EU are below 10 km there is a considerable potential.<sup>28</sup> At the same time, taxis and public transport - vehicles that travel many kilometres every day - should be swiftly electrified and integrated into new shared on-demand mobility solutions to better cater for the needs of all residents. Madrid, for instance, gives an "access guarantee" so that those who cannot benefit from exemptions can use public transport to come to the centre.<sup>29</sup> The Brussels region offers free public transport and access to car sharing for residents scrapping their cars.<sup>30</sup> The Belgian city of Ghent offers financial support for the purchase of electric vehicles that are shared through recognised car-sharing organisations.<sup>31</sup>

**Help small businesses, sole traders and charities go zero emission:** Providing targeted support to small businesses and charities whose vehicles run for many kilometres every day (like delivery vans, craftsmen) and that could not afford a transition to zero-emission vehicles otherwise is important to reduce pollution and enhance the public acceptance of a LEZ. London has put in place a scrappage scheme helping small businesses and charities to buy a LEZ-compliant vehicle, offering up to 6,000 pounds for purchase and running costs of an electric vehicle.<sup>32</sup> The future LEZ of the Grand-Paris region foresees allowances of 6000 to 9000 euros for small local businesses willing to switch their old car for a low and zero emission alternative.<sup>33</sup> Additional schemes exist at the level of the city of Paris.<sup>34</sup> SMEs in Brussels switching to compliant vehicles can benefit from up to 3000 euros in allowances.<sup>35</sup> Germany has created a fund for clean air policies to which both the car industry and the government contribute.<sup>36</sup>

**Help worse off families to purchase clean cars:** While switching to active modes of transport and public transport (see above) should always be the first option, there are also households that absolutely need a car (e.g. shift workers) and who cannot afford the purchase of a clean vehicle. Targeted financial support should be envisaged in such cases but be strictly limited. The Greater Paris LEZ, for example, already provides additional support to lower-income households<sup>37</sup> but such schemes should be developed further to avoid paying public money to households simply willing to buy a new car.

**Consider special rules for residents inside the LEZ:** In Madrid, less strict rules apply to registered residents and their visitors. In London people living within the ULEZ get more time (until 24 October 2021) to acquire a compliant vehicle. Besides, cities like London foresee discounts and exemptions for certain categories of drivers such as residents or disabled people.<sup>38</sup> And when most of the LEZ get more ambitious - often by 2025 - costs of zero emission cars are expected to drop significantly and reach parity with conventional cars, whereas a second hand market for these vehicles will have developed (e.g. from a new company car fleet today). When foreseeing exemptions, it is however important not to undermine the effectiveness of LEZ.

## **Citizens are in favour of Low-Emission Zones**

Even if policies that support the transition towards clean alternatives are put in place LEZ are sometimes portrayed as unpopular. This is not only contradicted by local experience, with citizens often supporting the expansion of traffic restrictions to their neighbourhoods like in Milan with the extension of the area C to the bigger area B<sup>39</sup> or the almost car-free centre of the Belgian city of Ghent.<sup>40</sup> Also, opinion polls confirm that citizens support LEZ. An IPSOS survey commissioned by T&E in 2018 showed that a majority of people supported LEZ.<sup>41</sup> 67% of people interviewed in nine European countries were either 'strongly' or 'somewhat' supporting the introduction of LEZ. Support was the highest in Hungary, Italy and Great Britain.

## **3. Well-designed Low-Emission Zones reduce air pollution**

As shown above Low-Emission Zones are justified and enjoy the support of citizens. And there also is a comprehensive body of research that has studied the effectiveness of LEZ.<sup>42</sup> The table on next pages summarises the findings of relevant scientific literature that analyses observed effects on air quality:

**Table 1 - Effects of Low-Emission Zones on Air Quality in Europe**

Location(s) of LEZ	Name of the scheme	Reduction of PM10	Reduction of PM2.5	Reduction of NO2 (or NOx if indicated)	Reduction of other pollutants	Remarks on the methodology	Reference (see full reference in annex 1)
5 EU Member States (Denmark, Germany, Netherlands, Italy and UK)	Environmental zones	Reduction of annual mean concentration of up to 7% in German LEZ	-	Reduction of annual mean concentration of up to 4% in German LEZ	Significant reduction of the traffic contribution to BC concentrations (15-17% in London) and total EC concentration (13-16% in Amsterdam, Berlin, Leipzig). Significant reduction of ratio of black carbon to PM10 in Milan.	Review of studies undertaken in 5 Member States. German LEZ found to be more effective in air pollution, probably because light-duty vehicles are also covered.	Holman, Claire, Harrison, Roy, Querol. Xavier, 2015
17 German cities	Environmental zones ('Umweltzonen')	-	-	4%	-	concentrations measured inside and outside LEZs in 17 German cities of 6 federal states (2005-2009)	Morfeld P, Groneberg D. A., Spallek M., 2014
19 German cities	Environmental zones ('Umweltzonen')	<5% at stations near traffic, ≤1% at all stations	-	-	-	Data on PM10 concentrations within and outside of LEZs from 19 German cities	Morfeld, P., Groneberg, D. A., Spallek, M., 2014
82 German cities	Environmental zones ('Umweltzonen')	up to 4% in city (up to 8% at stations with highest pollution)	-	-	-	difference-in-differences approach	Gehrsitz, Markus, 2017
137 German cities	Environmental zones ('Umweltzonen')	total reduction of 7.5 microgramms/m3 (stage 1 & stage 2 LEZ)	-	-	-	fixed effects panel data model for daily observations of PM10 concentrations from 2000 to 2009 with control, inter alia, for local meteorological conditions and traffic volume	Malina, C. & Scheffler, F., 2015
Amsterdam, NL	Environmental zone ('milieuzone') for heavy-duty only	traffic contribution reduced by 5.8%	-	traffic contribution reduced by 4.9%	Traffic contribution to EC reduced by 12.9%	Analysis of differences between a street frequently used by heavy-duty vehicles and an urban background location	Panteliadis, Pavlos et al., 2014
Berlin, DE	Environmental zones ('Umweltzonen')	3%	-	7-10%	Black Carbon concentration reduced by 15%	analysis of the relative contribution of the source sectors and black carbon data one year after introduction of the LEZ	Lutz, M., 2009
Brussels, BE	LEZ (Zone à basses émissions)	-	6.4% of PM2.5 emitted by light-duty vehicles	4.7% of NOx emitted by light-duty vehicles	no significant reduction in pollutant concentrations	Estimation of traffic emissions based on vehicle fleet observed	Bruxelles Environnement, 2019

					observed yet at official stations	by camera data. Reduction estimated for 6 months of the LEZ equivalent to estimated reduction over 12 months before.	
Leipzig, DE	Environmental zones ('Umweltzonen')	no statistically significant reduction	-	-	decrease in BC and particle number concentration (diameter 50 to 100 nm) in the vicinity of roads	specialized measurements of ambient black carbon (BC) mass concentrations and particle number size distributions	Rasch, F. et al., 2013
Lisbon, PT	LEZ ('Zona de Emissões Reduzidas')	29% (zone 1), 23% (zone 2)	not significant	12% (zone 1), 22% (zone 2)	-	Temporal trends were determined with a linear regression between the annual average concentrations and time).	Santos, M. et al., 2013
Lisbon, PT	LEZ ('Zona de Emissões Reduzidas')	annual average concentration reduced by 23% between 2011 and 2013, reduction significantly stronger inside LEZ	-	annual average concentration reduced by 12% between 2011 and 2013, but no significant difference between inside and outside LEZ	-	Analysis of the air quality data before and after the LEZ phase 2	Ferreira, Francisco et al., 2015
London, UK	toxicity charge	Concentration reduced by 2.46-3.07% compared to just over 1% outside LEZ	-	no discernible differences	-	Evaluation of the introduction of London LEZ by comparing trends inside and outside LEZ	Ellison, R.B., Greaves, Stephen, Hensher, David, 2013
Madrid, ES	LEZ ('Madrid Central') with features of a Zero-Emission Zone (see below)	-	-	Average of official stations shows a 17% reduction vs. previous 9 years. Inside the LEZ, 32% reduction in June 2019 vs. 2018, and 13% compared to years with lowest pollution.	-	Analysis of official data for period since creation of the monitoring network	Ecologistas en Acción, 2019
Milan, IT	LEZ with charge for polluting vehicles in centre ('ecopass zone' that later became Area C)	no significant differences	no significant differences	-	black carbon contribution to PM10 decreased by 47% in the Ecopass zone compared to the no-restriction zone	measuring simultaneously black carbon and PM mass concentrations with fixed monitoring stations	Invernizzi, Giovanni et al., 2011
Munich, DE	Environmental zone ('Umweltzone')	13% at traffic stations (19.6 % in summer, and 6.8 % in winter)	-	-	-	analysis of the routinely collected PM10 mass concentrations data by a semiparametric regression model	Fensterer, Veronika et al., 2014

The results of these studies can be summed up as follows: There is clear evidence that Low-Emission Zones can reduce air pollution but not for all of them available data shows significant reductions. The magnitude of the reduction in pollutants ranges from no discernible effect to a reduction of 32% (in this case for NO<sub>2</sub> pollution in Madrid Central).<sup>43</sup>

## The design of a LEZ is critical for its effectiveness

Looking at the reasons for the variation in the effectiveness of LEZ, researchers have identified several determining factors. More generally, they underline that the impact of the LEZ depends on the contribution of traffic to pollution levels. In cities where road transport is the dominant source of pollution the potential impact of a LEZ is greater.<sup>44</sup> But the main factor identified in the literature is the design of a LEZ, which determines its effectiveness and namely its ability to influence the change in the composition of the vehicle fleet. This depends on several key variables:

- **Territory covered:** The size of the LEZ is considered to be an important factor because it determines the residents who will be directly impacted, and what share of the vehicle fleet will be concerned.
- **Level of stringency:** Looking at the impact of several LEZ, Gehrsitz<sup>45</sup> finds that “more restrictive zones that only allow the cleanest vehicles into a city’s center are driving much of these results.”<sup>46</sup>
- **Enforcement of policies:** In Brussels, a first analysis of the LEZ implementation reveals that proper enforcement and penalties are key. LEZ infringements went down 70% as the city started to fine people.<sup>47</sup> Controlling foreign vehicles is equally important for effectiveness and public acceptance.
- **Exemptions granted to users:** Exemptions for certain groups or types of vehicles are important to consider but should be granted carefully and follow a strict timeline. Otherwise, there is a risk of opening loopholes as is the case in Italy, where many exemptions apply.<sup>48</sup>
- **Clarity and predictability of policies:** For users to adapt their behaviour and switch to cleaner vehicles or forms of mobility, a clear and predictable calendar must be established and communicated. This is also relevant for tourists for whom the lack of information and transparency is a problem, even if an [EU database on LEZ](#) already exists. Consulting stakeholders has also been identified by the French Environment Agency as key to the acceptance and effectiveness of LEZ.

## 4. The next step: from low towards zero emissions

In the previous section we have shown that LEZ can reduce air pollution provided that they are well-designed. At the same time the reductions observed so far are insufficient to reduce air pollution below legal limits all over the EU. This is confirmed not only by ongoing infringement procedures against 15 Member States but also in a recent special report by the European Court of Auditors that found that “EU citizens’ health [is] still not sufficiently protected” and that EU action had not delivered its expected impact.<sup>49</sup> Moreover, the ongoing revision of the WHO guidelines on air quality, which are expected to recommend lower limits in the next years, illustrates that a next step in clean air policies is indispensable.

And there is another strong argument for cities shifting up a gear: T&E’s recent analysis<sup>50</sup> of transport and climate policies shows that 100% sales of zero-emissions vehicles by 2035 will not on their own be enough to reach the targets of the Paris agreement. A faster phase-out of the existing fleet of vehicles with internal combustion engines is also needed to achieve fleet-wide zero emission by 2050, the analysis finds. Most of the existing LEZ do not require such a fundamental transition but do have the potential to play this important role. This future role is also officially recognised in the new EU guidance on “Sustainable Urban Mobility Plans”.<sup>51</sup> It is particularly interesting to look at the direction in which the frontrunners on air quality





		cycling and low emissions vehicles only (vehicles that emit less than 75g/km of CO <sub>2</sub> ).		opposing and 4% neither supporting nor opposing.	vehicles <sup>57</sup>
London, UK <sup>58</sup>	Zero-Emission Zone	phased introduction of a ZEZ covering central London and investigation of a City-wide ZEZ	local ZEZs covering the Barbican and Golden Lane estates and the City Cluster by 2022 <sup>59</sup>	-	Goal of 90% of motor vehicles entering the Square Mile are zero emission capable by 2030
Madrid, ES	'Madrid Central'	Combination of elements of a LEZ and a ZEZ. Access and parking rights depend on emission class of vehicles. Cars without a sticker cannot access the zone.	LEZ started on 30 November 2018, diesel vehicles to be phased out by 2024 and petrol vehicles by 2030	The city gives an 'access guarantee' that the centre can be accessed through public transport and special parking lots are made available.	Observed effects include NO <sub>2</sub> concentration inside the zone at lowest level since start of monitoring in 2010 (see table 1). No increase in pollution in the periphery. <sup>60</sup>
Oxford, UK	Zero-Emission Zone	Under current proposals vehicles that emit less than 75g of CO <sub>2</sub> /km from the tailpipe and capable of at least 10 miles of zero emission driving would be allowed into the zone.	Low emission and zero emission requirements planned to be introduced from 2020 onwards with two zones with different requirements.	-	Goal of setting a journey to zero transport emissions in Oxford by 2035.
Paris (City), FR	Low-Emission Zone ('zone à faibles émissions')	Phased introduction of a LEZ with phase-out of diesel vehicles by 2024 and petrol vehicles by 2030 as part of Paris Climate, Air and Energy Plan	First phase in force since 15 January 2017. Since 1 July 2019 ban of vehicles up to category 'Crit'Air 4' (diesel cars from before 2006, petrol cars from before 1997).	Does not apply to light-duty vehicles during the night and week-ends. <sup>61</sup>	Expected reduction of emissions: NO <sub>x</sub> by 19%, PM <sub>10</sub> by 8% and PM <sub>2.5</sub> by 13%. Goal: half exceedances of WHO guidelines. <sup>62</sup>
Paris metropolitan area, FR (79 communities)	'Zone à faibles émissions métropolitaine'	phased tightening of LEZ with ban of vehicles up to Crit'air 2 category (all diesel cars) by 2024 <sup>63</sup> and phase-out of all vehicles with an internal combustion engine by 2030	Since July 2019 first step of LEZ with ban of oldest vehicles (diesel from before 2001, petrol from before 1997).	Opinion polls show 75% of inhabitants support the introduction of a LEZ <sup>64</sup> , financial support of up to 17,000 EUR for purchase of a clean vehicle.	Goal of "100% clean vehicles by 2030"

## 5. Conclusions

The above analysis shows that there are not only very strong health and equity arguments for introducing Low-Emission Zones in European cities but that they can also deliver significant air quality improvements if they are well-designed. Citizens do understand this and a majority of them supports LEZ. Various examples show that policies exist to make sure all citizens are not only better protected but can also make the necessary transition towards clean mobility. If LEZ are necessary, they are however not sufficient given the magnitude of air quality and climate challenges. A gradual transition towards zero emissions is necessary and a number of cities lead by example. Other cities in Europe should be inspired by these examples and join the group of clean air champions.

## Further information

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## Annex 1: Full references of studies listed in table 1

(in the same order as in table 1)

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## Endnotes

<sup>1</sup> <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52018DC0330&from=FR>

<sup>2</sup> <https://www.eea.europa.eu/publications/air-quality-in-europe-2018>

<sup>3</sup> For an overview see [http://europa.eu/rapid/press-release\\_IP-19-1475\\_en.htm](http://europa.eu/rapid/press-release_IP-19-1475_en.htm) and in July 2019, Spain was also referred to court.

<sup>4</sup> <https://www.google.com/url?q=https://www.umweltbundesamt.de/themen/neun-fragen-antworten-diesel&sa=D&ust=1563872204054000&usg=AFQjCNEbm4xtL0oeU8UpC0XrfbkBEXbICQ>

<sup>5</sup> <https://www.paris.fr/actualites/nouvelle-etape-crit-air-des-le-1er-juillet-2017-4834>

<sup>6</sup> Holman, C., Harrison, R., Querol, X: Review of the efficacy of low emission zones to improve urban air quality in European cities, 2015.

<sup>7</sup> The first LEZ in Europe were introduced in 1996 in the Swedish cities of Stockholm, Göteborg and Malmö, see Holman, C., Harrison, R., Querol, X: Review of the efficacy of low emission zones to improve urban air quality in European cities, 2015.

<sup>8</sup> [https://www.transportenvironment.org/sites/te/files/publications/City%20bans%20are%20spreading%20in%20Europe\\_Report.PDF](https://www.transportenvironment.org/sites/te/files/publications/City%20bans%20are%20spreading%20in%20Europe_Report.PDF)

<sup>9</sup> [https://www.eltis.org/sites/default/files/urban\\_vehicle\\_access\\_regulations\\_and\\_sustainable\\_urban\\_mobility\\_planning.pdf](https://www.eltis.org/sites/default/files/urban_vehicle_access_regulations_and_sustainable_urban_mobility_planning.pdf)

<sup>10</sup> <https://www.lobbycontrol.de/2019/02/dieseldebate-ein-lungenarzt-aufruf-mit-verbindungen-zur-autoindustrie/>

<sup>11</sup> <https://www.reuters.com/article/us-germany-emissions-scheuer/german-minister-wants-eu-to-review-limit-on-toxic-diesel-particles-idUSKCN1PO32I>

<sup>12</sup> <https://www.theguardian.com/environment/2019/feb/05/germany-air-pollution-limit-eu-backlash-evidence-world-health-organisation>

<sup>13</sup> <https://www.cleanenergywire.org/news/eu-rebuffs-german-call-more-lax-nox-limits-slap-face-report>

<sup>14</sup> [https://www.who.int/en/news-room/fact-sheets/detail/ambient-\(outdoor\)-air-quality-and-health](https://www.who.int/en/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health)

<sup>15</sup> <https://www.theguardian.com/environment/ng-interactive/2019/may/17/air-pollution-may-be-damaging-every-organ-and-cell-in-the-body-finds-global-review>

<sup>16</sup> [https://www.who.int/news-room/fact-sheets/detail/ambient-\(outdoor\)-air-quality-and-health](https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health)

<sup>17</sup> [https://journal.chestnet.org/article/S0012-3692\(18\)32722-3/fulltext](https://journal.chestnet.org/article/S0012-3692(18)32722-3/fulltext)

<sup>18</sup> <http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/data-and-statistics>

<sup>19</sup> <http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/data-and-statistics>

<sup>20</sup> Special Eurobarometer 468: Attitudes of European citizens towards the environment, October 2017

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- <sup>21</sup> Costs estimated for the year 2016: <https://epha.org/wp-content/uploads/2018/11/embargoed-until-27-november-00-01-am-cet-time-ce-delft-4r30-health-impacts-costs-diesel-emissions-eu-def.pdf>
- <sup>22</sup> Ibid.
- <sup>23</sup> <https://www.transportenvironment.org/publications/diesel-true-dirty-story>
- <sup>24</sup> <https://www.vcoe.at/files/vcoe/uploads/News/VCOe-Factsheets/2018/2018-02%20Mobilitaetsarmut%20nachhaltig%20verringern/VC%C3%96-Factsheet%20Mobilit%C3%A4t%20als%20soziale%20Frage%20.pdf>
- <sup>25</sup> <https://www.sciencedirect.com/science/article/pii/S1361920919300392#!>
- <sup>26</sup> <https://airqualitynews.com/2019/07/09/air-pollution-has-twice-the-impact-on-lung-function-for-lower-income-households/>
- <sup>27</sup> <https://www.eea.europa.eu/highlights/protect-vulnerable-citizens>
- <sup>28</sup> Bleijenberg, Arie: New Mobility – Beyond the car era, 2018.
- <sup>29</sup> <https://www.madrid.es/portales/munimadrid/es/Inicio/Movilidad-y-transportes/Madrid-Central-Zona-de-Bajas-Emisiones/Garantia-de-acceso/Garantia-de-acceso/?vgnnextfmt=default&vgnnextoid=db8eda4581f64610VgnVCM2000001f4a900aRCRD&vgnnextchannel=eb6e96d2742f6610VgnVCM1000001d4a900aRCRD>
- <sup>30</sup> <https://www.lez.brussels/fr/content/particuliers>
- <sup>31</sup> <https://stad.gent/groen-milieu/producten/subsidie-elektrische-cng-deelwagen-voor-particulieren>
- <sup>32</sup> <https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/scrappage-scheme>
- <sup>33</sup> <https://www.ademe.fr/sites/default/files/assets/documents/rapport-zones-faibles-emissions-lez-europe-ademe-2018.pdf>, p. 94.
- <sup>34</sup> <https://reseauactionclimat.org/wp-content/uploads/2017/04/Les-Villes- respire -de-demain-repenser-la-mobilite%CC%81-face-a%CC%80-l%E2%80%99urgence-climatique-et-sanitaire-.pdf>
- <sup>35</sup> <https://www.lez.brussels/en/content/professionals>
- <sup>36</sup> <https://www.dw.com/en/german-cities-get-more-funding-for-air-quality-but-retro-fitting-plan-still-to-come/a-46565361>
- <sup>37</sup> <https://www.zonefaiblesemissionsmetropolitaine.fr/>
- <sup>38</sup> <https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/discounts-and-exemptions?intcmp=52218>
- <sup>39</sup> <https://www.ohga.it/prende-il-via-larea-b-a-milano-ecco-cosa-ne-pensano-i-residenti-e-chi-si-reca-in-citta-per-lavoro/>
- <sup>40</sup> <https://www.theguardian.com/cities/2016/nov/28/car-free-belgium-why-cant-brussels-match-ghents-pedestrianised-vision>
- <sup>41</sup> [https://www.transportenvironment.org/sites/te/files/publications/City%20bans%20are%20spreading%20in%20Europe\\_Report.PDF](https://www.transportenvironment.org/sites/te/files/publications/City%20bans%20are%20spreading%20in%20Europe_Report.PDF)
- <sup>42</sup> Such an evaluation is not an easy task and holds four fundamental difficulties (see Pasquier, A., & André, M., <https://hal.archives-ouvertes.fr/hal-01467083/document>): First, the effect of the LEZ needs to be separated from external effects and the impact of other policies. Secondly, the results must be compared with a scenario without a LEZ, in which certain improvements of air quality would have taken place as part of the normal fleet renewal. Thirdly, a variation in dispersion conditions and meteorology may interfere with the impact of a LEZ during a given period. And finally, data limitations and the relatively small number of official monitoring stations make it difficult to account for all factors. Researchers have chosen different strategies to deal with these difficulties, ranging from comparisons of air quality before and after the introduction of a LEZ or in and outside the LEZ to sophisticated statistical studies that control for numerous other potential variables.
- <sup>43</sup> <https://www.ecologistasenaccion.org/114930/balance-del-funcionamiento-de-madrid-central/>
- <sup>44</sup> <https://www.toi.no/getfile.php?mmfileid=49204>
- <sup>45</sup> Gehrsitz, 2017. See full reference above.
- <sup>46</sup> <https://www.toi.no/getfile.php?mmfileid=49204>
- <sup>47</sup> <https://environnement.brussels/news/decouvrez-le-premier-bilan-encourageant-de-la-zone-de-basses-emissions>

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- <sup>48</sup> <https://www.ademe.fr/sites/default/files/assets/documents/rapport-zones-faibles-emissions-lez-europe-ademe-2018.pdf>
- <sup>49</sup> <https://www.eca.europa.eu/en/Pages/NewsItem.aspx?nid=10750>
- <sup>50</sup> [https://www.transportenvironment.org/sites/te/files/publications/2018\\_11\\_2050\\_synthesis\\_report\\_transport\\_decarbonisation.pdf](https://www.transportenvironment.org/sites/te/files/publications/2018_11_2050_synthesis_report_transport_decarbonisation.pdf)
- <sup>51</sup> European Platform on Sustainable Urban Mobility Plans: UVAR and SUMP's Regulating vehicle access to cities as part of integrated mobility policies, draft of July 2019.
- <sup>52</sup> [https://assets.amsterdam.nl/publish/pages/863561/amsterdam\\_uitstootvrij\\_mei\\_2019-web.pdf](https://assets.amsterdam.nl/publish/pages/863561/amsterdam_uitstootvrij_mei_2019-web.pdf)
- <sup>53</sup> <https://www.amsterdam.nl/bestuur-organisatie/volg-beleid/duurzaamheid-energie/schone-lucht/>
- <sup>54</sup> <http://www.parlement.brussels/texte-de-la-declaration-de-politique-generale-du-gouvernement-bruxellois/>
- <sup>55</sup> <https://consultation.hackney.gov.uk/streetscene/city-fringe-ultra-low-emission-streets-1/results/ulevstreetssignedda.pdf>
- <sup>56</sup> <https://www3.hackney.gov.uk/ulev-streets>
- <sup>57</sup> <https://consultation.hackney.gov.uk/streetscene/city-fringe-ultra-low-emission-streets-1/results/ulevstreetssignedda.pdf>, p.6
- <sup>58</sup> As regards the new “Ultra-Low Emission Zone” (ULEZ) introduced in London in April 2019, no comprehensive assessment is available yet. The Mayor of London however stated that since the announcement of the policy in 2017 pollution levels had been reduced by 20%, see <https://www.london.gov.uk/questions/2019/12201>
- <sup>59</sup> <https://www.cityoflondon.gov.uk/services/transport-and-streets/Documents/draft-transport-strategy.pdf>
- <sup>60</sup> <https://www.ecologistasenaccion.org/114930/balance-del-funcionamiento-de-madrid-central/>
- <sup>61</sup> <https://www.paris.fr/actualites/nouvelle-etape-crit-air-des-le-1er-juillet-2017-4834>
- <sup>62</sup> <https://www.paris.fr/stoppollution>
- <sup>63</sup> <https://www.metropolegrandparis.fr/sites/default/files/2019-06/MGP-EC-DossierPressZFE-ImpPa%CC%80P-02-BD.pdf>
- <sup>64</sup> <https://www.metropolegrandparis.fr/sites/default/files/2019-06/MGP-EC-DossierPressZFE-ImpPa%CC%80P-02-BD.pdf>, p.6