

## POLICY DIALOGUE 1

# How can real-world vehicle emissions data help cities to become zero-emission: some evidence from Europe

Sandra Wappelhorst, Rachel Muncrief

MAY 2019



## **ACKNOWLEDGMENTS**

The author would like to thank the Polis network and Bruxelles Environnement for co-hosting one of the workshops that contributed to the content of this report.

This report was funded through the generous support of the FIA Foundation.

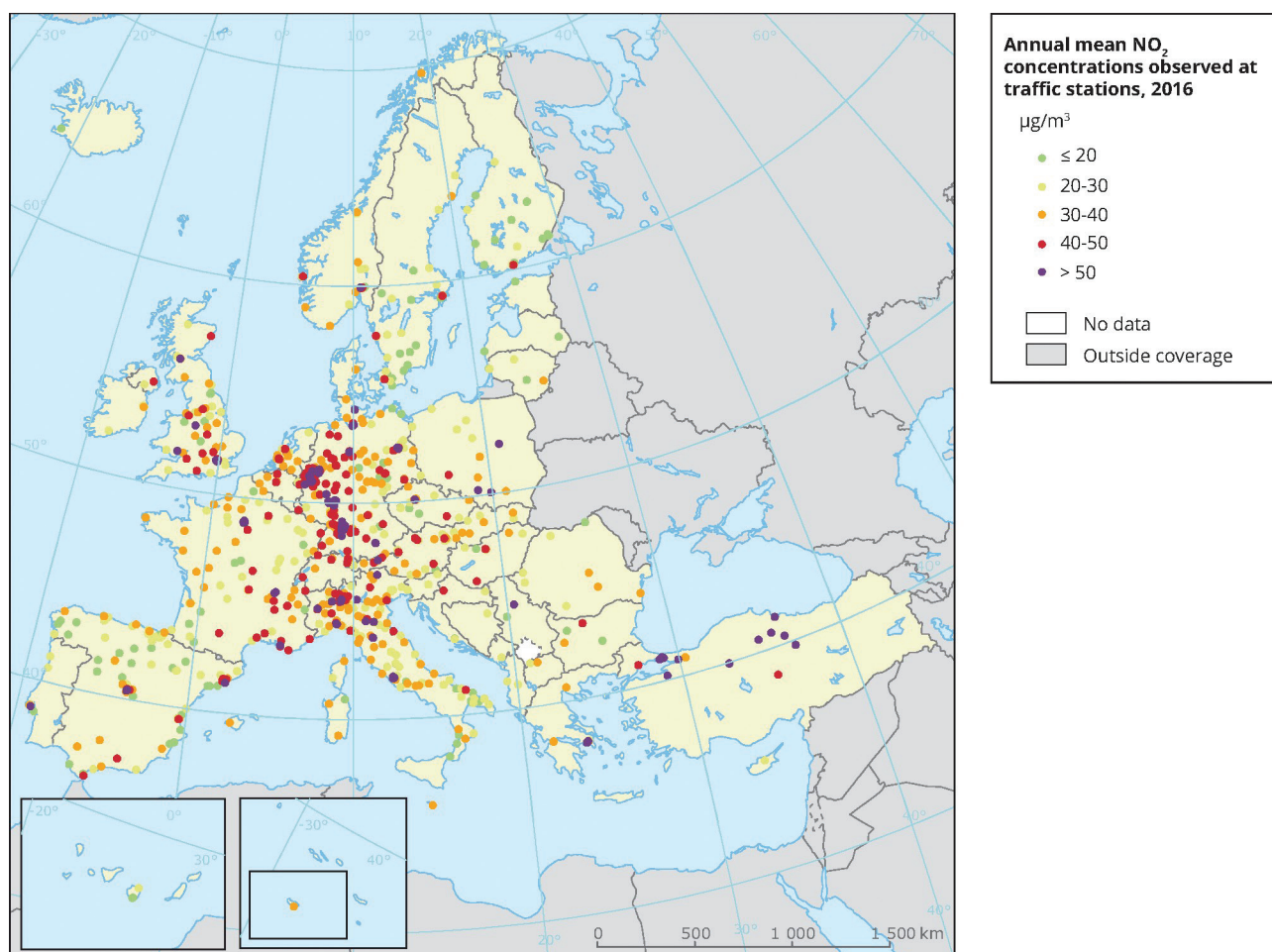
# INTRODUCTION

Poor air quality is a major issue for European cities, harming people's health and the environment. High levels of nitrogen oxides (NO<sub>x</sub>), particulate matter (PM), and ozone pollution significantly contribute to these problems. Excess NO<sub>x</sub> emissions above legal limits in the real world are linked to 11,400 early deaths in Europe each year and particulate emissions have even larger health impacts. Nitrogen dioxide (NO<sub>2</sub>) exceedances are an EU-wide problem, especially in large conurbations (see Figure 1). For example in London and Paris, motorized vehicles contribute to around 50% of urban NO<sub>x</sub> emissions. In London, the majority of its inhabitants are exposed to PM over 50% above air quality guidelines.

Policies to address vehicles' contribution to poor air quality are challenging as there are huge gaps between the tested and real-world values of vehicle emissions. Understanding real-world emissions is vital to developing effective policies to tackle air quality problems, such as low emission zones (LEZs), vehicle bans, or scrappage schemes. The TRUE Initiative's aim is to address these problems through the collection of real-world data on vehicle emissions, research, and outreach. The overall question is how to make best use of real-world emissions data to frame policy discussions.

This report builds on two events:

- On December 13th 2018, the TRUE Initiative hosted a one day symposium "Remote sensing data and



**Figure 1.** Nitrogen dioxide (NO<sub>2</sub>) emissions observed at traffic stations in European countries in 2016

Source: <https://www.eea.europa.eu/data-and-maps/figures/annual-mean-no2-concentration-observed-11>

low emission zones” at the FIA Foundation offices in London. Over 35 stakeholders participated in person as well as remotely. Participants represented government agencies, non-governmental organizations (NGOs), research institutes, and philanthropies. The purpose of the meeting was (1) to get a better understanding about what policies are being utilized by European cities to tackle transport related vehicle emissions and (2) to discuss options on how real-world emission data can be utilized to support these policies.

- On February 27th 2019, the TRUE Initiative, the Polis network, and Bruxelles Environnement co-hosted a one day workshop on “Zero-emission cities: exchange of best-practices between EU cities and regions” at Bruxelles Environment offices in Brussels. Over 60 stakeholders, mainly representatives from European cities and regions, participated. The aim of the workshop was to discuss their strategies and experiences in banning fossil fuel road transport vehicles at city level.

Building on the findings of these two events, this report provides an overview of policies aimed at tackling local air quality with the goal of eventually moving towards zero-emissions cities. The focus is on those European cities and regions that participated in the two events. This overview is followed by recommendations on how local and regional authorities and other stakeholders might make best use of real-world emissions data to frame local and regional policy discussions.

## THE IMPORTANCE OF REAL-WORLD EMISSIONS DATA

Measurement of exhaust emissions from vehicles during normal, on-road operation is key to any effective system for controlling air pollution in the transportation sector. It is essential to detecting discrepancies between certification-test performance and actual, “real-world” vehicle emissions, whatever the cause of the performance gap—equipment failure, normal deterioration with use, or deliberate efforts to cheat regulations. It gives regulators and researchers insight into both transportation’s contributions to local

air-quality problems and the effectiveness of policies intended to mitigate those problems.

The most widely known method of in-use vehicle emissions testing employs a portable emissions measurement system, or PEMS. This involves sampling and analyzing tailpipe exhaust with equipment mounted on an individual vehicle as it is driven over the road or on a closed course, and produces a detailed, second-by-second record of emissions from that single vehicle. PEMS is widely used by researchers. Remote sensing as a means of measuring motor vehicle emissions is less well known, though it is a well-established research technique in that area as well as others, and like PEMS has been successfully deployed by vehicle emissions regulators. Compared to PEMS testing it is less expensive in terms of both time and money. That plus the unobtrusive (“remote”) nature of the technique make it well-suited to fleet monitoring. More generally, the basic characteristics of the data collected by the two methods—detailed second-by-second data on an individual vehicle or small number of selected vehicles from PEMS, one-second or half-second samples from a potentially very large number of vehicles from remote sensing—show them to be complementary tools that, deployed together, can produce a more precise and detailed understanding of not only pollutant emissions from on-road transport but also policy performance.

City-level authorities are working to develop or improve policies that could be better informed with real-world emissions data obtained from remote sensing and other sources. For example, cities considering implementation of a LEZ or other type of vehicle restriction measure could utilize the data to predict the effectiveness of different policy iterations. For example, a city may choose to restrict all Euro 3 and 4 diesel vehicles believing that this would result in significant air quality improvements since NO<sub>x</sub> emissions limits for these vehicles are significantly higher than those of Euro 5 and Euro 6. However, it is likely that this policy will not have as significant an impact on air quality as expected due to the fact that in real-world operation there was no significant decrease in NO<sub>x</sub> emissions from diesel cars between Euro 3 to Euro 5.

## POLICIES TO TACKLE AIR QUALITY PROBLEMS AND CITY EXAMPLES

Some local and regional governments in Europe have introduced access regulations to certain areas of their city, aiming at improving congestion, pollution, noise, and accessibility. Access regulations include Ultra Low Emission Zones (ULEZs) and LEZs, congestion charging, car-free zones, limited access zones, and pollution peak measures. These policies are generally supported by accompanying measures that provide cost-effective and user-friendly alternatives and cover actions such as the promotion of public transport, pedestrianization, active mobility, parking management, subsidies for low-emission vehicles, or the installation of charging points for electric vehicles.

Cities across Europe are in various stages of implementing vehicle access regulations. The following list provides a summary of the status of these type of regulations from 9 selected European cities from both Eastern (Bulgaria, Czech Republic, and Poland), Western (Belgium, Switzerland, and UK), and Southern (Italy, Spain) Europe:

- The Belgium capital city of **Brussels** introduced a LEZ in 2018. The LEZ covers the entire region of Brussels and applies to passenger cars and light commercial vehicles, buses, and coaches. Trucks are not affected by the LEZ as they already pay for the national tolling scheme. Brussels's LEZ will be gradually implemented, limiting the traffic to minimum Euro 5 diesel and Euro 2 petrol vehicles by 2025. The enforcement of the LEZ is made through a network of 200 cameras, which will be extended to 300 by the end of 2019. The first months after the introduction of the LEZ show a decrease in the number of non-compliant vehicles entering the zone. The city is now looking into the possibility of banning all diesel and petrol vehicles in the post-2025 timeframe. Brussels has yet to collect data on real-world vehicle emissions in the city, however there is significant interest in doing so in the future.
- The Polish city of **Krakow** has introduced a pilot LEZ in the city center with the aim to permanently install access regulations to its city center. One of the city's major problems are high levels of PM emissions, but NOx emissions are also a huge concern. Particularly coal and wood heating are contributing to these problems, followed by transport as the second largest source of PM emissions. Between 70 and 75% of people in Krakow own old vehicles that only meet Euro 1-4 standard, of which over 50% are diesel cars. So far, there is little available data on real-world vehicle emissions in the city. In the second quarter of 2019, Krakow is planning to utilize remote sensing technology to collect data on vehicle emissions in order to assist their goal of introducing a permanent LEZ in the city center.
- The United Kingdom's capital city of **London** has done extensive work to tackle vehicle emissions. A congestion charge scheme was introduced in February 2003. In 2017, an additional Toxicity charge (T-charge) was introduced for vehicles that did not meet Euro 4 standard. In April 2019, the T-charge was replaced by an ULEZ which restricts pre-Euro 6 diesels and pre-Euro 4 petrol vehicles. Initially, the ULEZ will cover the congestion charging zone and will be expanded to the inner London area starting October 2021. In addition in 2008, a LEZ was installed covering most of Greater London with fines for drivers of non-compliant vehicles (lorries, buses, coaches, vans, motor caravans, ambulances). The LEZ emission standards will be tightened in October 2020. London has been using automatic number plate recognition (ANPR) to record number plates and has used remote sensing to collect data on vehicle emissions. In terms of effects, 96% of heavy duty vehicles and 98% of light vehicles comply with London's access regulation standards.
- Spain's capital city of **Madrid** launched a LEZ scheme in November 2018. The LEZ covers both individual cars and freight vehicles. The LEZ area is more than double the size compared to the previous scheme (residential priority areas) that was in place. The rules for entering the LEZ will gradually tighten over the following years. The enforcement of the LEZ is made by cameras and is based on a national

label system. The first impacts of the LEZ show a 20% decrease of total traffic, a 10% decrease of emissions, and less parking of older vehicles. However, since the launch of the LEZ, many cars drive and park just outside, increasing the problems in the areas adjacent to the LEZ.

- The Italian city of **Milan** expanded its LEZ in early 2019 to cover a much larger area of the city and to include passenger cars as well as trucks. The small central area is also utilizing a charging scheme. The LEZ will be phased in over a period of approximately 10 years. In the first year diesel vehicles of Euro 4 and older will be banned. By 2022, only Euro 5 and newer diesel vehicles will be allowed to enter the LEZ and by 2025, this will begin to apply to Euro 6 diesel vehicles and Euro 3 and older petrol vehicles. NO<sub>2</sub> emissions have been monitored in Milan over a period of two years, however has not yet been using remote sensing.
- The capital city of the Czech Republic **Prague** has a LEZ in place since 2016. It affects all vehicle types. The city is using roadside particulate measurement to detect polluting vehicles such as vehicles with removed diesel particulate filter. Since 2011, all new diesels must have a diesel particulate filter, but PM 2.5 levels are not improving in Prague. Emissions testing was conducted in Prague to try to learn more about real-world PM emissions. 24,000 vehicles were sampled within 10 days, of which about 1/3 were petrol vehicles, 1/3 diesel vehicles with diesel particulate filter, and another 1/3 diesel vehicles without a diesel particulate filter. For both particle number (PN) and PM, about 5% of vehicles contributed to 50% of particulate emissions.
- **Scotland** is planning LEZs in its four largest cities (Glasgow, Edinburgh, Aberdeen, Dundee). The aim is to allow Euro 6 diesel and Euro 4 petrol (and newer) in these LEZs, providing exemptions for certain vehicle types. Glasgow was the first city to introduce a LEZ in December 2018. The LEZ applies to local service buses, phasing in all vehicles by

the end of 2022. A penalty scheme will be used for non-compliant vehicles. In 2017, remote sensing data were collected in Scotland (140,000 valid records from 3 locations in 25 days). Scotland is planning to continue using remote sensing measurements and data to evaluate the accuracy of vehicles' Euro emission standards, the effects of different driving conditions of the Scottish vehicle fleet as well as the effectiveness of LEZs. Scotland intends to become "Europe's most comprehensive network of cutting-edge remote sensing air quality monitors on local and truck roads".

- Bulgaria's capital city **Sofia** has a LEZ in the city center in place which applies to heavy duty trucks. Sofia has adopted a sustainable urban mobility plan with the goal to improve transit speeds, to increase the comfort of public transportation, to change the modal split towards sustainable means of transportation, and to reduce pollution. For example, the city is planning to have 90% of their city buses to be Euro VI by 2019. In the end of 2018, Sofia started its first remote sensing project (4 locations, 20,000 measurements). This included display panels telling drivers if their emissions were high or not.
- **Zurich**, Switzerland's capital city, has no LEZs in place, but more than 20 years of experience with remote sensing. Since 2002, petrol NO<sub>x</sub> emissions have gone down steadily, while diesel NO<sub>x</sub> emissions have remained fairly constant. Total emissions have increased due to increasing diesel share. Data by model year shows diesel NO<sub>x</sub> emissions actually increased slightly through 2015 while standards decreased, with emission finally coming down in 2016. Temperature has little effect on petrol Euro 6 emissions, but petrol Euro 4-5 and diesel Euro 4-6 show rapid increases in NO<sub>x</sub> emissions above 20-25 degrees Celsius.

Table 1 summarizes urban access regulations including LEZs and other regulations for a larger number of cities and regions in Europe.

**Table 1.** Selection of European cities and regions that have urban access regulations (in alphabetical order).

Policy	City/Region	Comment
<b>ULEZ</b>	City of <b>London</b> (United Kingdom)	Replacement of T-Charge; ULEZ in place in the central London area since April 2019, to be extended to the inner London area in October 2021
<b>LEZ</b>	City of <b>Amsterdam</b> (Netherlands)	Extension planned to become an emission-free city by 2025
	City of <b>Arnhem</b> (Netherlands)	
	State of <b>Baden-Wuerttemberg</b> (Germany)	
	City of <b>Berlin</b> (Germany)	
	City of <b>Brussels</b> (Belgium)	
	Region of <b>Catalonia</b> (Spain)	Applies to the city of Barcelona and neighbouring cities, to be installed from temporary to permanently
	Region of <b>Flanders</b> (Belgium)	
	City of <b>Lisbon</b> (Portugal)	Extension of two LEZs
	City of <b>London</b> (United Kingdom)	LEZ including lorries since 2008; regulations will tighten in 2020
	City of <b>Madrid</b> (Spain)	Gradual implementation as part of Plan A (Air Quality and Climate Change Plan for the city of Madrid)
	City of <b>Milan</b> (Italy)	LEZ
	City of <b>Nijmegen</b> (Netherlands)	Applies for commercial vehicles
	City of <b>Oslo</b> (Norway)	Extension planned
	City of <b>Paris</b> (France)	Extension to neighbouring cities
	City of <b>Prague</b> (Czech Republic)	
	City of <b>Sofia</b> (Bulgaria)	
	City of <b>Strasbourg</b> (France)	
<b>Car-free and Limited Traffic Zones (LTZs)</b>	City of <b>Budapest</b> (Hungary)	Highly protected zone, restricted zone for freight
	City of <b>Czestochowa</b> (Poland)	LTZ
	City of <b>Krakow</b> (Poland)	Car-free zone
	City of <b>Lisbon</b> (Portugal)	Car access conditioned zone
	City of <b>London</b> (United Kingdom)	Car access conditioned zone (Congestion Charging Zone) in place since 2003
	City of <b>Milan</b> (Italy)	LTZ
	City of <b>Oslo</b> (Norway)	Car-free zone
	City of <b>Strasbourg</b> (France)	In place for the city center
<b>Urban toll rings</b>	City of <b>Oslo</b> (Norway)	Tolls for using urban ring roads, introduced in 1990
<b>Pollution peak measures</b>	City of <b>Barcelona</b> (Spain) City of <b>Brussels</b> (Belgium) City of <b>Budapest</b> (Hungary) City of <b>Madrid</b> (Spain) City of <b>Oslo</b> (Norway) City of <b>Paris</b> (France)	
<b>Other measures</b>	Region of <b>Baden-Wuerttemberg</b> (Germany)	Low-emission spaces, e.g. bike lanes
	City of <b>Oslo</b> (Norway)	National ban on diesel sales by 2025



Cities and regions are facing a variety of challenges when implementing vehicle access restrictions and other related policies. Below we summarize the primary challenges that we have compiled based on our discussions with city level representatives. In addition, we explore if there are any opportunities for real-world emissions data to be utilized to help address these challenges.

- **Public awareness and acceptance.** Policies that restrict mobility or city access are typically unpopular among the general public. That being said, much of the general public living in urban areas within Europe are well aware and concerned about the harmful health impacts of air pollution from vehicle exhaust. Therefore, there is an opportunity to utilize real-world emissions data to explicitly help consumers understand which vehicles are the highest polluters, how much they are polluting, and why they need to be restricted from the urban centers.
- **Regulatory design, predicting and monitoring impact.** As illustrated above, there are a number of different ways to design a vehicle restriction measure and many different details that policymakers must weigh and consider. For example: Where to set the boundaries of the restriction area? Which vehicles types and Euro standards will be restricted? Which vehicles will be exempted? Should a full ban be implemented or should drivers be able to pay a fee for entry? If a fee option is selected how much should it be? Over what timeframe should the measure be phased in? What accompanying measures (such as preferred parking or electric vehicle charging) would be implemented? Real-world emissions data might not be able to inform every one of those questions, but by utilizing real-world emissions factors many of these regulatory design decisions can be quantified and compared to each other to allow policymakers to understand the likely emissions impact of their proposed policy. Real-world emissions data can also be collected as a new policy is being phased in to monitor the emissions impact and ensure it is in line with what was predicted.
- **Legal framework.** City level policy makers have restrictions and limitations on the policies they are legally permitted to enact. For example, city level authorities have no control over the emissions standards that impact new and existing vehicles. In addition, in Europe, city officials who are implementing vehicle restriction measures are typically only permitted to differentiate restrictions based on certain variables such as vehicle type, fuel type, Euro standard, and model year. This can be difficult given the wide range of real-world emissions produced by vehicle models of a given model year or Euro standard. Therefore, city level authorities rely heavily on policies being made at the national and EU level to help them meet their air quality goals. In this case it could be quite helpful for city level authorities to collect and share real-world emissions data with national and EU authorities as they engage on measures to control vehicle emissions.
- **Costs and resources.** The costs of implementing new measures in cities can be high. Resources are required to ensure that the policy is well developed and implemented effectively. These costs include both personnel costs as well as hardware required for enforcing and monitoring compliance. Collecting real-world data is an important part of monitoring compliance and ensuring the desired outcomes are being realized. Ideally these types of policies can pay for themselves through fees and other charging schemes. And when the health benefits of the emissions reductions are monetized these schemes, if implemented effectively, will result in a high benefit to cost ratio.
- **Enforcement.** Enforcing vehicle restriction measures can be a significant challenge. There are a number of questions to be answered as to how to identify which vehicles are permitted within the restriction zone and how to identify when a unpermitted vehicle enters. Many cities are moving towards using license plate recognition systems for this purpose, although foreign vehicles may pose problems if the vehicle is not in the city's database. In addition, some cities use a sticker or labeling system, where only vehicles with a certain sticker would be allowed entry (this may change based on the air quality on a given day). Some cities use police to help enforce their LEZ. It is also necessary to have sufficient signage and information to inform drivers of the restriction.



- **West to East export.** As LEZs that have focused on restricting older diesel vehicles have grown across Western Europe, many have sold their old diesel cars. A large number of these high polluting cars have been exported to Eastern Europe which essentially results in shifting, instead of eliminating, the health burden from vehicles. Ideally these old vehicles would be scrapped instead of being exported and resold. Cities can put in place incentive schemes for consumers to scrap their old vehicles rather than selling them off. In addition, this issue adds a huge incentive for cities in Eastern Europe to implement LEZs and other similar measures on par with what is being done in Western Europe in order to deter people from purchasing these high polluting imported vehicles.

## RECOMMENDATIONS

In conclusion, we propose the following recommendations on how city agencies can make use of real-world emissions data to improve policymaking that is geared towards reducing, and eventually eliminating, vehicle pollution in cities:

- Leverage real-world emissions data for a publicity campaign to garner public support for new policies and help consumers make better vehicle purchasing decisions.
- Utilize real-world emissions data to calculate and compare the potential impact of different policy options and select the best option.
- Install remote sensing networks to track real-world vehicle emissions in the city and enable rapid policy responses to new information.
- Share real-world city-level emissions data when engaging with national and European level policymakers to promote impactful decisionmaking throughout all levels of government.
- Allow exemptions for vehicles that have been shown to have low real-world emissions.







#### TO FIND OUT MORE

For details on the TRUE rating and related questions, contact Rachel Muncrief, [rachel@theicct.org](mailto:rachel@theicct.org). For more information on the TRUE project, visit [www.trueinitiative.org](http://www.trueinitiative.org).

The Real Urban Emissions Initiative (TRUE) is a partnership of the FIA Foundation and the International Council on Clean Transportation.

#### TRUE—The Real Urban Emissions Initiative

FIA Foundation, 60 Trafalgar Square, London WC2N 5DS, United Kingdom

For more information contact: [true@fiafoundation.org](mailto:true@fiafoundation.org)

[@TRUE\\_Emissions](https://twitter.com/TRUE_Emissions)

[www.trueinitiative.org](http://www.trueinitiative.org)