Social aspects of low emission zones: Sofia case study

This is one of a set of five city case studies prepared as part of a study by the Institute for European Environmental Policy for the Clean Air Fund. The study investigates the social impacts of low emission zones (LEZ) and looks at how they can be deployed in a socially acceptable way, gathering support from the local population. The other case studies cover Milan, the Brussels-Capital Region, Warsaw, and Stockholm.

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Sofia is the capital of Bulgaria, located in southeastern Europe. Its area covers 492 km^2 (Municipality of Sofia, n.d.). It is the most populated Bulgarian city with a population density of 2,600 inhabitants per km^2 (World Population Review, 2024). 19.3% of the population is between 0-19 years old, 63.3% between 20-64, and 17.4% is 65 or older (Republic of Bulgaria National Statistical Institute, 2020), making a median age of 40.4 years old (ibid).

Sofia can be described as the economic centre of the country. In 2022, the capital's region alone accounted for 48.9% of the national GDP. Sofia had roughly double the GDP per capita compared to the national average (EUR 27.500 versus 13.200) (Republic of Bulgaria National Statistical Institute, 2024), and an average annual wage of 139.75% of the national average (Republic of Bulgaria National Statistical Institute, 2022). Despite being significantly wealthier than the rest of the country,

Sofia is still notably less wealthy than the EU standard, with an annual income equal to 45.35% of the EU average (Eurostat, 2022; Republic of Bulgaria National Statistical Institute, 2022).

LEZs in Bulgaria and Sofia

Bulgaria has experienced an improvement in air quality in recent decades, witnessing a reduction of more than 20% in air pollutants compared to 1990 levels (OECD, n.d.). Nevertheless, Bulgaria ranks among the most air-polluted countries in the EU, as illustrated in Figure 1 (IQAir, 2024). In 2021, over 13,000 premature deaths were registered due to low air quality (Statista, 2023). The main sources of air pollution in Bulgaria include domestic heating of coal and wood, combustion of coal for electricity production, industrial activities, and road transport (IQAir, 2024). In 2021, road transport was responsible for more than 40% of NO_X emissions in the country (European Environmental Agency, 2023).

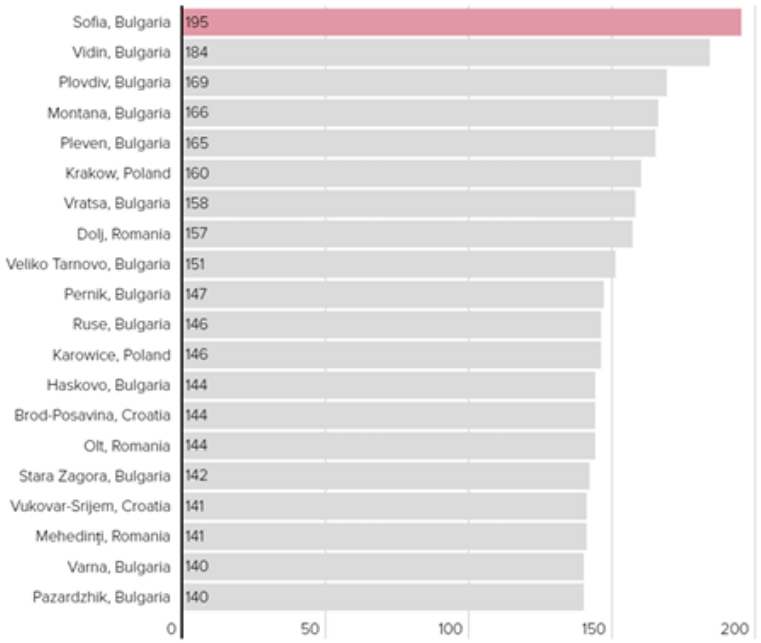

Figure 1: The areas in the EU with the highest number of PM related premature deaths. Numbers indicate premature deaths per 100.000 inhabitants. From (Guillot, 2022).

Bulgaria has continuously breached EU air quality legislation which has been reflected in numerous legal cases. In 2017, the Court of Justice of the EU (CJEU) urged Bulgaria to take adequate measures for systematically violating the daily and annual PM limit values of the Ambient Air Quality Directive (Directive 2008/50/EC). In 2019, the European Commission referred Bulgaria to the CJEU for violating the EU limit values for NO_2 (European Commission, 2019). In 2020, the country was brought before the court by the European Commission for failing to adhere to the ruling (European Commission, 2020). And, in 2023, Bulgaria was once again referred to the CJEU by the European Commission for failing to transpose the Clean Vehicles Directive (Directive (EU) 2019/1161) (European Commission, 2023).

To address the air pollution at a national level, Bulgaria has introduced various interrelated national air quality programs, including the National Program for Restricting Overall Annual National Emissions of Sulphur Dioxide, Nitrous Oxide, Volatile Organic Compounds and Ammonia 2007-2019, the National Program for the Improvement of Ambient Air Quality 2018-2024, and the National Air Pollution Control Program 2020-2030 (Borissov, 2020). Furthermore, in 2015, Bulgaria's Clean Air Law was revised through amendments, including the suggestion (but not requirement) for municipalities to create LEZs in case of increased health risks due to air pollution (Food and Agriculture Organization of the United Nations, 2023).

As shown in Figure 1, **air pollution levels in Sofia are no exception** to the national situation, exceeding both the EU and WHO air quality standards (Lee, Bernard, Dallmann, Braun, & Miller, 2021). Sofia's climatic and geographical conditions make the city particularly vulnerable to air pollution (Shuleva, 2023). Air pollution in Sofia is estimated to cause 15,000 premature deaths annually and EUR 2.6 billion in health costs (Tcolova & Vladimirov, 2023). Additionally, in 2019, 13.4% of local GDP was lost due reduced labour productivity and labour absenteeism attributable to air pollution (Deloitte, 2021).

One of the main sources of air pollution in Sofia is the composition of its vehicle fleet, whose average age is 18 years old (Lee, Bernard, Dallmann, Braun, & Miller, 2021). The city has a motorization rate of 663 cars per 1,000 inhabitants (INNOAIR, 2022), having seen a significant increase between 2012 and 2022 (Eurostat, 2024). In 2020, 36.8% of trips in Sofia were by public transport, 35.3% by car, 20.9% by foot, 1.1% by bike, 0.4% by scooter and the rest by a combination of public transport and foot (Panayotova, 2022).

One of the measures to tackle the air pollution at the city level is the introduction of a LEZ for traffic, making Sofia the first city in Eastern Europe to implement one (Clean Air Fund, 2023). The LEZ covers two areas, a "small ring" and a "large ring" as illustrated in Figure 2. The Small ring covers an area of 3.5 km^2 in the city centre, while the large ring occupies an area of 17 km^2 (Tcolova & Vladimirov, 2023).

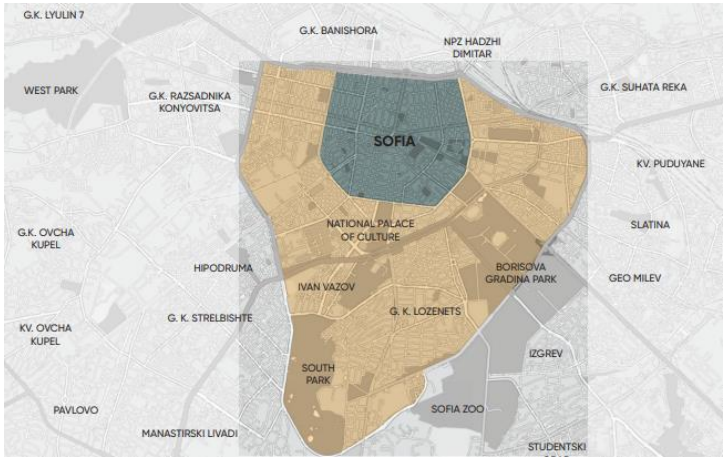

Figure 2: The location of Sofia's LEZ. The small ring is illustrated in blue, and the large ring is illustrated in yellow. Figure from Centre for the Study of Democracy (2023).

The LEZ in Sofia is implemented in several steps in the two areas. The key design features are described in Table 1.

Table 1: Key design features of Sofia's Small and Large ring. Information from (Sofia Municipality, n.d.; Voynova, 2024; Center for the Study of Democracy , 2023; Metropolitan Municipal Council, 2022; Minister of Transport, Information Technologies and Communications, 2024; Bulgarian Government, 2024; European Commission, n.d.).

	Small Ring	Large Ring
Date of implementation and changes	The small ring has the following implementation steps: 1. 1 December 2023 2. 1 December 2024 3. 1 December 2028 The restrictions apply from 1 December through February the following calendar year.	The large ring has the following implementation steps: 1. 1 December 2025 2. 1 December 2027 The restrictions apply from 1 December through February the following calendar year.
Vehicles included	Applies to passenger vehicles with maximum 9 seats (vehicle category M1) and vehicles of carriage of goods weighing maximum 3.5 tonnes (vehicle category N1) (European Commission, u.d.) Exemptions to the LEZ for traffic includes owners of tenants of residential properties within the LEZ, people with a preferential parking card, special traffic regime and public transport vehicles. Further exemptions can be applied for at the Centre for Urban Mobility, e.g., for people with personal right to company cars (Metropolitan Municipal Council, 2022, Art. 3., para 5-11).	Same as the small ring.
Requirements	The requirements are dependent on "ecological groups", which are determined by periodical inspection of the vehicles technical condition (Minister of Transport, Information Technologies and Communications, 2024). There are five ecological groups for motor vehicles in category M1 and N1, determined by their EURO standard, date of registration, content or carbon monoxide or smoke (Minister of Transport, Information Technologies and Communications, 2024, Art. 37a.). See full list with description of the ecological groups in Annex 1. From December 1st, 2023, the ban applied to the **first** ecological group. From December 1st, 2024, the ban will apply to the **first and second** ecological group. From December 1st, 2028, the ban will apply to the **first, second, and third** ecological group.	From December 1st, 2025, the ban applied to the **first** ecological group. From December 1st, 2027, the ban will apply to the **first and second** ecological group. The ecological groups have been subject to critique, e.g., in the public consultation, for ambiguity and impreciseness.

	Small Ring	Large Ring
Compliance and sanctions	Sanctions according to articles 41a and 41b of the national Law of Clean Air (Bulgarian Government, 2024). Fine of BGN 100 to BGN 1000 (approx. 50 to 500 Euro) or property sanction between 500 to 2000 BGN (approx. 255 to 1000 Euro). Compliance reportedly very low during the first phase of implementation, with lacking monitoring and no fines given.	Same as small ring.

A LEZ for domestic heating will be introduced alongside the LEZ for traffic and will apply to parts of the city from January 1st, 2025, and the entire municipality from January 1st, 2029 (Metropolitan Municipal Council, 2022). The LEZ will prohibit the burning of solid fuels where central heating and/or gas is an available option (ibid). This is a central measure, as domestic heating (together with traffic) is one of the main sources of Sofia's air pollution (Dubarinov, 2023).

Social Aspects – Investigations and Stakeholder Consultations

To gain a better understanding of the process leading up to the introduction of Sofia's LEZ, two stakeholder interviews were conducted in late June and early July 2024. A first interview was held with Dr. Angel Burov, Chief Assistant Professor at the University of Architecture Civil Engineering and Geodesy in Sofia (Burov, 2024). A second interview was held with Sevdalina Voynova, Director of Programmes at the Sofia Development Association (Voynova, 2024).

Burov (2024) described Sofia as "one of the most complex cases in Europe" with political and cultural tension surrounding the LEZ. Outlining a clear chronological timeline of steps leading to implementation of the LEZ is difficult. Rather, it was brought about by an interplay of efforts and actions from numerous people in different capacities, including researchers, public administration employees, engaged citizens, and NGOs (Voynova, 2024). The poor air quality conditions culminated in the city government losing a court case against citizens for dangerous air pollution levels in November 2021, where the Regional Court of Sofia ordered the local government to take action to reduce air pollution (Balgaranov, 2021). Structured advocacy was described as a must in a Bulgarian context (Burov, 2024), and engaged citizens and NGOs have played an instrumental role (Grossberndt, 2021). Also central for the implementation of the LEZ is INNOAIR: a project funded by the EU initiative Urban Innovative Actions, aimed at piloting solutions to improve air quality, including the introduction of the LEZ (INNOAIR, 2021).

The air quality is reflected in citizen's perceptions: only 23% of high-skilled workers in the city are satisfied with air quality, and 47% regard air pollution as the most critical issue in the city. Moreover, 60% of high-skilled workers considered leaving Sofia due to air pollution (Deloitte, 2021). Moreover, the results from a survey commissioned by the municipality show that 69%

of respondents recognize the impact of their daily behaviour as well as a joint responsibility between the municipality and the citizens to improve air quality (Sofia Municipality, 2018).

To further understand the national context of Bulgaria, and the local context of Sofia, it interesting to consider the country's recent history. Having been a satellite state to the Soviet Union and ruled by the single Bulgarian Communist Party for a majority of the second half of the 20th century (European Commission, 2024), has lingering consequences. Specifically relating to the LEZ, Voynova (2024) described how owning a car is seen as close to a human right. Getting a car during communist rule was associated with great administrative and economical difficulty, and the country has seen a surge in car ownership after "the fall of the wall" (Leviev-Sawyer, 2019). Against this backdrop, since a LEZ is restrictive in its nature, Voynova (2024) brought to fore the importance of communicating about the LEZ in a visionary and future-oriented way, making sure it has positive rather than negative connotations. In this way, she described how a sense of success and motion can be achieved to spur further action in a positive direction.

Moreover, acting in a context of low trust in institutions (European Commission, 2024) and high belief in conspiracy theories (Radio Bulgaria, 2024), Burov highlighted the need to underpin action with extensive research and measurements to be able to track progress, and offer a granular analysis including air pollution hot spots and different times of day (2024). In this regard, concerns are raised about the quality (e.g., in terms of assumptions, measurement points and modelling techniques), trustworthiness (e.g., showing different results to independent measurements), and completeness (e.g., not sufficiently accounting for other pollutants than PM such as nitrogen dioxide) of public data on air quality (Burov, 2024; Lecheva, 2024; Za Zemiata, 2024).

The country's relatively low purchasing power also has notable consequences for the LEZ and the car fleet. In 2017, 1 million of Bulgaria's roughly 2.8 million cars were 15-20 years old, and some 40% of cars were older than 20 years (Leviev-Sawyer, 2019). Burov (2024) accentuated the different financial prerequisites for incentivising new electric cars in e.g. a Bulgarian versus Norwegian context. Rather, solutions are needed that work for a wide range of people under different socio-economic conditions. In this respect, Burov (2024) emphasised the underutilised potential for retrofitting, improved cycling and walking infrastructure, and the sharing economy. Additionally, both the infrastructure and economic incentives currently favour car use over public transport, with car parking being significantly cheaper than a public transport ticket, and cycling and walking unsafe due to the high presence of cars.

As for consultations, Sofia Municipality launched a consultation by publishing the draft regulation for the LEZ together with the draft decision, a report, and a "partial ex-ante impact assessment" on its website (Sofia Municipality, 2022). The consultation was open for one month between mid-June and mid-July 2022 and received twelve written responses via email and post (Sofia Municipality, 2022). While most responses were positive towards the introduction of a LEZ in general, the consultation respondents brought to fore inter alia the following relating to the design aspects of the LEZ:

- Insufficient analysis and justification of the choice of area;
- Insufficient development of scenarios for impact with different choices for the design of the LEZ;
- Insufficient clarity on the ecological groups and how they relate to the level of pollution;
- Insufficient plan for accompanying measures to incentivise alternative means of transport such as cycling, walking, public transport, and car-pooling;
- Insufficient ambition in terms of geographical and temporal scope of the LEZ to have a significant and lasting impact;
- Insufficient plan to ensure compliance;
- Suggestions for more vehicle types and areas that should be exempted from the LEZ;
- Insufficient consideration of the LEZ's impact outside the zone;
- Insufficient target setting and measurability to evaluate impact;
- Insufficient consultation process and consideration of respondents' previous comments.

Another point from the consultation is the share of air pollution stemming from transport. In the documents accompanying the consultation, it is stated that the main source of PM pollution is domestic heating (56%), dust particles from other sources (some 31%), and transport (11%) (Sofia Municipality, 2022). Here, it is important to note that other investigations have found other results, and that PM is not the only contributor to air pollution (Burov, 2024; Za Zemiata, 2024).

Relatedly, Voynova (2024) emphasised the need for a holistic and structured approach in addressing multi-source problems such as air pollution, stating that the LEZ is "an important measure, but it will only work in combination with other measures". In this respect, it is positive that the LEZ for traffic is introduced together with a LEZ for domestic heating. It is also accompanied by other initiatives under the INNOAIR project, including a platform for on-demand transport responsive to consumer demand, and a plan for the introduction of a congestion tax (INNOAIR, 2023).

Regarding the insufficient consultation process, one respondent (Sofia Municipality, 2022, p. 54), stated that:

> *The opportunity for a wide public discussion before the adoption of the ordinance was missed. The citizens of the capital are not well aware of the forthcoming introduction of the [LEZ] – why, with what objectives, with what measures, how many and which citizens would be affected. The Possibility of civic participation in determining the parameters of the [LEZ] is limited to the present public consultation. This approach is not sufficient and can lead to civil resistance to an otherwise necessary measure such as a [LEZ]*[1].

This resonates with what Burov (2024) expressed in the interview, describing the consultation as only attracting the "usual suspects". Indeed, citizen participation in policymaking and

[1] Translated from Bulgarian to English by the author using the European Commission's translation service.

transparent and effective dialogue is important to rebuild institutional trust (Mascherini, 2024). Similarly, Voynova (2024) highlighted the importance of understanding the needs and wants of the population and taking measures accordingly. She stated there will always be different groups with different - sometimes conflicting – interests, making it impossible to please everyone. What is important is being able to demonstrate a balance between social interests and a strong consideration of social justice aspects.

To achieve this, it is important to "know your people, know the groups" (Voynova, 2024). Here, the first step is finding out what groups there are, and the second step evaluating to what extent their views are already set, and to what extent they are open to change. Additionally, unexpected interested groups and collaborators can be found with further investigations. Voynova points out that the tech industry has been surprisingly supportive of the city's initiatives for cleaner air, having an interest in attracting skilled labour. She stated that with further investigations, she would "probably discover three or four different groups that have different views and that could help you. And that is the most fun and interesting part" (2024).

In addition to the consultation by the municipality, investigations were conducted through the INNOAIR project (INNOAIR, 2021), including on the effect of cultural shift in transport on air quality, a passenger behaviour analysis, development of possible scenarios on cultural shift in transportation on air quality, and evaluation of citizen challenges. Moreover, the NGO Za Zemiata have published numerous reports on the topic, including Spatially Based Scenarios for the Introduction of Low Emission Zones in Sofia Municipality (Za Zemiata, 2023), Low-emission zones from transport: Study of international experience and conclusions for Sofia (Za Zemiata, 2020), and transport and air pollution looking at causes for the pollution in Sofia (Za Zemiata, 2019). Finally, the Clean Air Fund funded a study by the Center for the Study of Democracy on Smart Enforcement of the Low-Emission Zone in Sofia, Bulgaria (2023).

Transferable lessons and recommendations

Both in general, and especially considering the historical context, the economic prerequisites, and political environment, the measures to improve air quality in Sofia including the traffic LEZ is an important step forward towards cleaner air. Indeed, Sofia is breaking new ground as the first city in Eastern Europe to implement a LEZ. However, as highlighted by the interviewees and consultation respondents, the current design of the LEZ for transport holds significant room for improvement in terms of clarity and transparency, monitoring, and ambition for cleaner air.

While every European country, region, and even municipality has different prerequisites and contextual circumstances that should be considered in the implementation of a LEZ, the Sofia case offers some valuable insights that can be useful also in other contexts. The key lessons and recommendations emerging from the Sofia case study with regards to the social impacts and social acceptability are to:

1. **Be persistent and strategic in advocating for clean air policies.** The Sofia case makes clear the importance of bottom-up action, mobilisation, and collaboration between actors. Having worked strategically with publishing research, hosting public lectures, and not least taking legal action, NGOs, researchers, and engaged citizens inter alia have played an instrumental role in advancing the city's air quality agenda.

2. **Do your research and be transparent.** Set the facts straight from the beginning and create an extensive foundation for making informed decisions. Collect data on different sources of air pollution for a comprehensive view of the problem. Investigate different scenarios for the LEZ and decide path in dialogue with impacted stakeholders. This can create prerequisites for successful monitoring of progress, effective design and implementation, increased trust if accompanied by transparent communication, as well as serve as a foundation for improvement of the design of the LEZ.

3. **Have a holistic approach** and recognize where a LEZ can fit into the wider puzzle that determines a city's air quality. In the case of Sofia, this meant implementing the LEZ for traffic in combination with a LEZ for heating, tackling multiple sources of pollution simultaneously for increased effectiveness and acceptability.

4. **Know your people, know their needs.** Listen to citizens' concerns and hold wide and detailed stakeholder consultations: the loudest voices are not necessarily representative of the population. There may be unexpected groups to join forces with toward improved air quality. Know the population groups' transport needs, how different groups are impacted by the LEZ and design for social justice.

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Annex 1 Sofia ecological groups for vehicles

Ecological groups for vehicles in categories M1 and N1 as described in REGULATION No. H-32 of 16.12.2011 (2024).

1. (amended - SG No. 88 of 2023, in force from 20.10.2023) for motor vehicles with engines with forced ignition of the working mixture:

Ecological group	Ecological category (EURO)	Date of first registration	WITH idling at low revs	WITH idling at high revs
First (1)	No ecological category	until 1.07.1992	up to 4.5%	-
	EURO 1/I or EURO 2/II	until January 1, 1996	up to 3.5%	-
Second (2)	EURO 1/I, EURO 2/II or EURO 3/III	from 1.01.1993 until 31.12.2007	up to 0.5%	up to 0.3%
Third (3)	EURO 3/III, EURO 4/IV, EURO 5/V, EEV or EURO 6/VI	from 1.07.2002	up to 0.3%	up to 0.2%
Fourth (4)	EURO 4/IV, EURO 5/V, EEV or EURO 6/VI	from 1.09.2009	up to 0.2%	up to 0.1%

2. (amended - SG No. 88 of 2023, in force from 20.10.2023) for motor vehicles with self-ignition engines by thickening the working mixture:

Environmental group	Ecological category (EURO)	Date of first registration	Smoke with atmospheric filling	Smoke during forced filling
First (1)	No ecological category EURO 1/I, EURO 2/II or EURO 3/III	until 31.12.2002	up to 2.5 m^{-1}	up to 3.0 m^{-1}
Second (2)	EURO 3/III EURO 4/IV, EURO 5/V or EEV	from 1.01.2000 until January 1, 2007	up to 1.5 m^{-1}	up to 1.5 m^{-1}
Third (3)	EURO 4/IV, EURO 5/V, EEV or EURO 6/VI	from 1.01.2005	up to 0.7 m^{-1}	up to 0.7 m^{-1}
Fourth (4)	EURO 5/V, EEV or EURO 6/VI	from 1.09.2009	up to 0.5 m^{-1}	up to 0.5 m^{-1}

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