D2.14

A LENS on noise and emissions of L-category vehicles

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Revisions table

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1 Introduction to the project

Environmental noise and air pollution are a major concern worldwide. For road transportation, two-, three- and small four-wheeled vehicles (L-category vehicles) contribute substantially to this despite having a minor share of transport capacity. The LENS project was envisaged to support authorities, cities, regulators, industry and citizens in reducing L-vehicle noise and air pollution. In order to develop a better understanding of these vehicles, the following research was performed:

- Urban traffic monitoring, driving cycle analysis, and simulations to identify high noise and exhaust emission events.
- Development of innovative sensors and methods for noise and exhaust emissions for on board and advanced laboratory measurements.
- Extensive laboratory and on-road measurement campaigns for noise and exhaust emission of more than 150 L-vehicles.
- In-field surveys, partially combined with roadside inspections, in the three LENS pilot cities of Leuven, Paris, and Barcelona resulting in on-road noise and pollutant emission measurements of an additional 2,300 vehicles.
- Investigation of the widespread issue of vehicle tampering, identifying its prevalence, motivations, and impacts on exhaust emissions and noise, and proposing strategies for detection and prevention.
- Based on the gathered information and data, mitigation solutions were proposed, and an impact assessment was made, including a cost-benefit analysis.
- Policy recommendations for regulations and instruments to reduce noise and exhaust emissions were compiled, considering different stakeholders, including regulators, municipalities, and authorities.

2 Measurement technology, methods and data gathering

At the beginning of LENS, high noise and emission events were identified from urban roadside monitoring, simulations, and analysis of available data. These included, among others, high acceleration, start from standstill, engine revving, cold start and deceleration. Some of these events are insufficiently covered by current type-approval regulations; others are not covered at all. Representative real-world driving patterns for noise testing were defined for manual transmission vehicles, covering these conditions. Driving patterns were compiled in real-world comparable speed profiles that are usable in laboratory equipment to assess real-world exhaust emissions. Further details can be found in deliverable D6.1 “Real-world driving conditions” and deliverable D3.5 “Real-world driving patterns to assess LV noise and emissions”.

2.1 Development of measurement methods

Assessment of type approval measurement procedures and the outcomes of the investigations on high-emitting driving conditions led to the development of improved measurement methods for exhaust emission and noise.

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These procedures are outlined in deliverable D3.2 “Method and system for on-board noise measurement” and deliverable D3.1 “Method and systems for on-board measurement of pollutants emissions".

Exhaust emission type approval procedure uses a synthetic driving pattern, the worldwide motorcycle harmonised test cycle WMTC for in-laboratory tests, and type approval noise tests use specified driving patterns on dedicated test tracks called pass-by noise test. These are complemented with more dynamic additional sound emission provisions (ASEP). In order to perform exhaust emission tests with conditions relevant for on-road driving behaviour, procedures for Real Drive Emission (RDE) test were derived from the passenger car standard type approval (TA) tests. Additionally, LENS developed highly dynamic real-drive test cycles (RDC) for laboratory tests were developed, while noise testing required the creation of dedicated test protocols based on the outcomes from high-emitting driving condition investigations.

2.2 Development of Equipment

Based on the insights from the high-emitting driving conditions assessment and the demands from adapted and new measurement methods, LENS developed several novel equipment for the measurement of noise and exhaust emissions, specifically designed for on-vehicle use.

Smart Emission Measurement Systems (SEMS)

Existing Portable Emission Measurement Systems (PEMS), while well-established for passenger cars and heavy-duty vehicles, are unsuitable for small motorcycles or mopeds due to their weight, size and mounting requirements. To address these challenges, the consortium investigated Smart Emission Measurement Systems (SEMS) as a compact alternative. SEMS devices are lighter and easier to mount, although they provide less accuracy compared to full-scale PEMS. They rely on robust sensors rather than high-precision analysers and often omit exhaust flow measurements, instead of using engine parameters from the vehicle’s onboard diagnostics (OBD) system. For some vehicles, hybrid approaches were used, combining SEMS data with laboratory correlation runs to estimate exhaust flow and pollutant mass, or vehicle energy modelling.

Modified and specifically adapted measurement systems were developed and tested, which demonstrated the potential for small-scale, accurate emissions measurements in the field. However, they remain in prototype status and are not yet available for mass production. The results indicate that further miniaturisation, improved robustness, and better integration with lightweight vehicles will be necessary for large-scale deployment.

Particle Number 2.5 (PN2.5) Sensor

A major innovation in LENS was the creation of the PN2.5 sensor, which measures particles down to 2.5 nanometres. The sensor uses a condensation growth stage together with diffusion charging and electrical detection. Laboratory tests showed that it can detect ultra-fine particles with very high concentration sensitivity. The PN2.5 sensor filled an important measurement gap as standard condensation particle counters usually detect only particles above 10 nanometres and have a limited concentration range. Although the laboratory results were promising, the PN2.5 sensor is not yet ready for on-road use. Its design needs controlled temperature and flow conditions. This makes it more suitable for validation and calibration work in the laboratory. The project concluded that the concept is technically sound, but the sensor needs more miniaturisation, better stability, and greater robustness before it can be used reliably in portable systems for real-world operation. These innovative aspects are explained in deliverable D3.3 ”Optimised on-board measurement system including P2.5 sensor”.

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Fourier Transform Infrared Spectroscopy (FTIR)

Another key innovation within LENS was the design of a highly compact FTIR spectrometer for on-road measurement of gaseous emissions from L-category vehicles, bringing down the mass to below 40 kg and average power consumption to below 200 W. The system is capable of measuring emissions of nitric oxide (NO), nitric dioxide (NO_2), ammonia (NH_3), methane (CH4), nitrous oxide (N_2O), carbon monoxide (CO), carbon dioxide (CO_2) as well as formaldehyde.

On-board noise measurement system

Complementing the laboratory-based approach for noise measurements, the LENS project developed an on-board measurement system designed to capture noise data directly during real-world driving.

The monitoring system includes a digital Micro-Electro-Mechanical System (MEMS) microphone, and a GPS module connected to a compact microcontroller platform. This configuration enables the simultaneous recording of sound pressure levels and positional data, allowing correlations between specific driving conditions and the associated noise emissions.

The on-board noise measurement approach thus complements existing type approval methodologies by capturing data under realistic conditions that cannot be replicated on standardised test tracks. This approach enables a more holistic understanding of L-category vehicle noise behaviour, linking laboratory accuracy with real-world relevance.

2.3 Noise & exhaust emission measurements of 150 vehicles

The assessment of the existing fleet for noise and exhaust emission was conducted by in-laboratory and on-road measurements of noise and exhaust emission. New measurement methods and new equipment were used for the investigation.

Measurements of exhaust emissions

Laboratory tests of 60 vehicles included TA conditions and RDC to better reflect the real-world driving behaviour. The measurements aimed to determine the emission performance of the vehicle fleet for both regulated and currently unregulated pollutants, and to support the development and evaluation of on-road emission measurement equipment and procedures.

On-road RDE testing assessed the behaviour of L-category vehicles under conditions representative of their actual operation. A total of 112 vehicles were included in the on-road investigation, 90 of which underwent on-road emissions measurements, while 22 were tested under both RDE and TA conditions. This approach allowed direct comparison between real-world performance and regulated test results.

In the type-approval laboratory tests, most of the vehicles remained within their prescribed TA limits for regulated pollutants, such as carbon monoxide, hydrocarbons, and nitrogen oxides. Despite overall compliance with regulatory limits, certain vehicle subcategories, especially smaller two-stroke L1e-B mopeds (50cc engine capacity), exhibited high emissions due to limited aftertreatment systems and transient engine operations. Significant amounts of non-regulated pollutants, such as ammonia and unburned hydrocarbons, were also detected, and particle emissions were found to be rather high across a range of vehicles.

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The laboratory tests also showed a widespread difference between high and low emitters. Vehicles with optimised engine management and exhaust systems achieved low emissions across all pollutants, whereas others with less advanced technology or improper calibration produced elevated results even under TA conditions.

RDE tests consistently showed higher emissions compared to TA conditions due to the dynamic nature of real-world driving, including high accelerations, speed, and frequent transitions between acceleration, steady state and deceleration conditions. Particle number emissions were especially concerning, as they exceeded expectations and remain unregulated for L-category vehicles.

The results highlighted the gap between laboratory TA tests and real-world emissions. While most vehicles adhered to TA limits for regulated pollutants, laboratory tests underestimated real-world emissions, especially for particles and unregulated compounds like ammonia.

The findings stress the need for improved emission control strategies, expanded regulatory testing, and real-world driving scenarios to better address environmental impacts. While TA tests provide baseline data, they fail to capture the complexity of real-world emissions, underscoring the importance of RDE data for a more comprehensive evaluation of L-category vehicle performance. LENS provided further insights in the deliverable D4.4 'suggested revisions to exhaust emissions TA procedure'.

Measurement of noise emissions

Noise measurements were carried out on 112 vehicles in real on-road driving conditions. Of these, 90 were tested only in on-road situations, while 22 were measured both on the road and under type-approval conditions on a test track. A further 48 vehicles were tested solely under type-approval conditions.

The LENS project showed that while on-road noise measurement of L-category vehicles is achievable, it remains technically challenging due to the variability of real driving conditions. Results confirmed that vehicles produce higher noise levels in daily use than during type approval testing, with engine speed, load, vehicle velocity and rapid acceleration being the dominant influences.

Aggressive throttle use, strong acceleration and abrupt braking generated the loudest peaks, and some vehicles exceeded legal limits despite compliance under controlled conditions. Differences within the same vehicle classes underscored the impact of rider behaviour, maintenance and design. Although powerful engines tended to be noisier, certain low-powered vehicles were equally loud in specific manoeuvres.

Replicating real-world driving on controlled tracks allowed direct comparison with type approval data. Increased engine load and acceleration intensity consistently raised sound levels, but the high variability between vehicles indicated that stricter limits alone would not sufficiently reduce the most disturbing noise events in cities.

The results of the measurements confirmed a clear discrepancy between the noise levels recorded during type approval procedures and those generated in everyday use, showing that current regulations only partly reflect real driving behaviour.

Overall, the project confirmed that noise emissions in real traffic are driven by complex interactions between vehicle design, powertrain type, and user input. It also demonstrated that current type-approval procedures, while robust, do not fully capture these dynamics. The combination of controlled testing and

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on-board real-world measurements developed within LENS provides a more holistic framework for evaluating noise emissions. These outcomes establish a sound basis for refining noise regulations, improving urban noise management, and guiding future updates to UN type approval procedures to ensure they better reflect actual driving conditions (deliverable D4.5 Suggested revisions to TA for noise emission).

In-field survey on noise and exhaust emission

The in-field surveys assessed the noise and air pollution of passing L-category vehicles involved extensive roadside measurements in real traffic situations across the three city measurement campaigns. Measurements were conducted directly at the roadside over several days, allowing emissions and sound signatures to be observed as vehicles passed in ordinary traffic without interfering with their operation. This approach provides a realistic picture of how a wide range of L-vehicles perform in real-world conditions, and how they differ by location, generation, and user group.

For exhaust emission, the systems captured exhaust plumes from passing vehicles immediately after the tailpipe, from which the concentrations of key pollutants were determined. These included carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), and particulate matter (PM). In parallel, noise monitoring equipment was positioned to capture the sound profile of each vehicle, including its maximum sound pressure level and distinctive sound characteristics.

The field surveys confirmed that on the one hand, emissions from L-category vehicles have declined substantially as emission standards have become stricter, but they also showed that real-world emissions remain highly variable. This variability arises from factors such as fleet diversity, traffic conditions, and the presence of tampered or poorly maintained vehicles.

2.4 Study on tampering including field tests for noise & exhaust emission

Tampering is generally defined as any form of modification carried out by a vehicle user that places the vehicle outside its original type-approved specifications. These alterations, ranging from exhaust and engine control changes to air intake and fuel system adjustments, frequently worsen pollutant and noise emissions. The practice contributes to environmental degradation and public health risks across the EU.

L-vehicle user survey on tampering

LENS partners collected answers from more than 500 vehicle owners from more than twenty European Union countries, complemented by 64 in-person interviews in Greece. The demographic profile of participants shows a community predominantly composed of middle-aged men. Most respondents owned motorcycles registered after 2007, with Street, Naked, Supersport, and Superbike models forming nearly half of the sample. Two-thirds of the vehicles were purchased second-hand, and the majority were used for leisure rather than everyday transport.

The survey revealed that tampering is widespread and often multifaceted. The most common modifications involved replacing the original silencer with an aftermarket one, followed by changes to the air filter, the vehicle fairing, and the engine control software. Other frequent alterations included the removal of the silencer and the catalyst. In total, more than one-third of all modifications affected the exhaust system, while a significant proportion affected the electronic control unit and air intake components.

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As to motivation, almost half of the respondents stated that the primary reason for modifying their vehicles was to increase engine power. A further fifth admitted they were seeking a louder or more appealing sound, while others cited aesthetic improvements or better handling. Most modifications were carried out by the owners themselves, though nearly a third relied on workshops, and the majority of changes were permanent rather than temporary.

The consistency of responses across different countries suggests that the phenomenon of tampering is not confined to any specific region but is common throughout Europe. The deliverable D5.1 ‘LVs tampering and undesirable effects’ provides further insights into the survey data and its assessment.

In-field tampering measurements

In-field surveys were carried out in three different EU countries to identify tampered vehicles and measure noise and tailpipe emissions. Whereas the first in-field emission test took place in an urban environment of the Belgian city of Leuven, the second was conducted in the two French communes of Rueil-Malmaison, a Parisian suburb, and Dampierre-en-Yvelines, a destination for motorcyclists in the Paris larger region. The third tests took place at a busy arterial road in Barcelona, Spain.

The proportion of vehicles identified as tampered in Leuven and Barcelona was strikingly similar, at approximately 10%. The most altered components were the exhaust system and the muffler. The modified or tampered L-vehicles displayed several distinctive characteristics. Around 50% of the 2-strokes pulled over were tampered in contrast to only 9% of the 4-strokes. On average, the engines of the tampered vehicles were also considerably larger, with an average capacity of 446 cm^3 versus 285 cm^3 in non-tampered vehicles.

Moreover, these vehicles tended to be older, with an average age roughly two years greater than their unmodified counterparts. Despite these notable differences in engine type, size and age, there were no significant variations in terms of Euro emission class or overall vehicle mileage between the two groups. More information is provided in the deliverable D5.3 ‘Results of field surveys on LV tampering'

3 Mitigation solutions and impact assessment

Scenarios

Five main scenarios of potential mitigation solutions to reduce noise and exhaust emissions were identified and simulated through modification of the emission factors, the fleet, or vehicle use to assess their impact:

1. Strengthening type-approval regulations for noise and pollutant emissions, including real driving emissions testing.
2. Reducing illegal vehicle modifications (tampering) by vehicle checks through roadside and periodic technical inspections including automation, digital tools and market surveillance.
3. Local regulations: speed limits and enforcement to limit loud and polluting driving behaviour.
4. Access restrictions for loud and high emitter vehicles in specific areas or roads, including low emission zones for noise.
5. Accelerated fleet renewal: Incentives for the faster replacement of older vehicles by electric or less polluting models.

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Besides these scenarios, it was also found that sound emission levels in the EU CNOSSOS model for noise mapping are too low and therefore need to be updated to properly take L-vehicles into account.

Impact Assessment

The scenarios were assessed for the period from 2025 to 2050 and compared to the baseline situation in 2025. Two cases for fleet electrification were defined for the baseline: a low-penetration case with 17% electric L- vehicles by 2050 and a high-penetration case with 50% by 2050.

Based on the data from emission measurement investigations, emission factors for noise and exhaust emissions have been produced, thanks to the support of two essential tools for noise and air pollution. The PHEM simulation tool was used for exhaust emissions. It is a detailed model for 1Hz simulation of single motor vehicles and vehicle fleets, which calculates exhaust, brake and tyre emissions for all vehicle categories and for all driving conditions in 1Hz resolution and as a cycle average. Additionally, LENS used the Traffic Noise Emission Calculation Model (TRANECAM) for noise pollution, since it is a sophisticated European model for calculating road traffic noise and is often used in noise action planning, vehicle regulation analysis and environmental impact assessments. Those emission factors have been used within existing EU standard vehicle emissions calculator (COPERT) in order to estimate the emissions of the European fleet of L-category vehicles with a typical use for European drivers.

For pollutant emissions, the introduction of RDE testing delivers the largest cuts. By 2050, cumulative NOx reductions reach 28 kt in the high-electrification scenario and 41 kt in the low-electrification scenario. Fleet renewal is also effective, especially when electrification is high. Long-term average sound exposure levels (Lden) can be reduced by anti-tampering measures by up to 2 dB(A) in Southern Europe. Single events can be reduced by 3 dB and more by antitampering and driving behaviour measures. Access restrictions can reduce noise by up to 5.3 dB(A) in urban areas for Lden and 10 dB or more for single events. Driver awareness through roadside and digital communication can help improve driving behaviour. Driving behaviour can also be influenced by tools such as the Geco Air app to support eco-driving, lower emissions, and encourage environmental responsibility.

A detailed description of the scenarios is available in Deliverable 6.2 “Case-studies-intervention options”, and the contribution to the adaptation of the Geco air app to L-vehicles is available in deliverable D6.3 “Eco-mobility app for best practices on LV use”.

Cost-benefit Analysis

An exploratory cost-benefit analysis showed that scenarios that affect the existing fleet are generally cost-effective and can be implemented in the short term. Measures to reduce tampering are most cost-effective, together with access restrictions. As improved UN Regulations only affect new vehicles, it takes many years to produce benefits on a larger scale. Accelerated fleet renewal is also a long-term instrument and requires state subsidies, but has benefits both for noise and emissions, especially if tampered and older vehicles are replaced. More on the cost-benefit can be found in the deliverable D6.4 ‘Impact of interventions in decreasing LV noise and pollutant emissions'.

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4 Policy recommendations

The following recommendations are based on the LENS research results and expertise of all LENS partners, as well as exchanges with external experts, public authorities, and citizens' initiatives. They focus on evolving legislation and policy instruments to reduce the pollution impact of L-vehicles and are therefore addressed to specific stakeholders. A detailed version of the technical recommendations is available in deliverable D6.5 'Recommendations for quieter and cleaner LVs'.

4.1 European Commission, UNECE, and Member State Regulators

Introduction of RDE and harmonise type-approval testing

European institutions must focus on progressively strengthening emission control frameworks for L-category vehicles. The key priority is implementing Real Driving Emission (RDE) testing for LVs, as miniaturised Portable Emission Measurement Systems (PEMS) become technically reliable. Additionally, authorities should implement representative Real Driving Cycles (RDC) in laboratory testing, when necessary, alongside a revised WMTC Class definition and phase weighting to better reflect actual usage patterns.

Align L-Vehicle and M1 (Passenger Cars) Emission Standards and build a Unified EU Digital Governance System

Regulatory frameworks should include Particle Number and ammonia metrics to reduce health risks associated with these pollutants. More specifically, the current regulation of PN emissions from passenger cars should be adopted. Furthermore, establishing an EU-level digital emissions governance system would create a unified database aggregating data from RDE testing, Periodic Technical Inspection (PTI) results, and remote sensing campaigns, enhancing monitoring capabilities.

Comprehensive revision of UN type approval regulations for L-vehicles and PTI consideration

Current UN type-approval regulations for L-vehicle noise do not yet capture all driving conditions that produce excessive noise levels. The additional sound emission provisions should be amended to include high noise at all relevant speeds and driving conditions, limits for acceleration noise should be tightened to avoid excessive sound levels, and RDE should be introduced. Consideration of more effective in-service verification during type-approval, practical PTI measurement methods and clearer rejection thresholds are also needed.

Type approval procedures and in-service conformity checks should be better aligned to ensure vehicles maintain compliance throughout their lifecycle. This integration should include adapting type approval tests to facilitate straightforward in-service verification for PTI and roadside inspections.

Enhance the Environmental Noise Directive to accurately reflect the impact of L-vehicles

The Environmental Noise Directive, in particular the CNOSSOS-EU model for noise mapping, should be improved to better reflect the sound emission and impact of loud vehicles, by amending their source sound levels and dose-effect relationships. This could help trigger local noise action plans. Annoyance, sleep disturbance and

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health impacts of L-vehicle noise should be surveyed in relation to single events and assessed at the national and EU level to better quantify the impact as a basis to amend EU legislation and national and local interventions.

Increase EU-funding for advanced emission and noise measurement technologies

EU institutions should strengthen support to Member States through targeted funding for projects that accelerate the development of robust on-road emission measurement technologies, improve the integration of remote sensing and noise cameras into enforcement frameworks, and modernise Periodic Technical Inspection (PTI) systems to include emission and noise testing.

4.2 L-vehicle Industry (OEMs and aftermarket suppliers)

Specification of vehicle design to enable inspection friendly detection of tampering and defects

L-vehicle manufacturers should extend on-board diagnostic (OBD) access to provide more comprehensive vehicle information for assessing exhaust emissions and performance throughout standardised diagnostic interfaces. Vehicle design should consider PTI and roadside inspection requirements, ensuring easy access to emission control and noise relevant components.

Implement EU-wide labelling and approval systems for vehicles and aftermarket parts

Every new L-vehicle should display clear labelling showing its emission class and certified noise level. The EU should establish a central approval system for aftermarket components that applies to the same standards as original equipment, with only certified parts permitted for sale and listed in a public registry.

Integrated Design Approach for Consistent Environmental Integrity

Manufacturers should ensure vehicles maintain environmental performance throughout their life cycle, not just at certification. This requires designing compliance into vehicle systems to maintain emissions within a defined conformity factor and controlled noise levels throughout the vehicle's useful life. Additionally, manufacturers should implement integrated design approaches combining advanced control technologies with tamper-resistant features such as secure ECUs and traceable diagnostics.

4.3 Academia, research institutes, measurement equipment manufacturers and national testing facilities

R&D on measurement technology and regulatory innovation

Research efforts should focus on advancing measurement technology (PEMS and SEMS systems) to enable RDE introduction. For noise testing, on-board methods should be explored as a more comprehensive procedure. Dedicated acoustic quantities and machine learning techniques should be developed to detect tampered vehicles and those with loud and high emission driving behaviour.

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Gather more statistical data of the real-world representative driving behaviour of L-category fleet, including distinction per vehicle type characteristics and intended use

Researchers should conduct comprehensive testing of underrepresented vehicle types to better evaluate current fleet performance. This should include distinction between vehicle characteristics and intended use. Additionally, EU-wide health and annoyance impact data for L-vehicles should be collected through standardised surveys.

Standardise L-vehicle testing methodologies across the EU and introduction of on-board monitoring

National testing facilities should be formally recognised as integral to the European vehicle compliance ecosystem, providing certification services and technical support for enforcement agencies. Integrating on-board monitoring data into the testing process would enhance detection of illegal modifications.

4.4 Municipalities, surveillance and enforcement authorities

Implement effective urban access regulations and low-emission zones

Cities should prevent high-pollutant vehicles from entering urban areas through modernised access regulations that reflect both emission and noise performance. Current low emission zone requirements should be enhanced to better represent real-world fleet emissions.

Implement systematic roadside inspection and testing programs in urban areas

Member states should introduce systematic roadside inspections of L-category vehicles. These inspections should include comprehensive idle emission tests measuring carbon monoxide, hydrocarbons, nitrogen oxides, and particle number, alongside standardised stationary noise tests. Inspections should also incorporate visual examinations and diagnostic tools specifically designed to detect tampering of emission control and noise reduction systems.

Deploy advanced monitoring and intelligent enforcement systems

Municipal and regional authorities should invest in advanced monitoring and enforcement technologies throughout, including remote sensing systems capable of detecting both emission and noise irregularities from passing L-vehicles, identifying polluting or tampered vehicles, and noise psychoacoustic characteristics. Automated enforcement, such as mobile or fixed noise cameras, should complement data-driven analytics that distinguish between natural vehicle ageing and deliberate tampering. These advanced indicators help enforcement agencies identify illegal modifications and excessive sound while providing valuable input for urban planning to create quieter traffic routes and acoustic comfort zones.

National financial incentives to accelerate fleet renewal

Authorities should introduce financial incentives encouraging owners to replace older, high-emission models with Euro 5/5+ compliant or electric vehicles. Scrappage schemes offering compensation or tax benefits are particularly effective for withdrawing old vehicles, provided certification systems prevent outdated vehicles from re-entering circulation.

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4.5 L-vehicle users and citizens

Promotion of eco-driving applications and incentives

Cities and governments should encourage better driving habits through eco-driving applications, such as GECO Air, that reward efficient and quiet riding styles. Apps that provide feedback on acceleration, braking, and fuel use can be integrated into insurance schemes, municipal incentives, or community challenges to normalise responsible riding behaviour.

Promote and combine targeted enforcement with educational initiatives

Communication campaigns should highlight both the practical disadvantages of tampering and loud driving behaviour, including higher fuel costs, reduced engine lifespan, and potential insurance issues, and its environmental impact. Emphasising the social unacceptability of tampering and loud driving can gradually shift cultural norms within rider communities.

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