With the contribution of
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LIFE MONZA
Methodologies for Noise Low Emission Zones introduction and management

The use of smart noise monitoring system in urban Low Emission Zones, developed in the frame of LIFE MONZA project

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SCOPE

The introduction of **Low Emission Zones**, urban areas subject to road traffic restrictions, in order to **ensure compliance with the air pollutants limit values,** set by the European Directive on ambient air quality (2008/50/EC), is a common and well-established action in the administrative government of the cities and the impacts on air quality improvement are widely analyzed, whereas the **effects and benefits concerning the noise have not been addressed in a comprehensive manner.**

The definition, the criteria for analysis and the management methods of a **Noise Low Emission Zone** are not yet clearly expressed and shared.

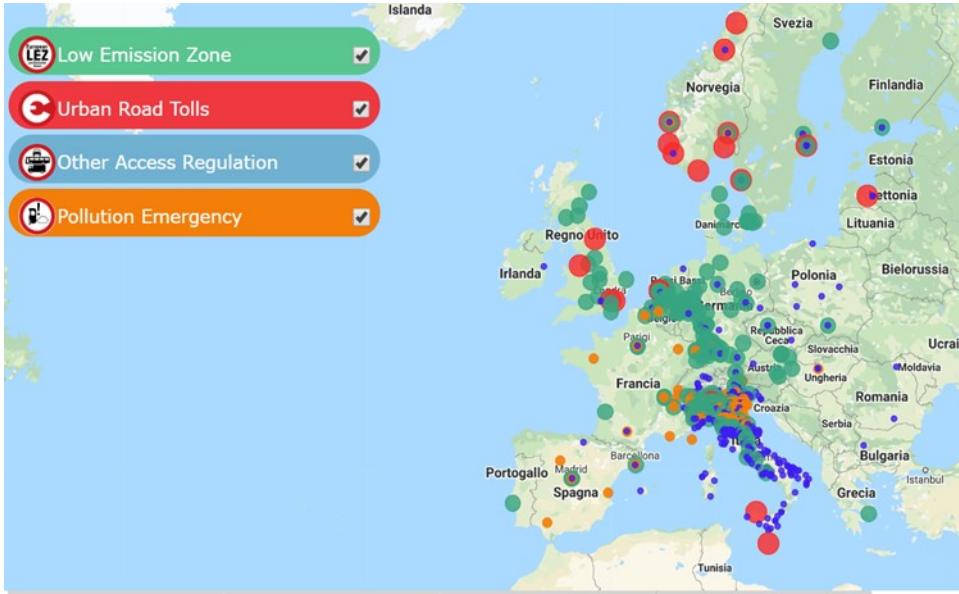
LIFE MONZA project (Methodologies fOr Noise low emission Zones introduction And management – LIFE15 ENV/ IT/000586) addresses these issues.
The project is started in 2016 and it is ended in June 2020

Urban Low Emission Zones

The restrictions may concern the prohibition of access to the most polluting vehicles, the speed limitations, the type of vehicle, heavy or light, the different time periods or payments for the access and these conditions can be decided and undertaken at national or local level.

The introduction of LEZs can be based on **national or local standards**, with different characteristics.

Currently in Europe there are many and different LEZ implementation and management procedures and there is the need to define common criteria, also evaluating the effects and benefits related to environmental and social aspects.



Source of the Map: https://urbanaccessregulations.eu/userhome/map
Portal developed with the support the European Commission
(last access 20 May 2020)

First OBJECTIVE of the project

The main objective of the project, co-funded by the European Commission, is to **introduce an easy-replicable method**, and related guidelines, for the **identification and the management of the Noise Low Emission Zone**, an urban area subject to traffic restrictions, whose **impacts and benefits regarding noise issues** have been analyzed and tested in the pilot area of the city of Monza, located in Northern Italy.

Guidelines for the introduction and management on Noise Low Emission Zone, defining operational methods and common criteria has been drafted, based on the results on the monitoring activities carried out in the pilot area of the project.

Further OBJECTIVES of the project

The second objective regards specific ***top-down measures***, adopted by the municipality and able to turn up the urban area in a permanent Noise LEZ, concerning infrastructural interventions

The third objective is to **reduce the average noise levels** in the pilot area of Libertà district, with positive complementary effects also on the **air quality** and benefits on **the quality of life** of the inhabitants

The fourth objective is to involve the population in an active management system (***bottom-up measures***) of lifestyle choices

Pilot area in Monza Municipality

Significant average levels of noise pollution affect a large number of citizens so that Libertà district is identified as a **hotspot in the Action Plan of the city of Monza**.

Noise strategic map of the city of Monza, dated 2017, highlights that in a range of 30 m from the Viale Libertà almost the 100% of the receivers is exposed to levels higher than 65 dB(A) during the day and 55 dB(A) during the night.

Top-down measures: infrastructural interventions for NLEZ establishment

undertaken by the municipality in order to turn up the area in a permanent Noise LEZ, concerning:

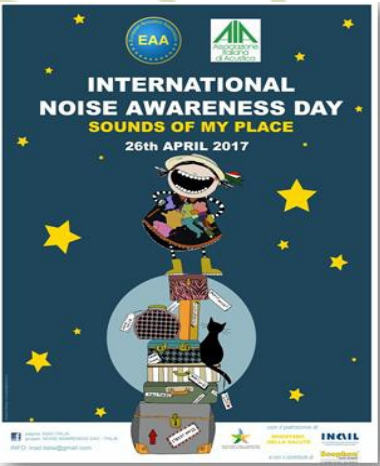
- **traffic management** (access restrictions to the transit of heavy vehicles; the speed vehicles reduction);
- **road paving substitution with new dense-graded low-noise paving, on Viale Libertà,** which guarantees results of 3-4 dB in term of acoustic abatement and an efficiency period of about five years from the laying.
- **road reshaping with lanes-width reduction and pedestrian crossings introduction**

bottom-up measures

People habits and voluntary actions implemented by the citizens can produce positive effects on the achievement of the environmental targets in the urban area where they live.

In order to encourage the local community involvement and to strengthen the dialogue between citizens and public bodies, many activities are carrying out, as:

- **meetings in primary and high schools to raise awareness about noise effects**;
- **ideas contest for students** for Noise LEZ picture and logo;
- ***pedibus*** service for schoolchildren;
- **questionnaires** on perceptions of specific noise impacts; on the quality of life, air quality and social aspects;



Monitoring activities and methods tested in pilot area

Many different monitoring activities, in ante and post-operam, have been carried out in pilot area, in order to evaluate **LEZ measures implementation** (road traffic restrictions, replacement of road pavement, pedestrians crossing), assessing the noise reduction, the complimentary effects on air quality and how these measures reflect on well-being conditions and quality of life for citizens living around the pilot area.

Noise Monitoring	• Class I instrumentation • Smart low-cost sensors
Air Quality Monitoring	• EU Directive requirements • Passive sampling
Social aspects	• Questionnaire

Noise Monitoring in pilot area

Noise Monitoring

- Class I instrumentation
- New Low cost Smart NOISE Monitoring System

Monitoring activities have been carried out referring to the **standard methods, using sound level meters of Class I precision**, and also by developing and using a **smart low-cost monitoring system**.

Ante-operam and post-operam monitoring campaigns have been planned in both the Spring/Summer period and the Autumn/Winter period. Ante-operam monitoring was carried out between Monday 20 and Monday 27 November 2017, the post-operam monitoring was carried out between Monday 21 and Monday 28 January 2019.

The **prototype system for smart monitoring activity of noise** has been designed and implemented, in order to be used as a continuous monitoring unit in the ex ante and ex post scenarios; 10 monitoring stations have been installed in the pilot area of Libertà district (June 2017) and they are continuously working.

After the end of LIFE MONZA project, the prototype will be given for free to Municipality of Monza that will take care of using it for monitoring activities in the three years after the project end.

Smart low-cost noise monitoring systems experiences and procedures

SNMS has been developed, based on the outcomes of the state of the art analysis

Smart low cost noise monitoring systems	
main characteristics arising from analyzed projects	
Short /long term noise measurement	long term noise measurement
Embedded pc monitoring system /Units with microcontroller and digital signal processor	Embedded pc monitoring system
Type of microphones	MEMS microphones ¼ - inch condenser low cost microphone
Time basis acquisition	Different values. In most frequent cases =1 sec;
Acoustic dynamic range	70 dB
Acoustic Measure range	Different ranges. 30 (40)-100 (110) dB(A)
Acoustic frequency range	20 Hz-20 kHz
Floor noise value	30-35 dB(A)
Tolerance	LAeq ±2 dB(A)
Acoustic indicators	In all cases studies: L_{Aeq}, L_{A10}, L_{A50}, L_{A90}; In some cases studies: $L_{A01;}$ L_{Ceq}, M_{60}, M_{70}, N_{cn}
Spectral data	1/3 octave
Calibration	Periodic calibration
additional characteristics	
weatherproof	Applied in all case studies
connectivity	Wifi/3G/4G
possibility of audio recording	Applied in some case studies
other properties	Extensible with temperature/humidity sensors, air pollution monitoring sensors, GPS logging etc; battery for energy storage.
Size of PCB assembly	10mm < x < 10 mm
Shape of PCB	Optimized to avoid diffraction effects
pilot area of implementation	
Urban/Suburban	Urban and sub-urban areas
Territorial scales	Different dimensions, from medium to large scale; (most frequent dimension in urban area: ≈1,00 km^2)
Number of stations	Different situations. For areas of medium spatial dimensions, in most cases, from 5 to 20 units

For an in-depth information, the deliverable is available at: http://www.lifemonza.eu/sites/default/files/A1.2%20Operational%20context%20Noise%20Monitoring%20Syste

Smart low-cost noise monitoring system – LIFE MONZA

acoustic parameters: overall A-weighted continuous equivalent sound pressure level, LAeq,1s and continuous equivalent sound pressure level, Leq,1s, as 1/3 octave band spectrum data;

timing for data recording: data acquired with a time basis of 1 second in order to permit the recognition of unusual events in the analysis phase;

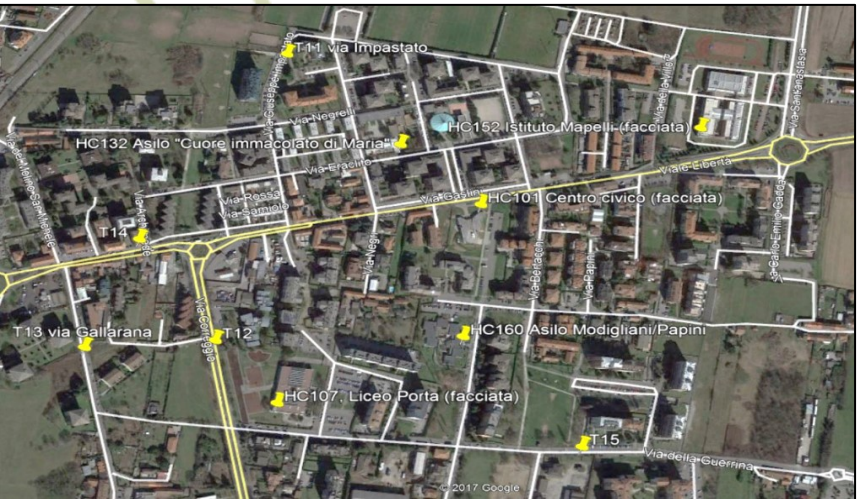
timing for data transmission: data will be sent every hour;

data transmission network: the data will be transmitted through the 3G cellular telephonic network;

power supply: small solar panel (30cm x 20cm) and battery for energy storage or direct connection to electricity network;

sensors location: on streetlight or on façade, height 4 m above the ground level

sensor type: ¼ or ½ inch low-cost microphone with removable rain protection;



floor noise < 35 dB(A);

requency response at nominal frequencies of 1/3 octave within the class I specs ± 1dB.

Smart low-cost noise monitoring system – LIFE MONZA

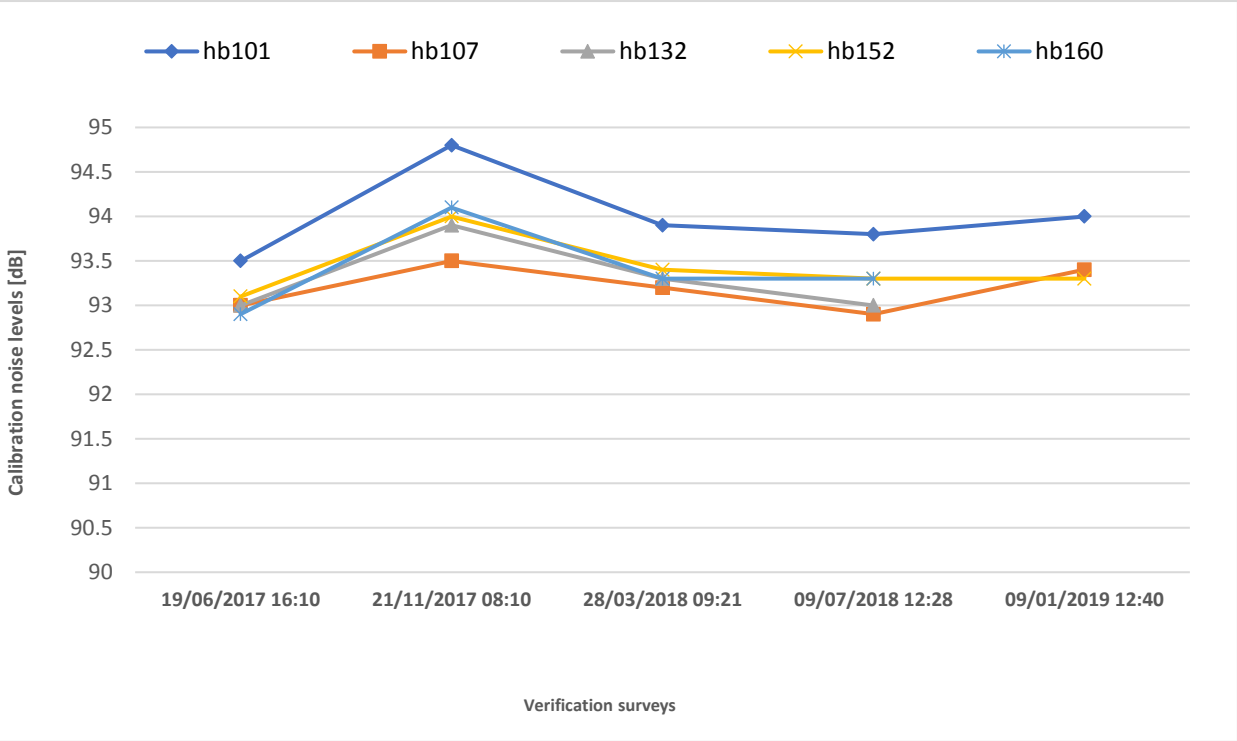
Two **types of microphones** have been used:
for **sensors placed on poles** that use solar panel energy, in order to obtain high performances of energy efficiency, digital MEMS microphones, adapted onto a ½ inch cylindrical plastic support to allow the insertion of a standard acoustic calibrator;

for **sensors placed on façades** that use power supply connection, electret microphones have been used. For reasons related to shielding for electromagnetic compatibility they have been adapted onto a ¼ inch cylindrical plastic support to allow the insertion of a standard acoustic calibrator.

Data have been post-processed by using Matlab;
$35 \leq LAeq,1s \leq 80$ dB automatically excluded as associated with exceptional events, which are not possible to recognize in real time, only in post-processing phase.

Smart low-cost noise monitoring system – LIFE MONZA

Smart Noise Monitoring System calibration procedures



1 kHz calibration check – Electret sensors placed on building's façades

For an in-depth information, the deliverable is available at:
http://www.lifemonza.eu/sites/default/files/LIFE_MONZA_FORMAT%20Technical%20Report_B3_finale.pdf

Comparison between Class I and Smart Sensors noise levels

Analysis of the results obtained for the acoustic parameters Lday, Levening and Lnight by the low-cost sensors and class I systems

	Period	Lday (06-20) [dB]	Levening (20-22) [dB]	Lnight (22-06) [dB]
Class I Instrumentation	Nov-17	59.5	58.8	56.5
Sensor HC101	Nov-17	64.6*	62.5*	59.2
	Difference	5.1	3.7	2.7
Class I Instrumentation	Jan-19	57.5	53.7	50.3
Sensor HC101	Jan-19	60.4	57.0	53.0
	Difference	2.9	3.3	2.7

January 2019: constant difference of about 3 dB between the sound pressure levels recorded by low-cost sensor and class I systems in all periods analysed (Day, Evening and Night time). Difference is due to the different position of the microphones;

November 2017: differences in day and evening periods are due to the activities happened nearby of the entrance of Civic Centre, where the sensor is located and they have been not taken into account.

Comparison between noise levels results in ante and post operam conditions

Comparison of the results obtained for acoustic parameters Lday, Levening and Lnight between the two measurement systems used in the monitoring of the ante and post-operam

	Period	Lday (06-20) [dB]	Levening (20-22) [dB]	Lnight (22-06) [dB]
Class I Instrumentation	Nov-17	59.5	58.8	56.5
	Jan-19	57.5	53.7	50.3
	Difference	2	5.1	6.2
Sensor HC101	Nov-17	-	-	59.2
	Jan-19	-	-	53.0
	Difference	-	-	6.2

In the Evening and Night periods, there are 5-6 dB of noise reduction, due to the passages of only light vehicles and the conditions of the traffic, which is is fluid (low-noise laying mainly works on the rolling noise); during the Day there are 2 dB of difference, due to the different traffic conditions (stop and go). It can be noted that the noise reduction is essentially due to the infrastructural interventions realized in the pilot area.

Evaluation of Smart Noise Monitoring System

Analysing the noise monitoring results obtained by using the low-cost sensor, and particularly taking into account the comparison of the noise levels recorded by Class I chain and by Smart Noise Monitoring System (SNMS), it is possible to highlight a good alignment between the noise values, with constant differences.

It is also possible to highlight that the Smart Noise Monitoring System (SNMS) is able to provide reliable data for long-term monitoring activities and to allow an acoustic characterization of urban areas, at small and medium scale.

The monitoring and calibration check of the Smart Noise Monitoring System (SNMS) must be continuously ensured, in order to have reliable results.

The noise monitoring and evaluation methods tested in the pilot area of the project can be applied in other contexts, at different scales, being valid instruments, able to evaluate the Noise Low Emission Zones effects on noise reduction.

Thank you for your kind attention

www.lifemonza.eu

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