Research Article

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LIFE MONZA: project description and actions' updating

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Abstract: 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 cities. The impacts on air quality improvement are widely analysed, whereas the effects and benefits concerning the noise have not been addressed in a comprehensive manner. As a consequence, the definition, the criteria for the analysis and the management methods of a Noise Low Emission Zone are not clearly expressed and shared yet. The LIFE MONZA project (Methodologies fOr Noise low emission Zones introduction And management - LIFE15 ENV/IT/000586) addresses these issues. The first objective of the project, co-funded by the European Commission, is to introduce an easy-replicable method 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 will be analyzed and tested in the pilot area of the city of Monza, located in Northern Italy. Background conditions, structure, objectives of the project and actions' progress will be discussed in this article.

Keywords: Environmental noise, Low Emission Zones, urban planning, top-down approach, bottom-up approach, low noise paving, smart noise monitoring system

1 Introduction

Air pollution and noise are the two main environmental problems in Europe and, currently, road traffic is the most dominant source of environmental noise with an estimated 125 million people [1] affected by noise levels greater than 55 dB Lden.

Low Emission Zones (LEZs), as urban areas subject to road traffic restrictions, have been implemented in Europe in order to comply with the air quality objectives introduced by the European Directive on ambient air quality (2008/50/EC) [2], as a measure able to improve environmental quality and to reduce health risks due to traffic conditions.

In particular, the EU Directive 2008/50/EC [2] considers the establishment of LEZs a measure to be adopted in air quality action plans, whereas the EU 2002/49/EC Environmental Noise Directive (END) [3] does not provide a definition of LEZ in relation to noise and it is not considered as an action to be included in the noise action plan drafting.

The END focuses on the assessment of people exposed to environmental noise, drafting strategic noise maps, on preventing and reducing environmental noise where necessary and preserving acoustic quality where it is good, drawing up action plans. It also focuses on ensuring public information on environmental noise and its effects. Annex V of END - Minimum requirements for action plans suggests some examples of actions that competent authorities should take into account, as traffic and land-use planning, and those issues can be considered in Noise LEZs introduction and management. Furthermore, important contributes to the environmental noise management according to END requirements have been given by some concluded European projects such as LIFE+2013 DY-

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NAMAP, LIFE+2010 QUADMAP, LIFE+2010 HARMONICA, LIFE+2009 NADIA, LIFE+2008 HUSH [4–11].

Currently, LEZs have been introduced in more than 100 cities in Europe, becoming the most common measure adopted in EU, considering road traffic planning, and they are being considered for other cities worldwide [12].

LEZs implementation in Europe is promoted also according to the objectives of the Europe 2020 strategy, particularly regarding the identification of eco-innovation solutions, able to find a balanced environmental improvement, also considering the technical and economic feasibility and the social acceptability.

There are many different typologies of LEZs, based on various classes of most pollutant vehicles which are restricted from entering, diverse speed limits, different time periods, etc. Municipalities may choose the types of vehicles restricted in a LEZ according to the degree of emission reduction that is needed – only heavy-duty vehicles, or also light duty vehicles, passenger cars, motorcycles and scooters – based on local assessment [13]. The LEZs introduction can reduce road traffic, optimize traffic flows and induce people to a lower use of cars, enhancing public transport and defining positive effects on mobility management, social wellbeing and environmental impacts.

In Germany, Denmark, Holland, Sweden and Czech Republic a national legislation on LEZ already exists, but, currently, LEZs implementation procedures vary widely among cities, many approaches are used and there is not a commonly shared legal framework, at EU level, so that a harmonized management method is needed.

The effects of LEZs implementation on air quality improvement are widely analysed. Many studies have been carried out having different and contrasting results and in most cases LEZs represent an effective measure to reduce traffic-related air pollutants levels, whereas the effects and the potential benefits concerning the noise reduction have not been addressed in a comprehensive manner. However, noise issue is not taken into account and consequently no specific interventions against noise have been foreseen and implemented.

Consequently, at this time, there is a lack of a comprehensive and integrated administrative process about LEZs and noise issue is, in fact, not considered. The definition, the criteria for the identification and the management methods of a Noise Low Emission Zone, the effectiveness and the potential benefits on noise reduction are not clearly analyzed, expressed and shared yet.

LIFE MONZA project (Methodologies fOr Noise low emission Zones introduction And management - LIFE15 ENV/ IT/000586) addresses these issues. The project begun in September 2016 and it is supposed to end on June 2020. The project coordinator is ISPRA, Istituto Superiore per la Protezione e la Ricerca Ambientale, and the associate members of the projects are the Department of Industrial Engineering of the University of Florence, the Engineering Company Vie en.ro.se. and the Municipality of Monza.

In the current paper the project objectives and the pilot area will be described, together with the main activities to be implemented. Moreover, updates about the progress of each main activity will be given.

2 LIFE MONZA objectives

The LIFE MONZA project aims at introducing an easy-replicable method, and related guidelines, for the identification and the management of the Noise Low Emission Zone (NLEZ), to be intended as an urban area in which road traffic restrictions have been implemented and where low noise levels are present. Impacts and potential benefits of the new method regarding noise issues will be analyzed and tested in a selected pilot area of the city of Monza, located in Northern Italy.

The second objective regards specific top-down measures, adopted by the municipality and able to turn up the pilot area in a permanent NLEZ, consisting in infrastructural interventions and traffic management.

The third objective is to involve people in an active management system of more sustainable lifestyle choices (bottom-up measures) related to the reduction of noise and the improvement of air quality and wellbeing conditions in their living and working environment.

The fourth objective is to reduce the average noise levels in the pilot area of the Libertà district, with positive complementary effects also on the air quality and benefits on wellbeing conditions of inhabitants. In the district there are significant average levels of noise pollution affecting many citizens and it is identified as a hotspot in the Noise Action Plan implemented by the city of Monza, according to END requirements. In particular, a main average noise reduction and an air quality improvement are expected in correspondence of the Viale Libertà axis, due to the foreseen top-down measures to be put into practice. Moreover, less significant but still relevant noise reduction are expected in the entire Libertà district, thanks to both the top-down measures implemented in the Viale Libertà and the bottom-up actions to be encouraged inside the district itself.

Figure 1: NLEZ pilot area boundaries (Libertà district).

3 The case study

The city of Monza has started to develop an Urban Traffic Plan aimed to achieve three important goals: a new parking pricing policy in the city centre and in the immediate surroundings, a park&ride scheme to connect peripheral areas with the city centre by shuttle buses, the implementation of Limited Traffic Zones. Among the Limited Traffic Zones to be implemented, the Libertà district has been chosen as a pilot area in which the methodologies for NLEZs introduction and management will be tested. The Libertà district (Figure 1) is a densely populated residential area with about 15.000 inhabitants, located in the North-Eastern side of the city of Monza, in which a major road (Viale Libertà), daily crossed by about 30.000 vehicles, and roads affected by medium-low traffic are present. Viale Libertà is one of the most important access roads to Monza from the Eastern surrounding area and towns and it is currently also the primary East-West corridor of the city centre.

Due to its common characteristic of residential area and to the presence of a main and of several smaller roads, that of Libertà district has been considered an easily generalizable urban context and replicable in other areas of the city and in different European cities.

The area has been identified as a hotspot in Noise Action Plan and, in particular, based on Noise Mapping dated 2012, it can be observed that in a range of 30 m from the Viale Libertà almost the 100% of the receivers is exposed to noise levels higher than 65 dB during the day and higher than 55 dB during the night.

In the LIFE MONZA project, infrastructural interventions (top-down measures) to reduce the average noise levels due to the road traffic will be designed and implemented in a section of Viale Libertà, detecting also the potential positive effects on air quality, with respect of the surrounding area. The effects of these top-down measures, together with the promotion of bottom-up measures carried out by citizens, will allow the Libertà district to become a permanent NLEZ.

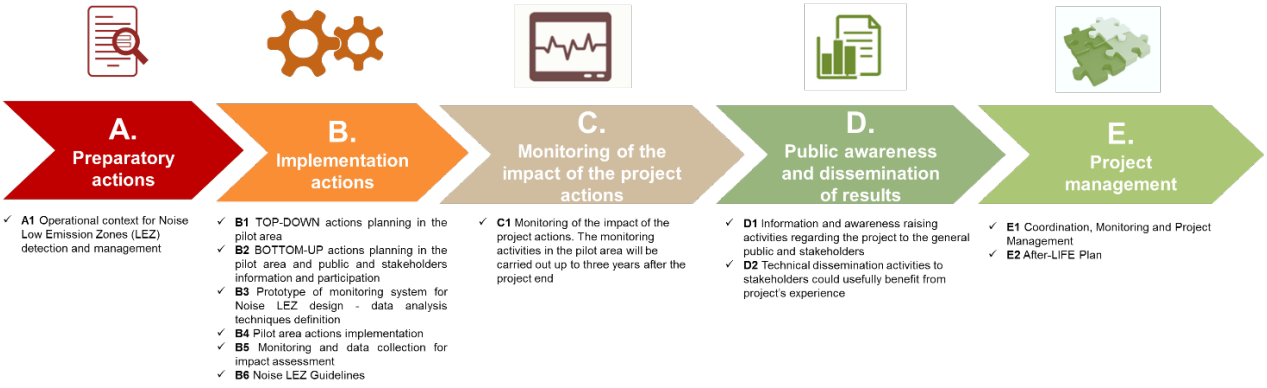

Figure 2: LIFE MONZA Project structure.

4 LIFE MONZA organizational structure

The LIFE MONZA project is structured in five Packages, each of which consists of different actions as displayed in Figure 2.

Preparatory actions (Package A) concern the updating of the currently available environmental and legislative framework on monitoring systems for noise and air quality, health indicators, etc. with regards to the NLEZ context.

Implementation actions (Package B) are referred to the design of top down and bottom up actions and their application in the pilot area. In particular, some tasks are dedicated to the infrastructures actions (silent asphalt designing, LEZ formal introduction, actions to limit high vehicles transit) and to the detailed designing of methods to be applied in order to actively involve citizens in the Project. Moreover, these actions will be dedicated to the designing of monitoring systems (a prototype system for smart monitoring activity of noise), techniques for the data analysis and restitution and to all the ante and post-operam monitoring activities with specific attention to road traffic, noise, air quality and health. Finally, Package B includes the drafting of guidelines for the introduction and management of NLEZ.

Monitoring actions (Package C) regard the monitoring of the impact of the projects action to be carried out both during the project and for three years after its conclusion.

Finally, in order to ensure the compliance with the demonstrative character of the Project as well as its management, Actions D and E are respectively planned to guarantee adequate communication and dissemination activities as well as a good project management.

In Figure 3 the timetable of the Project actions is shown.

5 First results achieved in each Project Package

At December 2017, after about 14 months from the beginning of the Project, some Actions turn out to be already concluded (A.1 and B.3), the majority of Actions are in progress (B.1, B.2, B.5, B.6, C.1, D.1, D.2, E.1) while other Actions (B.4 and E.2) have not started yet.

In the following paragraphs the main objectives of each Actions and already achieved results are described.

5.1 Preparatory actions (Package A)

The main objective of Package A, make up on the Action A1, is to achieve a state of the art review about the legislative and technical requirements on NLEZ as well as the most up to date noise and air quality monitoring systems and the most existing suitable health indicators of the effects due to noise and air pollution.

Action A1 was concluded on December 2016 and the main output was an Abacus on operational context on NLEZ (including sections devoted to noise, air, traffic and health topics) with several technical sheets about different analysed issues (available at http://www.lifemonza.eu/sites/default/files/A1%20Abacus%20on%20operational%20context%20on%20Noise%20Low%20Emission%20Zone.pdf).

Inside the Abacus, the European, Italian and local (concerning the city of Monza) legislation regulating measures to be taken by the Municipalities to reduce noise and environmental pollution and to implement Limited Traffic

Action		2016				2017				2018				2019				2020				2021			
Action numbe	Name of the action	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
A. Preparatory actions (if needed)																									
A.1	Operational context for Noise Low Emission Zones (LEZ) detection and management			■	■																				
B. Implementation actions (obligatory)																									
B.1	TOP-DOWN actions planning in the pilot area				■	■	■	■	■	■															
B.2	BOTTOM - UP actions planning in the pilot area and public and stakeholders information and participation				■	■	■	■	■	■															
B.3	Prototype of monitoring system for Noise LEZ design - data analysis techniques definition				■	■	■																		
B.4	Pilot area actions implementation										■	■	■	■	■	■									
B.5	Monitoring and data collection for impact assessment						■	■	■	■	■	■	■	■	■	■	■	■							
B.6	Noise LEZ Guidelines						■	■	■	■	■	■	■	■	■	■	■	■							
C. Monitoring of the impact of the project actions (obligatory)																									
C.1	Monitoring of the impact of the project actions						■	■	■	■	■	■	■	■	■	■	■	■	■						
D. Public awareness and dissemination of results (obligatory)																									
D.1	Information and awareness raising activities regarding the project to the general public and stakeholders					■	■	■	■	■	■	■	■	■	■	■	■	■	■						
D.2	Technical dissemination activities to stakeholders could usefully benefit from project's experience					■	■	■	■	■	■	■	■	■	■	■	■	■	■						
E. Project management (obligatory)																									
E.1	Coordination, Monitoring and Project Management			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■						
E.2	After-LIFE Plan																	■	■						

Figure 3: LIFE MONZA timetable.

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

Figure 4: Analysis of the state of the art about smart low-cost noise monitoring systems.

Zones (*e.g.* Legislative Decree n.285/1992, Decree of President of Republic n. 250/1999, Resolution of City Government n. 180/2014 and 270/2014, annual Orders of Monza Mayor) was described. Moreover, the analysis of the experiences and procedures developed in Europe on the smart and low-cost noise monitoring systems was conducted, in order to update the information for the definition of the operating context related to the problems of noise monitoring and also to provide support for prototype development. In particular, the main characteristics arising from the analysed projects and research are reported in Figure 4.

In this frame, networking activities were started with the LIFE DYNAMAP project [4] and with the Eurocities and FONOMOC networks [14, 15] dedicated to the acoustic monitoring.

In addition, a "conceptual framework" about the study design regarding the definition of the macro and microscale location criteria of the measurement points for the assessment of air quality in the area where the NLEZ will be implemented has been made, together with a brief review of systems for diffusive gas sampling and Land use regression models. The literature review was deepened also to identify the health indicators useful for the evaluation of the interventions covered by the project. Given the structure and timing of the project, it was decided to select proxy indicators of health status, modifiable in the time of evaluation of the study, related to quality of life (QOL). Finally, a review about existing types of interventions concerning low noise pavings, traffic regulation interventions, strategic interventions and noise barriers has been made and it is summarized in Figure 5. For each of the considered typologies of interventions, dedicated data sheets have been prepared and included in the Abacus.

TABLE OF CONTENTS

List of key-words and abbreviations:
LEZ area, interventions, effects, air quality, noise, health.

Number of typology of intervention	Typology of intervention	Number of the schedule on the specific intervention	Specific intervention
1	Low Noise Pavings	1.1	Use-surface "open graded"
		1.2	Use-surface "gap graded"
		1.3	Use-surface "dense graded"
		1.4	Use-surface "microtappeto"
		1.5	Use-surface "dense graded with expanded clay"
		1.6	Use-surface "gap graded with the addiction of polymers SBR/NR"
2	Interventions on traffic regulation	2.1	Chicane/road narrowings
		2.2	Roundabouts
		2.3	Speed bumps
		2.4	Safety islands
		2.5	Electronic devices for speed control
3	Strategic Actions	3.1	Urban Traffic Plan
		3.2	Public electric vehicles
		3.3	30 km/h zones
4	Noise barriers	4.1	Traditional noise barriers
		4.2	Low barriers

Figure 5: List of analysed typologies of interventions.

5.2 Implementation actions (Package B)

Implementation actions (Package B) represent the real core of the LIFE MONZA project since they include all the tangible interventions, including also monitoring activities, to be implemented.

The main objectives of Package B with related obtained results, when already available, are the following:

– Designing of a low noise paving, of two pedestrian crossing, of a lanes' width reduction in the Libertà street to be also forbidden by heavy vehicles (Action B.1).
  These interventions have been chosen on the basis of the characteristics of Viale Libertà during the project proposal preparation and they have been subsequently selected and defined among the general and adaptable ones listed in the Abacus. In particular, the low noise paving has been considered as a suitable solution due to the presence of traffic moving smoothly, while the pedestrian crossings and the lanes' width reduction are needed in order to reduce the average speed of vehicles. Finally, heavy vehicles, which are present in a relevant percentage and are one of the major causes of CO_2 production, will be forbidden and forced to use an alternative route distant form the residential zone. Considering the only use of the low noise paving, a reduction of at least 3 dB(A) is expected in correspondence of all receiver buildings and areas located up to 30-50 m from the Viale Libertà. An additional noise reduction of 1-1.5 dB(A) is expected due to the heavy vehicles limitation, to the pedestrian crossing intervention and to the lanes' width reduction.
  Finally, infrastructural interventions, together with bottom-up ones (Action B.2 inducing the reduction of the use of vehicles) are supposed to produce additional benefits not only along the Viale Libertà, but also in the whole Libertà district (0.5-1 dB additional noise reductions are expected as a consequence of bottom-up actions).
– Involvement of the population in the project at different level: meetings with stakeholders, citizens, students, organization of ideas contexts, availability of awards for virtuous citizens who implement bottom-up actions as suggested by dedicated tutorials, design of a free App and the "games" to be included to encourage citizens to implement "green actions" such as Pedibus and using of bicycles, submission of questionnaires mainly focused on health, mobility habits and noise perception (Action B.2).
  Focusing on questionnaires, whose last version will be soon added to the Project website, a diachronic sample survey was designed.
  With regard to the sample extraction, a stratified random sampling strategy was adopted. To establish its numerosity, given the reference population, defined as the citizens living in the study area between the ages of 18 and 80, was 6.150 units, a formula[1] taking into account the correction factor for finite populations was used, thus determining a sample of 570 units to be divided among the 12 cells identified by the crossing of the three chosen stratification variables (gender, age class and spatial location with respect to Viale Libertà), proportionally to their size in terms of resident population.
  The questionnaire is divided into sections that concern, in addition to the socio-demographic structural data, housing, the perception of the quality of life in the neighbourhood, that of air pollution and noise, health, mobility and knowledge of the LIFE MONZA project and its possible impacts on some aspects of the local system. The questionnaires will be sent by post, filled in self-administration and delivered directly by the interviewees to collection centres set up for this purpose. Furthermore, a second form of compilation was provided via the Internet, giving a direct access to the questionnaire to each interviewee.

1 $n = (z^2 p \bullet q / e^2) \bullet (1\text{-}f)$, where "n" is the sample width, "z" is the coefficient depending on the confidence level of the estimate, i.e. the level of confidence that the result is included within the established error limit "e", "p • q" expresses the variability, "1-f" the correction factor for finite populations (with "f" sampling fraction where f = n/N, with N indicating the reference population), *P. Corbetta, methodology and techniques of social research, Il Mulino, 1999, pp. 323-324.*

Table 1: Noise, air quality, socio-economic, climate parameters selected for the GI.

TYPOLOGY	DESCRIPTION	PARAMETER	UNIT
NOISE	Average value on the noise LEZ area	Lden	dB(A)
	Average value on the Viale Libertà buffer (30 m)	Lden	dB(A)
	Average value on the Viale Libertà buffer (30 m)	Ld	dB(A)
	Average value on the Viale Libertà 30 m buffer	Ln	dB(A)
	% of people exposed to Lden values > 65 dB(A) in the noise LEZ area	%	/
	% of people exposed to Lnight values > 55 dB(A) in the noise LEZ area	%	/
	% of people exposed to Lden values > 65 dB(A) in the Viale Libertà 30 m buffer	%	/
	% of people exposed to Lnight values > 55 dB(A) in the Viale Libertà 30 m buffer	%	/
AIR QUALITY	Particular matter	PM10	$\mu g/m^3$
	Particular matter	PM2.5	$\mu g/m^3$
	Other air pollutants	NO_2	$\mu g/m^3$
	Greenhouse gas emissions	CO_2	metric tons/year
SOCIO-ECONOMIC	Commercial Activities	N° of commercial activities in the noise LEZ	/
	People employed in commercial activities	N° of people employed in the noise LEZ	/
	Services activities	N° of services activities in the noise LEZ	/
	People employed in services activities	N° of people employed in the noise LEZ	/
CLIMATE	Areas potentially affected by climate change covered by adaptation measures	/	km^2

Two surveys have been planned: the first, currently on going, aimed at defining the situation ex ante, the second aimed at evaluating changes occurred after the implementation of the infrastructural interventions and of the other bottom-up measures foreseen by the Project.

– The delivering of the executive project for the realization of all the interventions in the pilot area (including economic framework and specifications and safety coordination during the design phase) (Action B.1) and the detailed design and implementation of interventions defined during Action B.1 (Action B.4)
– Collection of data about air quality, road traffic, noise (by using both traditional and smart noise monitoring systems) (Action B.5).

The first four ex-ante air quality monitoring campaign (inside the NLEZ) have been carried out during spring (3-23 May 2017) with the mobile laboratory located in Viale Libertà, during summer (14-31 July 2017), during fall (8-27 November 2017) and during winter (February 2018).

Hourly (SO_2, CO, NO_2, NO_X) and daily (PM10, PM2.5) averages have been measured using the respective European reference methods.

Moreover, the particle number concentration (PNC) and size distribution in the $0.3 \div 10$ μm range, have been measured with an aerosol particle sizer, while continuous measurement of black carbon (hourly averages) and aerosol light absorption properties have carried out using a Multi Angle Absorption Photometer. Moreover, daily averages concentration of organic and elemental carbon mass concentration on the collected PM10 samples have been assessed.

Concerning noise monitoring, by using low cost sensors, they have been monitoring since June 2017 in 10 locations. Concerning noise and traffic monitoring by using class I instrumentations, in the week 15-23 May 2017 a continuous monitoring of noise and traffic has been carried out for 7 days in two fixed locations, in addition to a series of spot measurements in various daytime periods in 10 locations in the neighbourhood.

The subsequent monitoring week was carried out from 20 to 27 November 2017, repeating both the

weekly measurements in the two fixed locations and the spot measurements in 10 positions.
The systematization of all data collected in the monitoring action previously described has been regularly continuing.
Data collected will be then elaborated in order to evaluate the air quality, noise, social and health information parameters indicated in the Project proposal and reported in Table 1.

– Development of NLEZ guidelines (Action B.6).
The purpose of NLEZ guidelines is to improve the NLEZ planning process considering noise aspects in planning process and to validate it as an important measure for traffic management and urban planning, being able to match air quality, noise topic and health benefits. The guidelines' contents, devoted to identifying and manage NLEZ, will be based on the results of the actions carried out in the pilot area of the Libertà district and will regard the following activities:
  – criteria to be adopted in order to identify a noise LEZ (size of the area, number of inhabitants, typologies of affecting noise sources, etc.);
  – top-down actions planning (action B.1), concerning the interventions ensured by the municipality (traffic management, road paving substitution, limitation of the vehicles speed);
  – bottom-up action planning (action B.2), regarding the public involvement, in order to share lifestyle choices having effects on noise reduction and on air quality improvement (improving the use of bycicles, pedibus service) and also in order to discover and build together the "genius loci" of the area, defining a territorial identity of the NLEZ area, through initiatives presented as a challenge to plan/build a part of their city;
  – traditional noise monitoring systems and smart noise monitoring systems (action B.3);
  – data analysis techniques definition.
– The design and implementation of a smart noise monitoring system, as a prototype, composed by 10 low cost microphones to be placed along the Libertà street but also in other streets of Libertà district (Action B.3) The definition and preliminary check of the prototype of the noise smart monitoring system. In particular, the prototype technical specifications were defined [16] keeping in mind the aim of a long-term monitoring activities (Action B.3). These are expected to be useful to understand the variability of acoustic climate in the pilot area with mainly reference to "LAeq" parameter.
According to the previous general requirements and to the outcome of the carried-out state of the art analysis, the following main specifications of monitoring units are defined:
  – acoustic parameters: overall A-weighted continuous equivalent sound pressure level, "LAeq" and continuous equivalent sound pressure level, Leq, as 1/3 octave band spectrum data;
  – timing for data recording: data will be acquired with a time basis of 1 second in order to permit the recognition of unusual events in the eventual analysis phase (unusual events could be recognised in a semi-automatic manner by carrying out some specific statistical an analysis, *e.g.* performing an analysis on percentiles levels. the unusual events recognition process is currently under evaluation);
  – timing for data transmission: data will be sent to the remote server every one hour;
  – data transmission network: the data will be transmitted through the 3G cellular telephonic network;
  – power supply: solar panel (max expected size 60cm × 60cm) 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);
  – frequency response at nominal frequencies of 1/3 octave within the class I specs ± 1dB

Starting from the specs listed above, the monitoring system architecture has been mainly based on monitoring units designed in the LIFE DYNAMAP project (these units comply with all the specs) [4], tailoring the data transmission, storage and post-analysis to the needs of the LIFE MONZA project (this latest aspect is not dealt with in the present paper).

A first smart monitoring unit has been installed on a building of the the University of Florence in Sesto Fiorentino (Florence) and has been tested for a period of two months. Once tests have been successfully completed, ten control units have been acquired and the respective measurements positions have been chosen (Figure 6) according to a representative and homogeneous distribu-

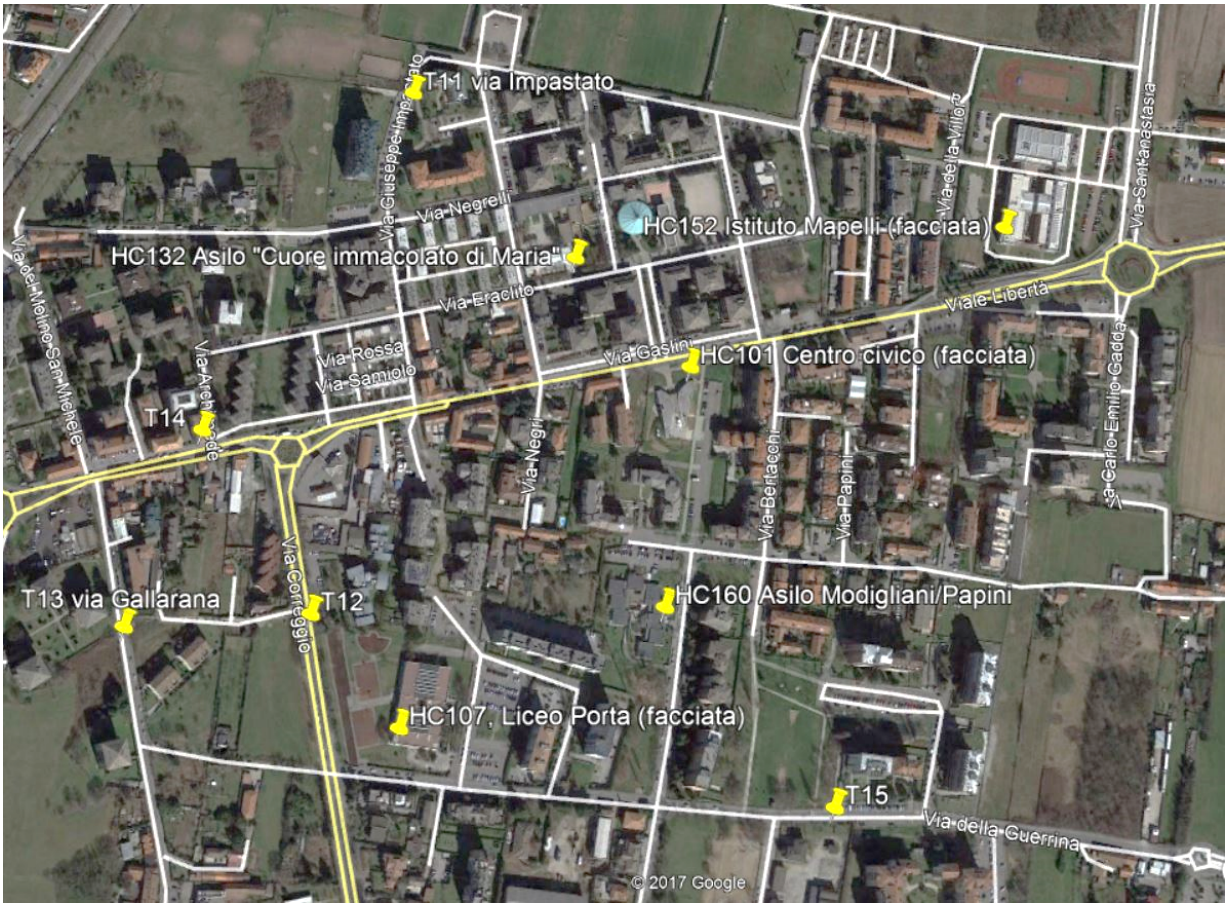

Figure 6: Selected noise monitoring positions.

tion in the Libertà district and taking into account the different typologies of streets and the presence of sensitive receivers (*e.g.* schools). In particular, three microphones have been placed along the Viale Libertà, the main street of the district where the traffic flow mix is expected to mainly change from the ante to the post-operam scenario.

Moreover, a periodic check of the low-cost system has been planned to understand if the measurement accuracy is maintained in time or if sensors need to be repaired or replaced. In fact, two on-site operation checks have been positively carried out in 2017 at all the installed control units with traditional instruments in Class I (Action B.5). The first check has been carried out by means of a calibration control, the second check consists of performing coupled measurements by using both class I instrumentations and low-cost sensors. Specifically, the class I microphone has been positioned in front of the low-cost one and it has been verified that the deviation of the values measured by the two microphones according to the "LAeq" parameter are kept below 1.5 dB (A).

5.3 Monitoring of the impact of the Project actions (Package C)

The main aim of Package C is to progressively verify that implementation actions belonging to package B are realized according to the originally defined objectives and that the quantitative expected results are achieved. Specifically, a Global Index (GI) combining air quality, noise pollution, road traffic, health and socio-economic parameters and a Smart Global Index, a simpler version of the GI including at least noise indicators, will be developed.

Concerning Package C, a first achieved result is the completion of the state art analysis concerning existing complex environmental indicators. During this phase several articles, books and guidelines have been analysed and it turned out that a complex indicator perfectly fitting the project objectives has not been developed yet. As a consequence, a specific work will be carried out in the next periods in order to adapt the existing and already validated indicators to the environmental, health and socio-economic parameters to be monitored in the frame of the LIFE MONZA project.

Figure 7: Documents presented during some dissemination events.

The parameters illustrated in Table 1 have been selected and agreed among Project partners to be introduced in the GI.

5.4 Public awareness and dissemination of results (Package D)

The main objective of Package D is to structure a dynamic, multidisciplinary and spread system to inform, communicate, intrigue and make the method tested in the pilot area transferable and replicable, by involving stakeholders, general public and end users. Another goal is to make people aware of the health risks caused by the noise impact and the poor air quality, encouraging and stimulating people to act in first person to contribute to the improvement of the environmental quality.

In the perspective of disseminating the project activities, but also of finding and testing new forms of citizens' involvement, until this moment project partners have participated to two International Congresses and to one Italian Congress presenting some papers and to several meetings about noise. Moreover, a specific event to celebrate the 25^{th} anniversary of LIFE projects has been organized in Florence and on the occasion of the Noise Awareness Day dissemination activities with several hundred students have been organized at some schools located in the Liberty District.

6 Conclusions

In the recent past several studies about Low Emission Zones (LEZs) have been carried out in Europe showing that, in most cases, they represent an effective measure to reduce traffic-related air pollutants. However, the effects and the potential benefits concerning the noise reduction have not been addressed in a deep manner yet. The main objective of the LIFE MONZA Project, started in September 2016, is to develop and test an easy-replicable method, and related guidelines, for the identification and the management of the Noise Low Emission Zone (NLEZ) able to reduce the average noise levels but with positive complementary effects also on the air quality and benefits on wellbeing conditions of inhabitants. The procedure will be firstly applied in the pilot case of the Libertà District, by adopting top-down strategic measures and involving citizens in an active management of more sustainable lifestyle choices related to the reduction of noise and the improve-

ment of air quality and wellbeing conditions in their living and working environment.

In the current article the project structure is illustrated in terms of Packages and specific Actions. Moreover, the main results achieved until December 2017 are presented, in terms of: the development of an Abacus on operational context on NLEZ, the definition and first tests of the prototype for the noise smart monitoring system, the selection of noise, air quality, socio-economic and climate parameters to be used to build the environmental Global Index.

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References

[1] Noise in Europe 2014. EEA Report- No 10/2014 European Environment Agency (2010).

[2] Directive 2008/50/EC of the European Parliament and of the council of 21 May 2008 on ambient air quality and cleaner air for Europe.

[3] Directive 2002/49/EC of the European parliament and of the Council of 25th June 2002 relating to the assessment and management of environmental noise.

[4] Sevillano X., Socorò J.C., Bellucci P., Peruzzi L., Radaelli S., Coppi P., Nencini L., Cerniglia A., Bisceglie A., Benocci R., Zambon G., DYNAMAP – Development of low cost sensors networks for real time noise mapping, Noise Mapping Journal, 2016; 3:172-189.

[5] Carfagni, M., Bartalucci, C., Borchi, F., Governi, L., Aspuru, I., Bellomini, R., Gaudibert, P., Petrucci, A., Weber, M., Life+2010 QUADMAP project (QUiet Areas Definition and Management in Action Plans): the new methodology obtained after applying the optimization procedures, Proceedings of the 21^{st} International Congress on Sound and Vibration, Bejing, 13-17 July, (2014).

[6] Borchi, F., Bartalucci, C., Carfagni, M., Governi, L., Zonfrillo, G., Bellomini, R., Wolfert, H., Aspuru, I., Gaudibert, P., LIFE+2010 QUADMAP project (QUiet Areas Definition and Management in Action Plans): results of post operam data analysis and the optimized methodology, Proceedings of 22nd International Congress on Sound and Vibration, Florence, July, (2015).

[7] Bartalucci, C., Borchi, F., Carfagni, M., Governi, L., Bellomini, R., Luzzi, S., Asdrubali, F., D'Alessandro, F., Schiavoni, S., Contributions to END interpretation and implementation from the Italian case studies of EU funded projects HUSH, NADIA and QUADMAP, Proceedings of 23rd International Congress on Sound and Vibration, Athens, Greece, 10-14 July, (2016).

[8] Vincent B., Gissinger V., Vallet J., Mietlicky F., Champelovier P., Carra S., How to characterize environmental noise closer to people's expectations, Proceedings of the 42^{nd} INTERNOISE Congress, Innsbruck, Austria, 15-18 September, (2013).

[9] Schiavoni S., D'Alessandro F., Conte A., The contribution of LIFE+NADIA project on the implementation of the European Directive on Environmental Noise, Noise Mapping Journal, 2015; 2:13-30.

[10] Borchi, F., Carfagni, M., Governi, L. The H.U.S.H. project - A harmonized methodology for action planning, Proceedings of the 9th European Conference on Noise Control, 345-350, Prague, Czech Republic, 10-13 June, (2012).

[11] Borchi, F., Carfagni, M., Curcuruto, S., Governi, L., Silvaggio, R., HUSH project results: definition of a platform for an integrated and harmonized noise Action Plan and proposals for revision of Italian legislation and END Directive, Proceedings of AIA-DAGA Congress, Merano, Italia, (2013).

[12] Ecorys, Feasibility study: European city pass for low emission zones, Annex A: Standards and Guidance Document. Rotterdam, (2014).

[13] http://urbanaccessregulations.eu/

[14] http://www.eurocities.eu/

[15] https://workinggroupnoise.com/fonomoc/

[16] Bartalucci C., Borchi F., Carfagni M., Furferi R., Governi L., Silvaggio R., Curcuruto S., Nencini L., Design of a prototype of a smart noise monitoring system, Proceedings of 24^{th} International Congress on Sound and Vibration, London, UK, 23-27 July, (2017).