LIFE E-VIA

“Electric Vehicle noIse control by Assessment and optimisation of tyre/road interaction”

LIFE18 ENV/IT/000201

Deliverable	
Content	Technical Report Action B5
Action/Sub-action	Action B5: Soundscape analysis
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List of keywords: soundscape analysis, soundwalks, optimized asphalt, electric vehicle, subjective data

Abbreviations:

EV Electric vehicle

ICEV Internal Combustion Engine Vehicle

WHO World Health Organization

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Executive Summary

The main aim of the LIFE E-VIA project is to tackle traffic noise pollution, in a future scenario involving a consistent portion of electric and hybrid vehicles.

The present deliverable is the outcome of the action B5 of LIFE E-VIA that was foreseen to investigate people's perception regarding noise applying a soundscape approach, to assess the benefits of the use of the optimized asphalt developed in the frame of the project (Action B2) and laid down in a section of a pilot street in Florence in mid July 2021 (Action B3). An additional aim of action B5 is to raise people's awareness on road traffic noise pollution and promote electric vehicles technology and low noise asphalts.

Action B5 is split into 3 sub-actions:

- Sub action B5.1- Soundwalks and interviews in the pilot area.
- Sub action B5.2 - Interview in the pilot road on an electric vehicle "taxi".
- Sub action B5.3 - Ante and post operam interviews with residents.

In order to assess the perception of soundscapes at different outdoor locations close to the pilot area, a cycle of soundwalks was organized and carried out from April to November 2022, that is after the project intervention, and involved 80 participants (Sub action B5.1). The analysis of data collected through a questionnaire submitted to participants shows that if we focus on comparing the two listening points of the soundwalk's itinerary located in the pilot street, the one located on the sidewalk of the section repaved with the optimized asphalt is considered slightly better in terms of soundscape quality and traffic noise pollution than the one located at the section of the street with repaved with a standard asphalt. These results suggest that the optimized asphalt may be one of the factors that plays a major role in improving the quality of the perceived soundscape. This hypothesis is supported by the results of both: i) the assessment of audio recordings and ii) of the evaluation of acoustic comfort inside the electric taxi while passing through the stretch of the street repaved with the optimized asphalt. These evaluations were performed by the same sample that took part to the soundwalks experiences. Indeed, a higher number of subjects evaluated the quality of the (recorded) soundscape inside an EV passing on the optimized asphalt as "good", compared to a share of 10% as regards the recording inside an ICEV and inside an EV passing on new but standard asphalt. Moreover, 70% of the subjects interviewed inside the electric taxi indicated the LIFE E-VIA optimized asphalt as the one with the best performance in terms of acoustic comfort. It is also important to emphasize that the survey conducted through the distribution and collection of ante-operam and post-operam questionnaires to people living in the section of the street targeted by the intervention, has demonstrated that the repaving of the pilot street has improved the quality of the soundscape and significantly reduced the perceived road traffic noise. As an illustration, according to 61% of the respondents to the post operam questionnaire traffic noise has decreased after the intervention. Concurrently, 77% of the respondents assessed the intervention as positive, in terms of reduction of road traffic noise perceived from home.

In conclusion, the 3 sub-actions of Project Action B5 have demonstrated the benefits that the re-pavement of an urban street with the LIFE E-VIA optimized asphalt can bring in terms of soundscape perception.

In addition, although not specifically provided for in any project action, three noise and traffic monitoring campaigns were conducted by partners VIENROSE and I-POOL prior to the paving of the new asphalt in the Florence pilot case, immediately after the intervention, and approximately 16 months later. The results obtained showed a reduction of 4.4. dB(A) in terms of Lnight between the first and second phases and a loss of performance of about 1.5 dB(A) in the following months.

1 Introduction

1.1 The pilot case in Florence and Action B5

Action B5 is strictly related to the Project Objective n.5 dealing with the possibility of raising people's awareness on noise pollution and health effects and investigating people's perception regarding noise applying the soundscape methodology.

Specifically, Action B5 is dedicated to the implementation of a soundscape holistic approach to assess the benefits of the intervention carried out in the pilot road (Paisiello Street) and to raise participants awareness of the issue of traffic noise and the possible solutions offered by the increase in the use of electric vehicles and high-performance road pavements.

The abovementioned intervention refers to the re-pavement of a section of Paisiello street with an innovative low-noise asphalt (hereafter also referred to as "optimized asphalt"), developed in the frame of the project to reduce traffic noise pollution (Figure 1). It is important to note that Paisiello street is characterized by a significant housing density and by a high level of traffic caused to its proximity to the Florence city center and to public offices (e.g. Regional Agency for Environment Protection ARPAT).

Figure 1 - The Pilot case in Florence

The intervention was carried out in mid July 2021 (Figure 2).

Figure 2 - The re-pavement of the pilot street

Action B5 is split into 3 sub-actions:

- B5.1 Soundwalks and interviews in the pilot area
- B5.2 Interview in the pilot road on an electric vehicle “taxi”
- B5.3 Ante and post operam interviews with residents

The following sections will present in detail how the three sub-actions were designed and expose the results of the interviews and survey conducted in each sub-action.

All the 3 sub-actions deal with the application of a holistic soundscape approach. Indeed, recent studies demonstrate that, in addition to the need to ensure noise levels complying with the values set out in the 2018 World Health Organization - WHO guidelines [1], it is very important to assess whether certain interventions are able to improve the perception of the soundscape by citizens. Notably, by using soundwalk holistic approach scholars have pointed out that in some cases (post operam scenarios) even if the noise levels are maintained or only slightly reduced with a change in the type and spectral characteristics, significant improvements in the soundscape's perception are detected.

2 Sub Action B 5.1: soundwalks and interviews

2.1 Introduction

In order to assess the benefits of repaving a stretch of road with the optimised asphalt from the point of view of subjective perception and to involve the population, soundwalks and interviews were organised in the area. In particular, the experiences included:

(i) soundwalks with five listening points, with the aim of assessing the participants' perception of environmental noise;
(ii) binaural headphone listening of four audio recordings to assess the perceived soundscape inside a vehicle.

A soundwalk is an excursion on foot with the intention of listening closely and consciously to sounds [2]. It is a practice that involves walking and listening and provide participants with a unique sensory experience that goes

beyond the visual, physical features of a specific space. Generally, the essential purpose of a soundwalk is to encourage the participant to listen discriminately, to make a critical judgement about the sounds heard and their contribution to the balance or imbalance of the acoustic environment. Specifically, in this context, the soundwalk has been designed as a method to evaluate participants' perceptions of the soundscape (external/environmental noise) in selected locations close to the pilot area (including the sections of the pilot street concerned by project intervention).

Concerning binaural headphone listening of recordings, participants to soundwalks have been asked to listen to audio recordings made inside an EV and ICEV passing through different stretches of the pilot road with different type of asphalt pavements (see section 2.2.2 for details) and evaluate the quality of the soundscape. This experience was foreseen in order to analyse differences in terms of perception between the external perception of the soundscape (as assessed during soundwalks) and internal noise/soundscape inside a vehicle.

A questionnaire was designed and submitted to participants to be filled in during each experience.

2.2 Methods

2.2.1 Soundwalks

The soundwalks were organized in the area surrounding the project pilot street.

Concerning the itinerary of the soundwalk, five significant stopping points were selected (Figure 3). Specifically:

- Listening point n.1 in a quiet area inside a garden of an association and close to sport facilities;
- Listening point n.2 at the section of the pilot street repaved with the LIFE E-VIA optimized asphalt;
- Listening point n.3 at the section of the pilot street repaved with standard asphalt;
- Listening point n.4 in a street parallel to the pilot street;
- Listening point n.5 in the patio of an ex industrial renovated space (Manifattura Tabacchi)

Figure 3 - Soundwalks itinerary, 5 Listening Points

Each soundwalk was structured as follows:

1. Brief introduction to the soundwalk and to the LIFE E-VIA project;
2. Ear cleaning exercises;
3. Walk in silence with stops at the listening points;
4. At each listening point: listening in silence to the surrounding soundscape (3-4 minutes) and successively filling in the section of the questionnaire concerning each location;
5. Conclusion.

During the phase in which the participants were left to listen in silence to the surrounding soundscape (3-4 minutes), acoustic measurements and audio recordings were also carried out. The processing of the acoustic measurements made it possible to evaluate the consistency between the subjective and objective acoustic assessment.

As regards ear cleaning exercise, they were designed based on a literature review in the field [3] to help participants training conscious listening. Indeed, while hearing is an automatic skill, listening requires a certain level of concentration and engagement with the surrounding environment. During the exercise participants are asked to focus on and write down different type of sounds perceived in the soundscape around them (specifically, pleasant/unpleasant, close/distant, in motion/static, natural/mechanical/anthropic sounds) and then to follow a sound source with closed eyes.

2.2.2 Audio recordings

Four different binaural recordings were carried out inside an ICEV or an EV with a dummy head made available by HEAD acoustics company, while driving on specific stretches of the pilot road with different pavements (Figure 4) and correspond to the following audio-recordings that voluntary participants were asked to listen to and evaluate in terms of perceived soundscape quality:

- Inside an ICEV while passing through a section of the road with Optimized Asphalt
- Inside an EV while passing through a section of the road with Optimized Asphalt
- Inside an EV while passing through a section of the road with New but standard Asphalt
- Inside an ICEV while passing through a section of the road New but standard Asphalt

Figure 4 - Binaural recordings inside the vehicle

Participants were asked to listen to the above-mentioned audio recordings with binaural headphones in a room located close to the soundwalk itinerary (Figure 5). Listening sessions were organized right after each soundwalks experience.

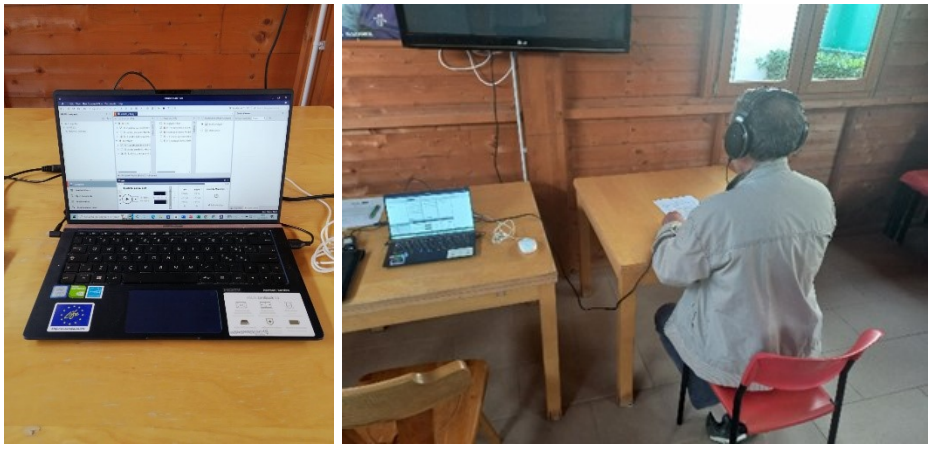

Figure 5 - Listening to binaural recordings

2.2.3 Questionnaire design

The structure of the questionnaire submitted to soundwalks participants consists of three main sections including a section related to the ear cleaning exercises.

Specifically, the questionnaire includes:

- A Section on personal information composed of:
  - 6 questions on age, gender, education, occupation, and nationality of the participants.
  - 3 questions to collect data on the relation of participants with the urban location where the sound walk took place (e.g. frequency and motivation of the attendance of Paisiello Street)
  - 1 question on personal sensitivity to sounds;
- A section related to the ear cleaning exercise;
- A section dedicated to each listening points of the soundwalks. For each location the questionnaire includes 5 questions which focus on the assessment of different type of sound sources (traffic, technologic, anthropic, nature) on the characteristics of the soundscape (e.g. pleasant, chaotic, disturbing etc.) and on the evaluation of the quality of the urban landscape and soundscape including its appropriateness.

An additional part of the questionnaire was submitted to participants that listened to the audio recordings and includes, for each listening, a question on the quality of the (internal) soundscape.

The schematic structure of the full questionnaire (including both the part on the soundwalk and the part on the audio recording) is displayed in Table 1. The full questionnaire template, translated in English language and including an introductory section presenting the project and the survey, is made available in Appendix I.

Section	Question
Personal Information	Age
	Gender
	Education
	Occupation
	City of residence
	Nationality
	Familiarity with the place
	Frequency
	Reasons
	Personal sensitivity to noise
Ear cleaning exercise	Sounds identification
Listening points (5 questions, one for each listening point)	Intensity of sounds
	Quality of soundscape
	Appropriateness of soundscape
	Characteristics of soundscape
	Quality of urban landscape

Table 1 - Structure of the Questionnaire

Dissemination actions were put in place to engage participants. The initiative was disseminated through the social media accounts of Vie en.ro.se Ingegneria (e.g., Facebook) and by preparing ad-hoc leaflets (Figure 6), These were distributed in social gathering places close to the pilot area (cafes, a music school, sports facilities, secondary school). The leaflets were also sent by emails to several residents that had participated in the ante-operam survey (see section 4).

Figure 6 - Leaflet

2.3 Results

2.3.1 Soundwalks' survey

From April to November 2022 seven soundwalks were carried out with groups of 10-13 people, which are considered small enough to not modify the surrounding sound environment and to be properly thought about how to behave. A total of 80 participants took part in the soundwalks cycle. Each soundwalk experience lasted approximately 40 minutes and was guided by Vie en.ro.se technical staff.

During the ear cleaning exercises carried out in an area close to LP1, participants were able to perceive and recognize different type of sounds reported in Table 2. Not surprisingly, nature sounds (e.g., leaves, wind) are considered the most pleasant sounds, while traffic noises are categorized as unpleasant.

Close sounds	Distant sounds	Pleasant	Unpleasant	In motion	Static	Nature sounds	Mechanical sounds	Anthropic sounds
Tennis ball	Cars	Leaves	Traffic noise	Cars	Tennis	Wind	Traffic	Voices
Leaves	Traffic	Wind	Cars	Traffic	Wind	Leaves	Noice	Steps
Wind	Voices	Trees	Motorcycles	Voices	Air system		Air system	Tennis ball
		Anthropic sounds						

Table 2 - Results of the ear cleaning exercise

The following paragraphs present the descriptive analysis of the data collected during the soundwalk by means of the self-administered questionnaire.

Demographic profile

As regards the gender distribution of participants, women participation rate (58%) was higher than the male one. The most represented age groups were the one ranging from 18 to 25 years and the one from 66 to 77 years. Indeed, the majority of the sample is composed of students and retired people (Figure 7 - Soundwalks participants' Age and OccupationFigure 7). As regards education, almost 77% of the respondents has at least a high-school diploma (Figure 8).

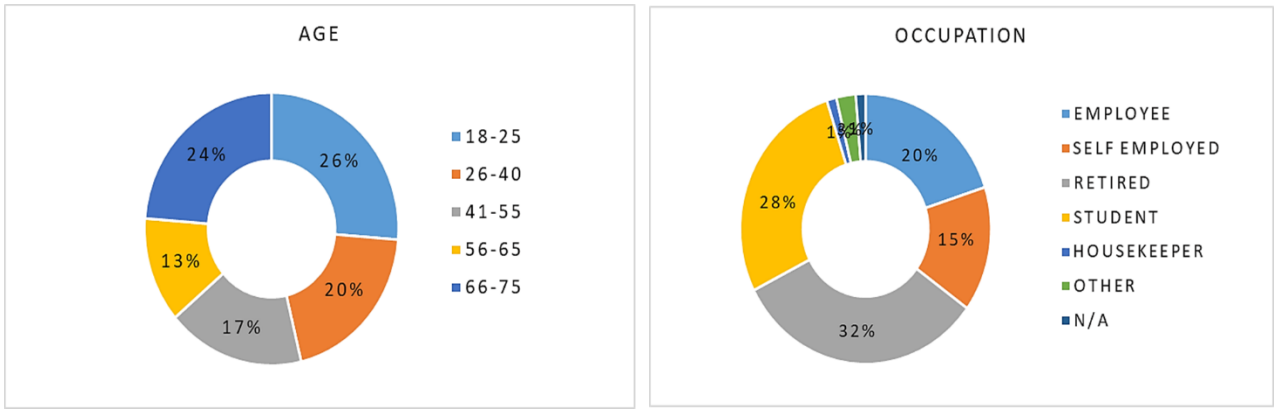

Figure 7 - Soundwalks participants' Age and Occupation

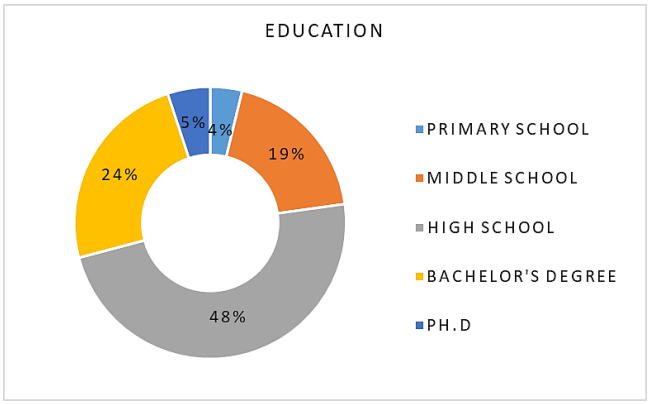

Figure 8 - Soundwalks participants' Education

Concerning the attendance of the area (pilot street) 38% of those who already know the pilot street, that is 71 out of 80 participants, attends the area everyday (most of them live there), 28% few times a year (especially as a transit area), 24% once a week (e.g. for leisure activities at sport facilities located in the area) (Figure 9).

Figure 9 - Pilot street attendance and main reasons

Concerning noise sensitivity, it is important to note that 78 respondents out of 80 assessed their sensitivity to sounds selecting a value ranging from 7 to 10 in an eleven-point scale, corresponding to an "high" and "very high" sensitivity (Table 3).

Options	0	1	2	3	4	5	6	7	8	9	10
Frequency	0	0	0	0	0	0	2	31	40	2	5

Table 3 - Respondents noise sensitivity

Soundscapes evaluation

As regard the evaluation given by participants to the soundscape to the soundscape perceived at each listening point, a comparative data analysis shows that LP3 is perceived as the most disturbing location; instead, LP1 and LP5 are the most enjoyable and relaxing sites in terms of perceived sound environment (Figure 10).

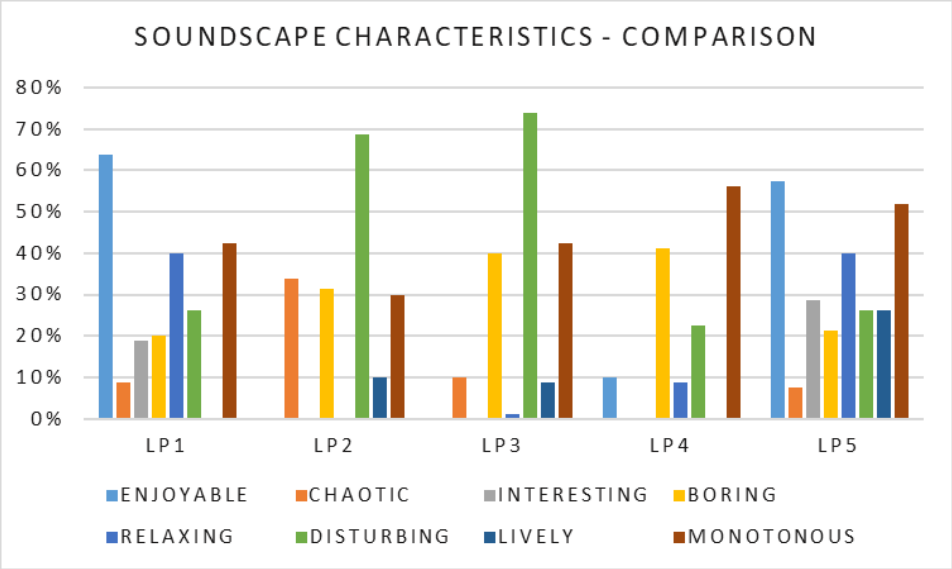

Figure 10 - Evaluation of soundscape characteristics

As regards sound sources, according to respondents, traffic noise is perceived with a slightly less intensity in LP2 and LP4 than in LP3 (Figure 11). Specifically, LP3 is the only location where the total number of participants evaluate traffic sounds at least as “fair”. At LP2 the number of participants that evaluate traffic sound as “fair” “high” or “very high” is slightly lower (almost 80%). Noteworthy, LP2 corresponds to the location close to the section of the street that was repaved in July 2021 with the LIFE E-VIA optimized asphalt, LP4 is located in a parallel street generally characterized with a lower level of traffic while LP3 is located in the section of the pilot street that was repaved with a standard asphalt.

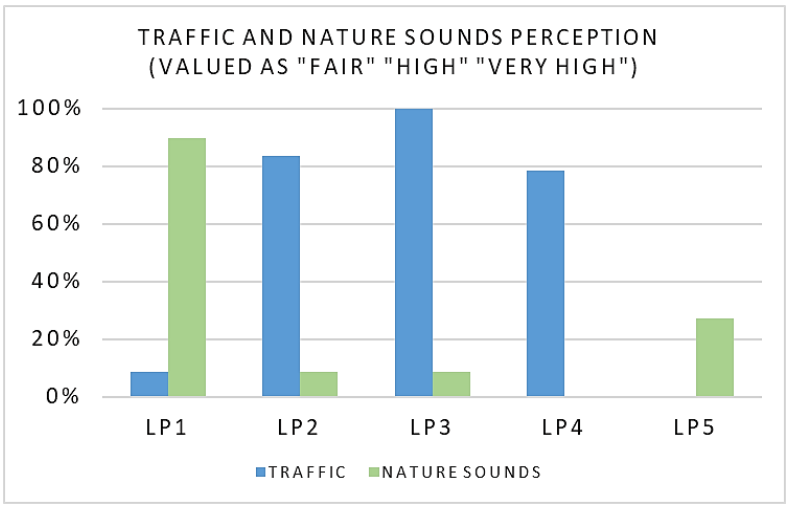

Figure 11 - Evaluation of sound sources

These results are reflected in the assessment of the quality of soundscape and landscape, the great majority of participants assesses the soundscape quality of LP2 and LP3 with 4-6 values on a 11-scale, respectively 98% and 86% (Figure 12). Most respondents also values the landscape at the location close to the pilot street as “fair” (Figure 13).

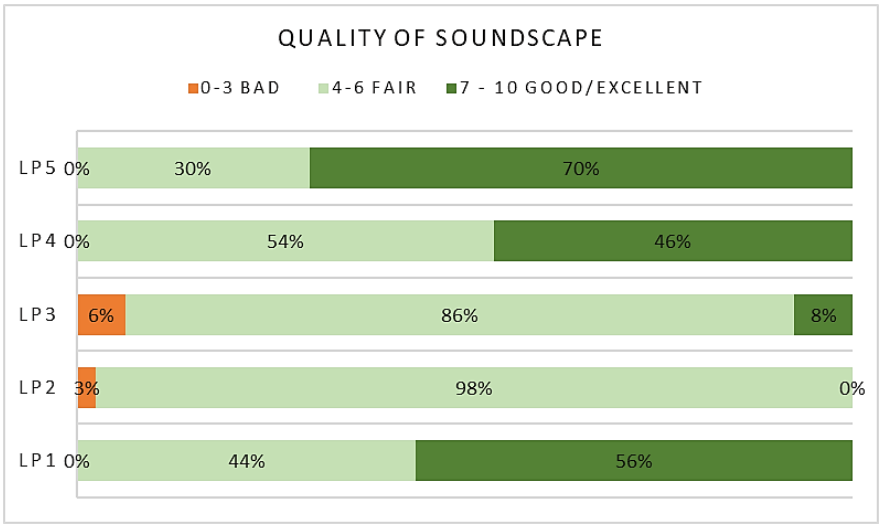

Figure 12 - Assessment of the quality of soundscape

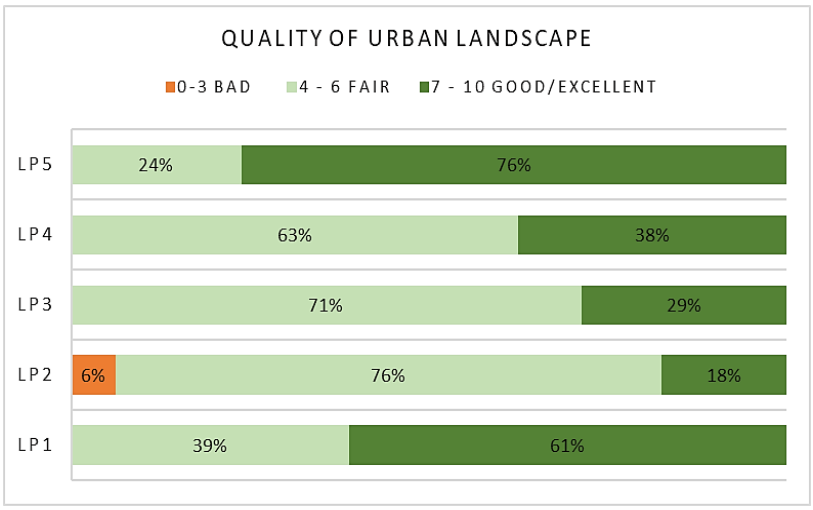

Figure 13 - Assessment of the quality of urban landscape

Moreover, all the sites selected as listening points are considered as having an “appropriate” soundscape by most of the participants, except for LP3 which corresponds to the higher portion of “uncertain” (Figure 14).

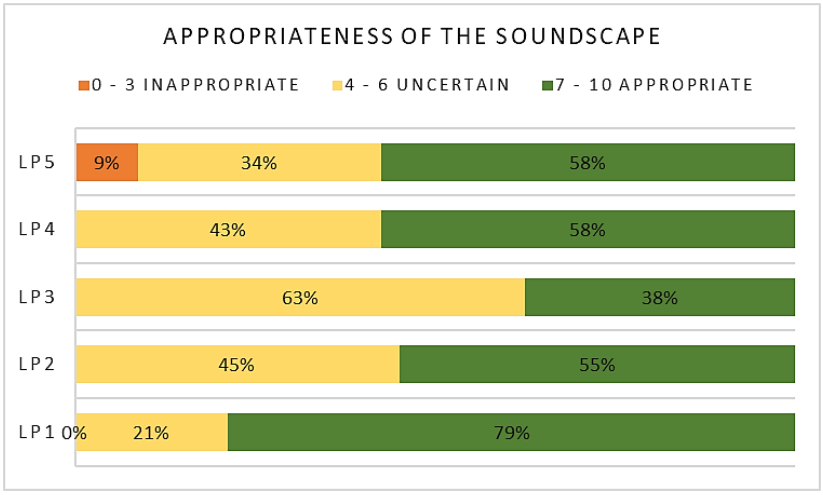

Figure 14 - Appropriateness of the soundscape

If we focus on the results concerning the two listening points located in the proximity of the pilot road, data show that at LP2, corresponding to the section of the street with re-paved with the optimized asphalt, 16% of the subjects perceived traffic noise as «fair» (Figure 15), instead, at LP3 (section repaved with the standard asphalt) all the subjects evaluate it as at least «high» (Figure 16).

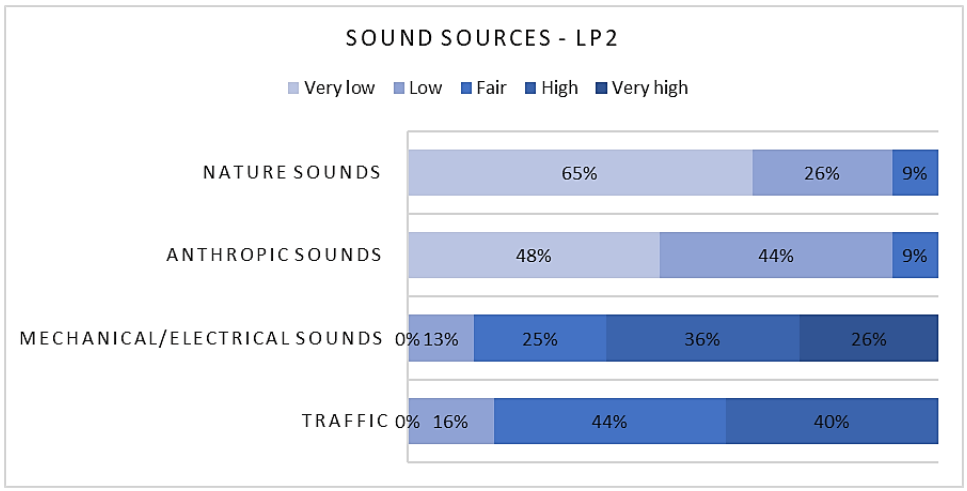

Figure 15 - Sound sources perception at LP2

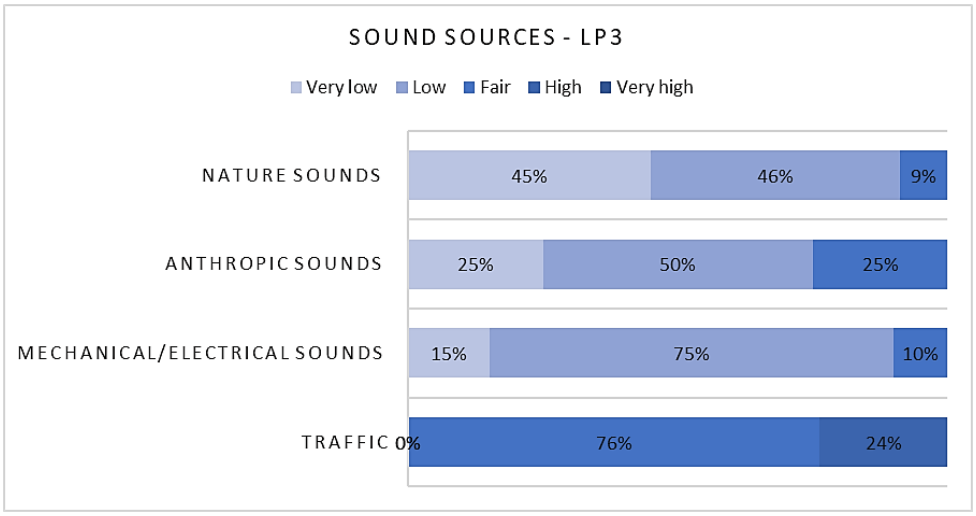

Figure 16 - Sound sources perception at LP3

As shown by the following charts, concerning the assessment of soundscape characteristics, at LP2 51% of participants agreed and 18% strongly agreed to describe it as disturbing (Figure 17). At LP3, 74% of participants agreed to describe the soundscape as disturbing (Figure 18).

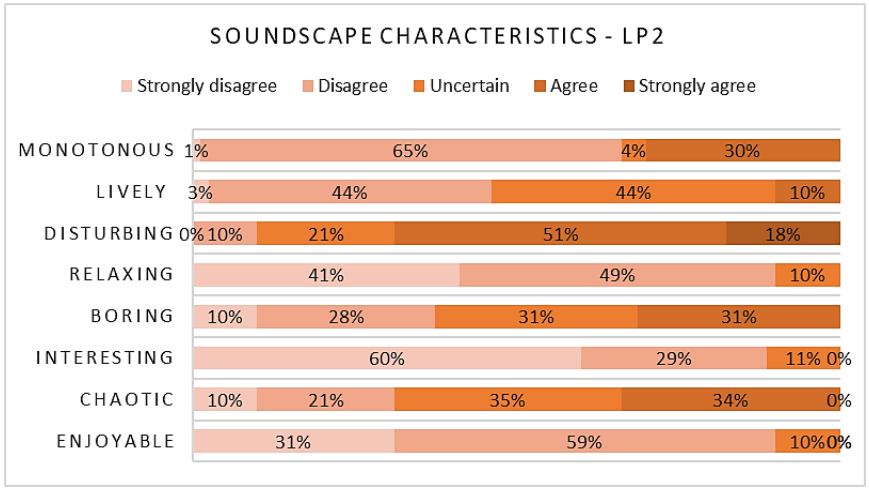

Figure 17 - Soundscape characteristics at LP2

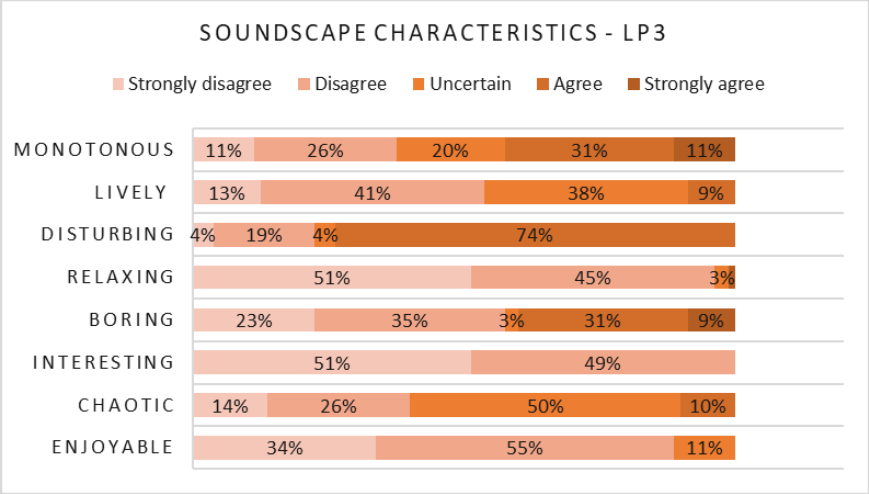

Figure 18 - Soundscape characteristics at LP3

2.3.2 Participants' evaluation of audio-recordings

The sample that participated at the sessions organized to listen and assess audio recordings is the same one that took part to the soundwalks. Data analysis shows that 30% of the subjects evaluated the soundscape inside an EV passing on the optimized asphalt as "good" while the percentage is just 10% as regards the sound perceived inside and ICEV and an EV crossing a street section with standard asphalt. It is relevant to note that the recording of the passage on the optimized asphalt inside an ICEV is perceived as the worst one, suggesting the relevance of noise produced by an ICEV engine (Figure 19).

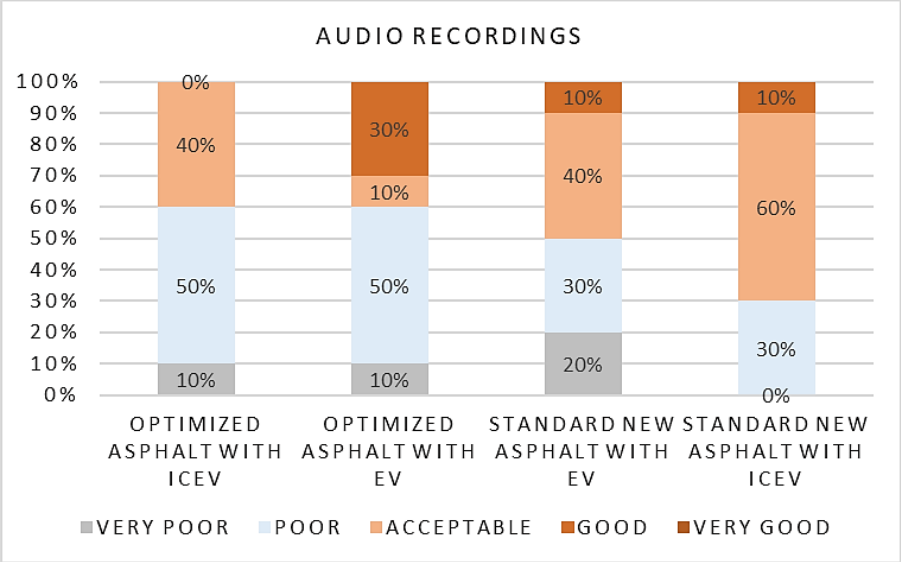

Figure 19 - Evaluation of audio recordings

3 Sub Action B 5.2: interviews on an electric taxi

3.1 Introduction and method

In order to assess participants perception of the acoustic comfort inside an electric vehicle, interviews on an electric taxi were organized. Participants were asked to evaluate the soundscape perceived inside the car and share their impression regarding acoustic experience while passing, as taxi passengers, through the following sections of the pilot road/area: 1) section with LIFE E-VIA optimized asphalt, 2) section with new but standard asphalt, 3) section with worn asphalt (Figure 20). A Nissan Leaf taxi was rented to carry out this acoustic experience. The trip for each passenger lasted almost 5 minutes.

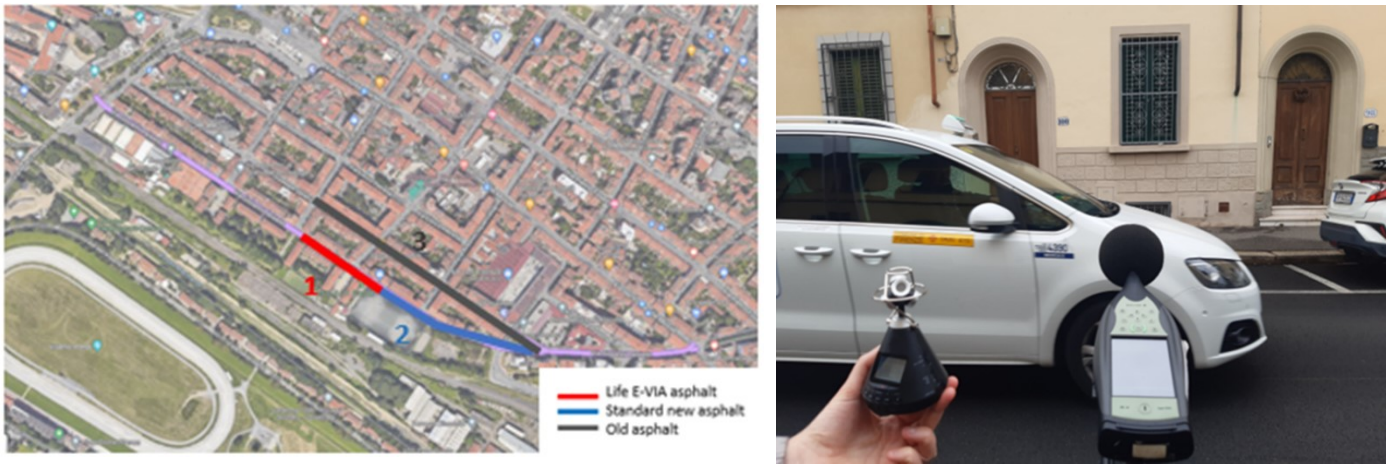

Figure 20 - Electric taxi trip

3.2 Analysis of qualitative interviews

Interviews inside the electric taxi were conducted after the soundwalk and audio listening sessions. Interviews to 80 participants were carried out, corresponding to the same sample of the soundwalks' survey. Data analysis shows that 70% of the sample indicates the LIFE E-VIA optimized asphalt as the one with the best performance in terms of the perceived soundscape quality inside the EV, compared to the worn asphalt and the new but standard asphalt (Figure 20). It is also relevant to highlight that the taxi driver reported the following during the trip: "*While driving and passing through the optimized asphalt I perceived a quieter sound environment and a smooth feeling*".

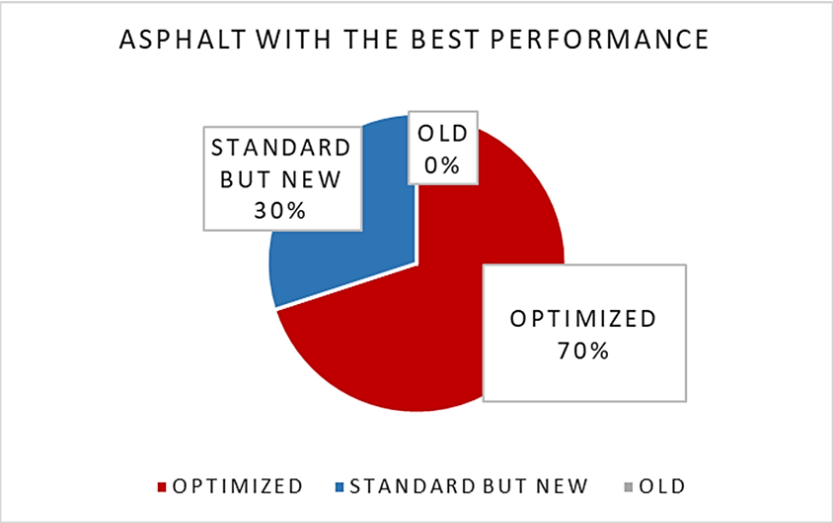

Figure 21 - Results of the interviews on the electric taxi

4 Sub Action B 5.3: ante and post operam interviews with residents

4.1 Introduction

In the frame of Action B5, Sub-Action B5.3, we conducted a survey to evaluate citizens' responses to the project's interventions carried out in the pilot case in Florence (Paisiello Street). It is important to refer that the pilot case foreseen in the original project proposal changed.
Originally, it was foreseen to carry out an interview campaign with a semi-random sample of at least 100 people to be identified, by voluntary adherence, on one or more electric bus lines the route of which involved the passage on different types of asphalt (old, normal, optimized). In the new pilot street, selected after the writing of the proposal, no bus lines are present; consequently, the typology of survey and the questionnaires foreseen for the original pilot case were modified accordingly. In particular, instead of carrying out the survey on electric busses, an ante and post-operam questionnaire have been designed and submitted to Paisiello street's residents to evaluate the soundscape perception before and after the interventions carried out in the frame of the LIFE E-VIA project. The main aim of the survey was to evaluate the improvement of acoustic perception related to the implementation of the noise optimized asphalt with respect to a standard one (hereafter also referred to as "the intervention").

4.2 Survey design

4.2.1 Ante-operam questionnaire: design and distribution

The structure of the ante-operam questionnaire consists of 16 questions divided into two sections. The first section on "Personal information", composed of 6 questions, was designed to collect data in relation to age, gender, education, occupation, city of residence and nationality of the respondents. The second section is composed of a set of 10 questions focusing on: i) dwelling location and windows orientation; ii) feelings regarding soundscape and landscape perception and noise annoyance; iii) expected effects of interventions and noise reduction; iv) sensitivity to noise.
The questions included in the questionnaire are closed-ended questions, in particular most of them are multiple-choice questions where only one answer can be selected. In specific cases, Matrix questions, a group of questions displayed in a matrix form were employed. Regarding the scales used in the questionnaire, eight questions adopted a Likert scale: two five-point Likert scale questions and six eleven-point Likert scale questions. Specifically, in one matrix question a five-point scale, ranging from "very low" to "very high", was provided to allow respondents to assess the intensity of external sounds perceived from dwelling (question D3, see Table 1). Moreover, in another matrix question, which focuses on the characteristics of the soundscape, a five-point scale ranging from "strongly disagree" to "strongly agree" was adopted. In addition, in six questions a scale ranging from 0 to 10 was employed to allow respondents to evaluate respectively: the quality of the soundscape (D4), the appropriateness of the soundscape (D5), the quality of urban landscape (D7), the importance of the effects of planned interventions for noise reduction on the value of the property (home/apartment) (D8) and on health (D9), personal sensitivity to noise (D10).
The schematic structure of the ante-operam questionnaire is displayed in Table 4. The full questionnaire template, translated in English language and including an introductory section presenting the project and the survey, is made available in Appendix II.

Section	Question	Question code
Personal Data	Age	I1
	Gender	I2
	Education	I3
	Occupation	I4
	City of residence	I5
	Nationality	I6
Dwelling Information	Windows orientation	D1
	Rooms with windows on Paisiello street	D2
Perception of Soundscape and Landscape	Intensity of sounds	D3
	Quality of soundscape	D4
	Appropriateness of soundscape	D5
	Characteristics of soundscape	D6
	Quality of urban landscape	D7
Expected effects of planned interventions	Effects on home value	D8
	Effects of noise reduction on health	D9
Sensitivity to noise	Personal sensitivity to noise	D10

Table 4 - Structure of ante-operam questionnaire

Before administering the questionnaire, a pilot test was carried out among a small group of colleagues who do not work in the field of acoustics. Good feedbacks as regards the structuring and understanding of the questions were given.

An informative letter (Figure 22) was provided to residents in the section of street selected for the re-paving intervention with noise optimized asphalt on the 5th of July 2021, a couple of days before the questionnaires' delivering. The letter presented the LIFE E-VIA project and its objectives and the main aim of the questionnaire to be delivered. Residents were selected as the survey target group as they are expected to be the main beneficiaries of the project intervention in terms of traffic noise reduction.

Successively, the questionnaire in Italian language was distributed door-to-door. Specifically, 92 ante-operam questionnaires were delivered between the 7$^{th\ of}$ July and the 9th of July 2021.

Figure 22 - Informative letter

4.2.2 Post-operam questionnaire: design and distribution

The structure of the post-operam questionnaire consists of 18 questions divided into two sections (see Table 5). The first section was designed to collect data on personal information. The second section is composed of a set of 12 questions focusing on: i) dwelling location and windows orientation; ii) feelings regarding soundscape and landscape perception and noise annoyance; iii) traffic noise; iv) effects of interventions; v) sensitivity to noise. The schematic structure of the post-operam questionnaire is displayed in Table 5, while the full questionnaire template, translated in English language, is made available in Appendix III.

Fourteen questions are the same questions asked in the ante-operam questionnaire, specifically: the set of questions of the section on personal data (I1-I6) and on dwelling information (D1-D2), the set of questions on soundscape and landscape perception (D3- D7) and the last question on personal sensitivity to noise (D12). This allows for a direct comparison of the answers given by respondents in the ante-operam questionnaire with the answers to the post-operam questionnaire that follows the implementation of the low noise asphalt in the selected section of Paisiello street. The specific section that focuses on the perceived effects of the concluded intervention is composed of questions that aims to evaluate: i) the type of effects (positive or negative) of the implementation of the new asphalt on the traffic noise perceived from home; ii) the effects of the intervention on the value of respondents' home and on their health. This section is preceded by a question on the changes of traffic noise perceived in the previous month (following the intervention). As regards the Likert scales adopted, in the questionnaire there are two matrix questions using a five-point scale and eight questions with an eleven-point scale (from "0" to "10"). As an example, the section aiming to assess the effects of repaving the road with a low noise asphalt includes three questions adopting an eleven-point Likert scale (D9- D11).

Section	Question	Question code
Personal Data	Age	I1
	Gender	I2
	Education	I3
	Occupation	I4
	City of residence	I5
	Nationality	I6
Dwelling Information	Windows orientation	D1
	Rooms with windows on Paisiello street	D2
Perception of Soundscape and Landscape	Intensity of sounds	D3
	Quality of soundscape	D4
	Appropriateness of soundscape	D5
	Characteristics of soundscape	D6
	Quality of urban landscape	D7
Traffic Noise	Perceived changes in traffic noise	D8
Effects of interventions	Effects on traffic sounds	D9
	Effects of on property value	D10
	Effects on personal health	D11
Sensitivity to noise	Personal sensitivity to noise	D12

Table 5 - Structure of the post-operam questionnaire

101 post-operam questionnaires were distributed door-to-door between the 15th and the 17th of September 2021, that is two months after the installation of the optimized asphalt.

4.3 Results

4.3.1 Descriptive analysis

Descriptive analysis has been adopted as initial approach for the quantitative analysis of collected data. This type of analysis allows the transformation of raw data into a form that makes them easy to understand and manipulate in order to generate deeper information.

4.3.1.1 Ante-operam results

The total number of questionnaires distributed door-to-door was 92; 56 completed ones were returned, giving a response rate of roughly 60%.

Concerning the section on "personal data", the results show that the number of male participants is almost the same of female ones (27 versus 28) and the majority of the respondents are in an age range between 41 and 65 years (Table 6). A great majority of the respondents, corresponding to approximately 78%, have at least a high school diploma (Table 7). Moreover, as regards their occupation, the largest group, 22 out of the total of 56 respondents, corresponds to people who are employees in the public or private sector. In addition, a significant share of the sample, 21% of the total, is a retired person (Table 8). The great majority of respondents are Italian citizens, resident in Florence (Table 9).

Note that in each table and graphic, answers not provided by respondents for each specific question are indicated as "NA": not answered.

Age	
Options	*Frequency*
18-25	4
26-40	9
41-55	17
56-65	14
66-75	8
>75	4

Table 6 - Respondents' age (ante-operam - AO)

Education	
Options	*Frequency*
Primary School	2
Middle School	5
High School	20
Bachelor's Degree	20
Ph.D	1
Master	3
N/A	5

Table 7 - Respondents' level of education (AO)

Occupation	
Options	*Frequency*
Employee	22
Self-employed	11
Retired	12
Student	3
Other	4
N/A	4

Table 8 - Respondents' occupation (AO)

City of residence	
Options	*Frequency*
Florence	51
Other	4
N/A	1

Table 9 - Respondents residence (AO)

Concerning the section on dwellings, almost all the respondents (54 out of 56) live in a house or apartment with windows overlooking the pilot case street (Paisiello street) (Table 10). Specifically, the bedroom and the living room are the rooms which in most cases have the windows orientated on Paisiello street (Table 11Table 11).

House with windows overlooking the street	
Options	*Frequency*
Yes	54
No	2
N/A	0

Table 10 - Dwelling location (AO)

Rooms overlooking the street	
Options	*Frequency*
Bedroom	39
Single bedroom	22
Living room	41
Kitchen	13
Bathroom	10
Other	9

Table 11 Rooms overlooking the street (AO)

The great majority of the respondents (89%) thought that the interventions planned to reduce noise could increase the value of their property (Figure 23). Additionally, a slightly narrower majority of the respondents (84%) answered that the reduction of noise levels close to their home could positively affect their health, selecting a value ranging from 7 to 10 on an eleven-point scale (Figure 24).

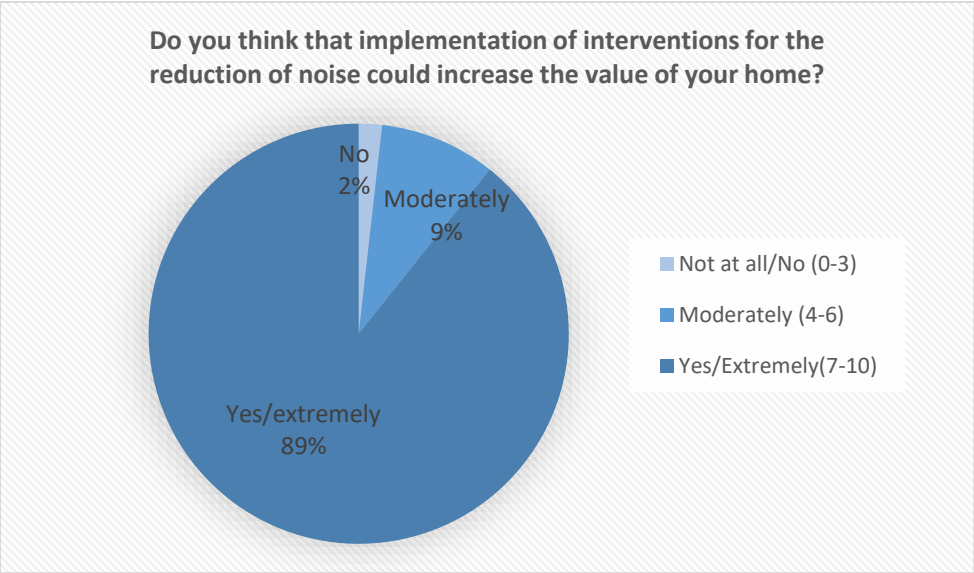

Figure 23 - Expected effects of interventions on home value (AO)

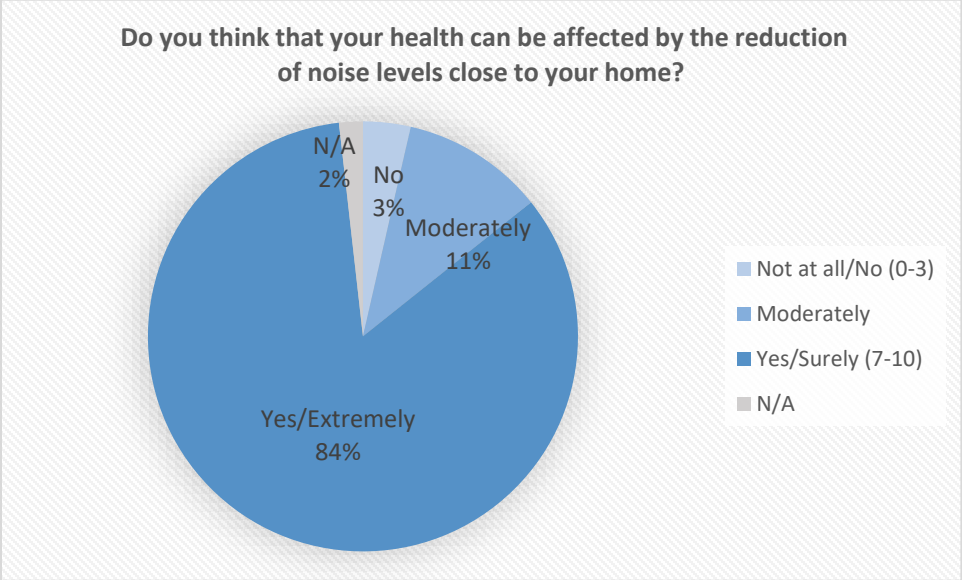

Figure 24 - Expected effects of interventions on health

Table 12 shows the frequency of answers to the last question “how do you assess your sensitivity to sounds?”. It is important to note that 29 respondents out of 56 assessed their sensitivity to sounds selecting a value ranging from 8 to 10 in an eleven-point scale, corresponding to an “high” and “very high” sensitivity.

Noise sensitivity

Options	*Frequency*
0 (very low)	0
1	1
2	1
3	0
4	1
5	7
6	5
7	12
8	10
9	6
10 (very high)	13
N/A	0

Table 12 Respondents' noise sensitivity (AO)

The remaining results of the ante-operam questionnaire, that refer to the section focusing on citizens perception on soundscape and urban landscape, will be presented in paragraph 4.3.1.3 on comparative analysis. Here they will be compared to the answers given to the same set of questions present in the post-operam questionnaire.

4.3.1.2 Post-operam results

The total number of the post-operam questionnaires distributed door-to-door was 101; 56 completed ones were returned, giving a completion rate of roughly 55%.

The number of female respondents is slightly higher than the number of male participants (29 versus 26). The majority of the respondents are in an age range between 41 and 75 years (Table 13), and approximately 71% of the sample has at least a high school diploma (Table 14). As regards their occupation, the largest group, 22 out of the total of 56 respondents, corresponds to retired people, the second group in term of frequency consists of people who are employees in the public or private sector (Table 15). The great majority of respondent are Italian citizens, resident in Florence.

Age	
Options	*frequency*
18-25	4
26-40	9
41-55	16
56-65	9
66-75	12

Table 13 - Respondents' age (PO)

Education	
Options	*Frequency*
Primary School	6
Middle School	7
High School	23
Bachelor's Degree	14
Ph.D	1
Master	2
N/A	2

Table 14 - Respondents' education level (PO)

Occupation	
Options	*Frequency*
Employee	16
Self-employed	7
Retired	22
Student	3
Other	7
N/A	1

Table 15 - Respondents'occupation (PO)

Concerning the section on dwellings, a great majority of the respondents (48 out of 56) live in a house or apartment with windows overlooking the pilot case street (Table). Specifically, the bedroom and the living room are the rooms which in most cases have the windows orientated on Paisiello street (Table 17).

House with windows overlooking the street	
Options	*Frequency*
Yes	48
No	8
N/A	0

Table 16 -Dwellings location (PO)

Rooms overlooking the street	
Options	*Frequency*
Bedroom	27
Single bedroom	15
Living room	34
Kitchen	12
Bathroom	8
Other	10

Table 17 - Rooms overlooking the pilot street (PO)

Noteworthily, according to 61% of the respondents to the post operam questionnaire, the perceived traffic noise had decreased during the preceding months (Figure 25). Indeed, the majority of the sample selected a value between 6 and 10 in an eleven-point Lickert scale. Moreover, a significant majority of the respondents (77%) positively assessed the effects of the re-paving of Paisiello road with a low noise asphalt (Figure 26). In particular, 31 respondents out of 56 valued the beneficial effect selecting a value between 8 and 10 (Table 16 - Frequency of the evaluation of project's interventions (PO)Table 16). The number of the respondents that assessed the project interventions as negative, is very low (2 respondents).

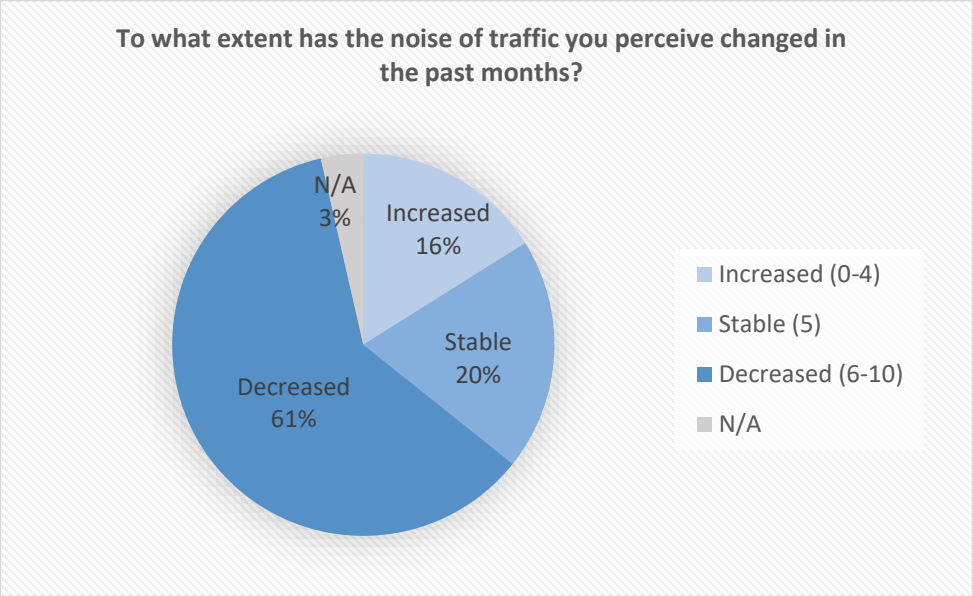

Figure 25 - Changes in traffic noise (PO)

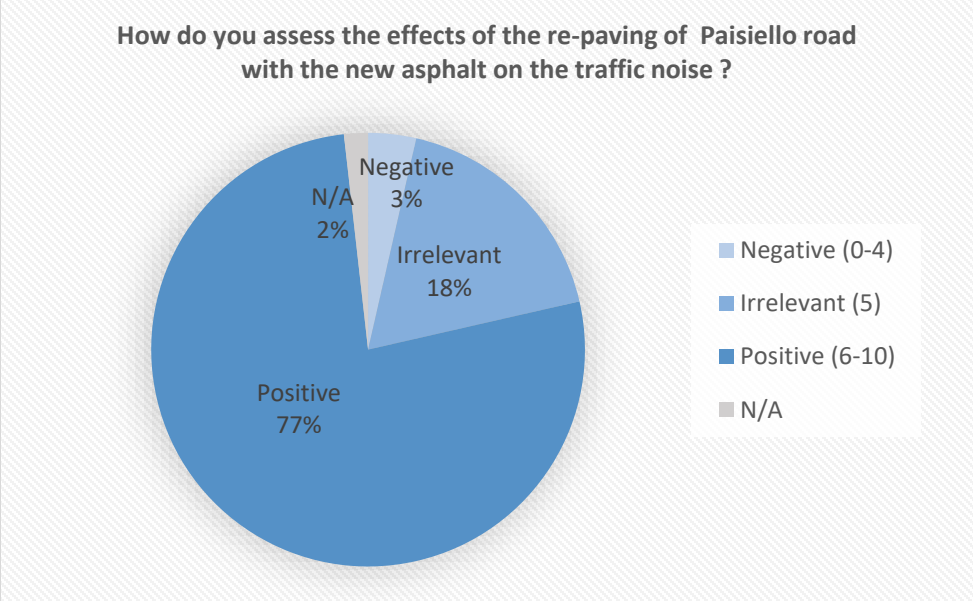

Figure 26 - Evaluation of the effects of project's interventions (PO)

How do you assess the effects of re-paving of Paisiello road with the new asphalt, on the traffic noise?												
Options	0	1	2	3	4	5	6	7	8	9	10	N/A
Frequency	0	0	1	0	1	10	8	4	22	7	2	1

Table 16 - Frequency of the evaluation of project's interventions (PO)

As regards the specific effects of the interventions, according to 32% of the subjects the implementation of the low-noise asphalt has increased the value of the property (house or apartment), while 53% of the respondents though that the value of the property had moderately increased (Figure 27). Moreover, 53% of the respondents thought that the reduction of noise levels close to their home, caused by the use of the new type of asphalt, will have positive effects on their health (Figure 28).

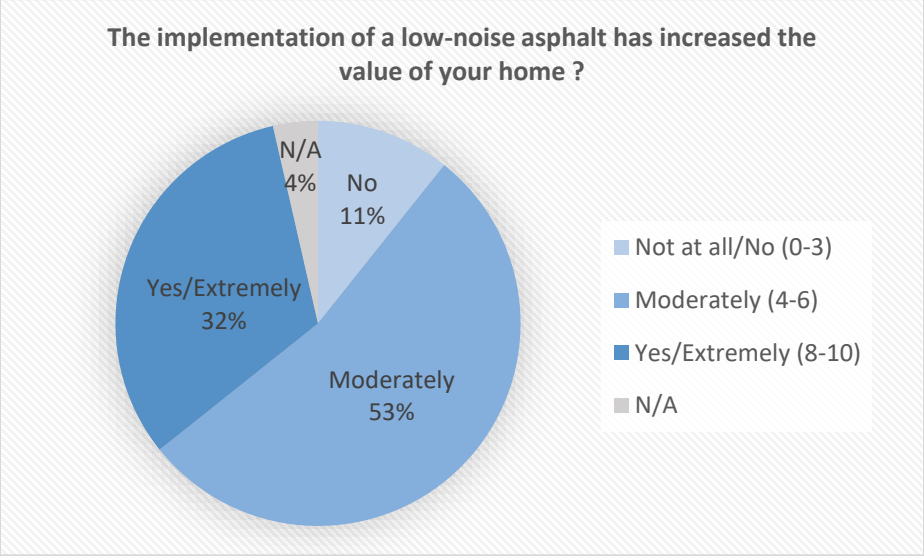

Figure 27 - Effects of project interventions on home value (PO)

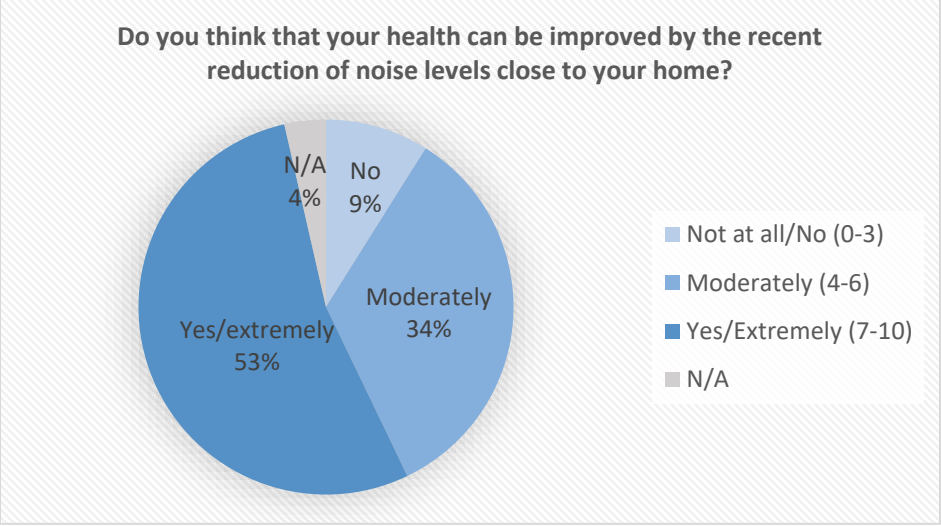

Figure 28 - Effects of project interventions on health (PO)

As shown in Table 17Table 17, sensitivity to sounds is assessed by most of the respondents (45 subjects out of 56) with a value higher than “5”, on an eleven-point scale.

Noise sensitivity

Options	*Frequency*
0 (very low)	0
1	0
2	2
3	1
4	1
5	6
6	11
7	12
8	12
9	6
10 (very high)	4
N/A	1

Table 17 - Respondents noise sensitivity (PO)

4.3.1.3 Comparative analysis

In this paragraph, a comparative analysis of the same questions included in the ante-operam and post-operam questionnaires will be provided.

In the ante-operam period traffic noise was well perceived. As showed in Figure 29 and displayed in Table 18, 22 subjects out of 56 defined this type of sound as “very high”. In the post-operam period, the number of people who perceived traffic sound as “very high” and “high” considerably decreased; indeed, results show a reduction of respectively -64% and -26% compared to the results of the ante-operam questionnaire. Concurrently, residents who assessed the traffic sounds as “low” has quintupled following the implementation of project interventions, compared to the ante-operam period. This is in line with the answers given to the question included in the post-operam questionnaire “to what extent has the noise of traffic you perceive changed in the past months?” (see Figure 25).

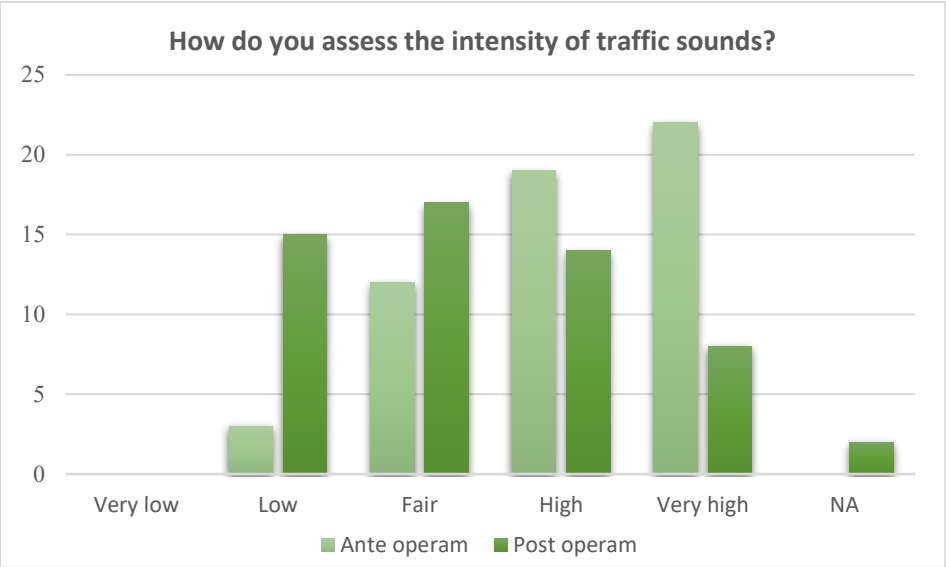

Figure 29 - Intensity of traffic noise (AO-PO)

How do you assess the intensity of traffic sounds in the soundscape around you?		
Options	Ante operam questionnaire	Post operam questionnaire
Very Low	0	0
Low	3	15
Fair	12	17
High	19	14
Very high	22	8
N/A	0	2

Table 18 - Intensity of traffic sounds - frequency distribution (AO-PO)

As regards the perception of technological sounds (e.g., sounds of sirens, constructions etc.), after the implementation of the low-noise asphalt, respondents who evaluated this type of sounds as “very high” decreased from 8 to 1 subject (Table 201). Instead, Table 192**Errore. L'origine riferimento non è stata trovata.** shows that the evaluation of anthropic sounds (e.g. voices, steps, children etc.) by respondents did not change significantly. If we take into consideration the sum of subjects who evaluated this type of sounds as “fair”, “high” or “very high” we observe a relatively small decrease of their number after the realization of the intervention. As displayed in Table 21, the perception of nature sounds did not significantly change; both in the ante-operam period and in the post-operam period most of the respondents assessed this type of sound in the soundscape close to their home as “low” or “fair”.

How do you assess the intensity of technological sounds in the soundscape around you?		
Options	Ante operam questionnaire	Post operam questionnaire
Very Low	7	5
Low	16	25
Fair	16	13
High	6	8
Very high	8	1
N/A	3	4

Table 201 - Intensity of technological sounds (AO-PO)

How do you assess the intensity of anthropic sounds in the soundscape around you?		
Options	Ante operam questionnaire	Post operam questionnaire
Very Low	1	5
Low	27	24
Fair	17	17
High	7	7
Very high	3	1
N/A	1	2

Table 192 - Intensity of anthropic sounds (AO-PO)

How do you assess the intensity of nature sounds in the soundscape around you?		
Options	Ante operam questionnaire	Post operam questionnaire
Very Low	8	7
Low	31	27
Fair	10	16
High	6	3
Very high	0	0
N/A	1	3

Table 21 - Intensity of nature sounds (AO-PO)

Concerning the question “how do you assess the quality of the soundscape around you?”, we observe a significant reduction of respondents who evaluated the soundscape as a low-quality soundscape, rating it with a value ranging from 0 to 4 on an eleven-point scale (Figure 30). In particular, while before the intervention the highest share of respondents evaluated the quality of the soundscape close to their home as very bad or bad, after the repaving of the street the highest share of respondent evaluated it as fair.

Similarly, Figure 31 shows that the appropriateness of the soundscape has enhanced. While before the intervention 6 subjects out of 56 assessed the soundscape as appropriate to the urban context, corresponding to roughly 11%, after the re-pavement works 16 subjects out of 56, that is 29% of the respondents, assessed it as appropriate.

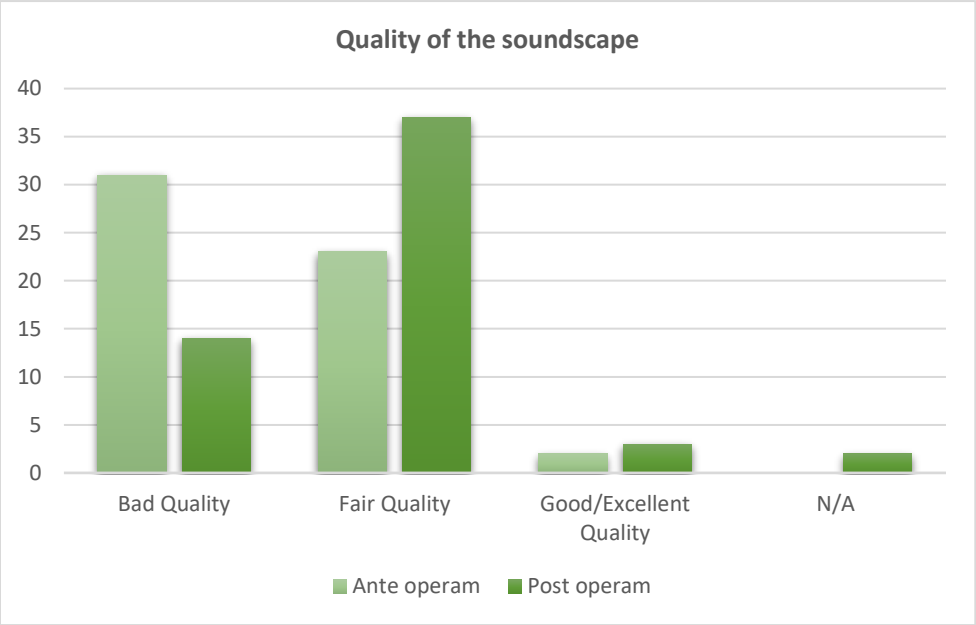

Figure 30 - Quality of soundscape (AO-PO)

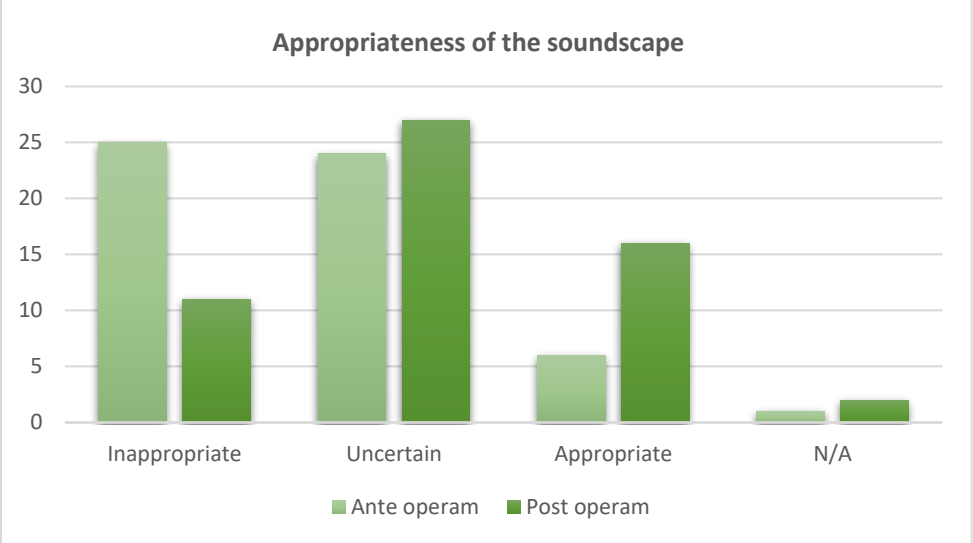

Figure 31 - Appropriateness of the soundscape (AO-PO)

Instead, as shown in Figure 32, according to the respondents' perception the quality of the urban landscape slightly decreased after the re-pavement works. However, it is important to note that both in the ante-operam and post-operam questionnaires, the great majority of the sample assessed the quality of the urban landscape at least as fair.

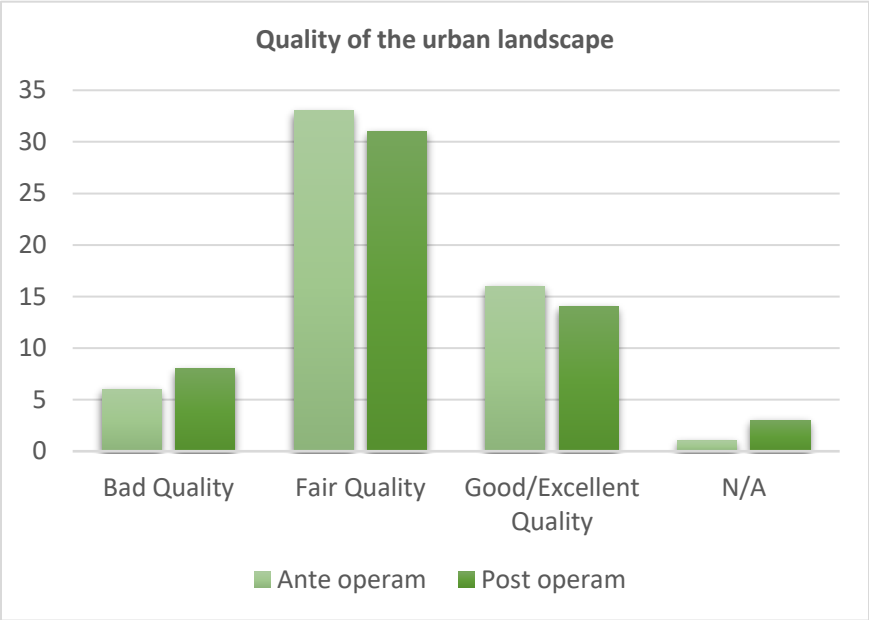

Figure 32 - Quality of the urban landscape (AO-PO)

The abovementioned results regarding the assessment of the quality of the soundscape are in line with the results of the comparative analysis of the given answers to the question focusing on the characteristics of the soundscape (question matrix D6). Indeed, the percentage of the respondents who evaluated the soundscape with positive characteristics (enjoyable, interesting, relaxing, lively) increased after the realization of the interventions. Concurrently, as shown in Table 22, we observe a significant decrease of the number/percentage of the respondents assessing the soundscape as "disturbing".

To what extent do you agree with the following statements about the soundscape around you? (Ante Operam)								
Options	Enjoyable	Chaotic	Interesting	Boring	Relaxing	Disturbing	Lively	Monotonous
Strongly disagree	28,6%	10,7%	35,7%	12,5%	35,7%	3,6%	5,4%	21,4%
Disagree	33,9%	21,4%	23,2%	23,2%	32,1%	19,6%	23,2%	21,4%
Uncertain	21,4%	12,5%	23,2%	25,0%	8,9%	7,1%	35,7%	33,9%
Agree	8,9%	41,1%	10,7%	21,4%	16,1%	33,9%	25,0%	10,7%
Strongly Agree	3,6%	8,9%	0,0%	12,5%	0,0%	32,1%	5,4%	7,1%
N/A	3,6%	5,4%	7,1%	5,4%	7,1%	3,6%	5,4%	5,4%
To what extent do you agree with the following statements about the soundscape around you? (Post-Operam)								
Options	Enjoyable	Chaotic	Interesting	Boring	Relaxing	Disturbing	Lively	Monotonous
Strongly disagree	17,9%	17,9%	32,1%	23,2%	28,6%	17,9%	7,1%	10,7%
Disagree	28,6%	28,6%	21,4%	17,9%	19,6%	25,0%	12,5%	26,8%
Uncertain	19,6%	16,1%	19,6%	26,8%	23,2%	16,1%	35,7%	46,4%

Agree	21,4%	23,2%	19,6%	19,6%	21,4%	28,6%	35,7%	8,9%
Strongly Agree	5,4%	7,1%	0,0%	3,6%	0,0%	8,9%	3,6%	1,8%
N/A	7,1%	7,1%	7,1%	8,9%	7,1%	3,6%	5,4%	5,4%
				Difference				
Options	Enjoyable	Chaotic	Interesting	Boring	Relaxing	Disturbing	Lively	Monotonous
Strongly disagree	-10,7%	7,1%	-3,6%	10,7%	-7,1%	14,3%	1,8%	-10,7%
Disagree	-5,4%	7,1%	-1,8%	-5,4%	-12,5%	5,4%	-10,7%	5,4%
Uncertain	-1,8%	3,6%	-3,6%	1,8%	14,3%	8,9%	0,0%	12,5%
Agree	12,5%	-17,9%	8,9%	-1,8%	5,4%	-5,4%	10,7%	-1,8%
Strongly Agree	1,8%	-1,8%	0,0%	-8,9%	0,0%	-23,2%	-1,8%	-5,4%
N/A	3,6%	1,8%	0,0%	3,6%	0,0%	0,0%	0,0%	0,0%

Table 22 Soundscape characteristics (AO-PO)

To sum up, the comparison of the results of the ante-operam questionnaire with the results of the post-operam questionnaire shows that, according to residents in the pilot street, after the realization of the project interventions:

- The intensity of traffic noise has decreased.
- The quality of the soundscape has improved.
- The appropriateness of the soundscape with the urban context has improved.

Specifically, in the post-operam questionnaire a significant majority of the respondents (77%) positively assessed the effects on the perceived traffic noise from their home of the re-paving of a section of the street with a low noise asphalt.

As regards the effects of the interventions, in the ante operam period, 84% of the respondents thought that their health would be positively affected by a reduction of noise levels close to their home. In the post operam period, the majority of the sample (53%) thought that the perceived reduction of noise levels would significantly improve personal health.

However, while before the intervention 89% of the residents who responded to the questionnaire expected that the street repavement with a low noise asphalt would significantly increase the value of their home, the percentage declined to 32% in the post operam questionnaire, where we observe a high percentage of respondents according to whom the intervention has moderately increased the value of the home. This can be explained by the fact that respondents are more likely to overreport the expected effects before an intervention they consider urgent, in this case to reduce the annoyance caused by road traffic noise.

Finally, it is important to point out that the positive results of the survey in terms of the reported beneficial effects of the re-paving are supported by the request of the residents to re-pave the whole street with the low noise asphalt developed in the context of the LIFE E-VIA project.

4.3.2 Statistical analysis

4.3.2.1 Link between Pearson chi-square test and regression model

Variable		χ^2	DoF	p-value
Age		2.3173	5	0.8037
Gender		2.1455	3	0.5428
Education		4.3015	6	0.636
Occupation		7.3956	5	0.1928
Residency		1.1813	2	0.554
Nationality		2.1569	2	0.3401
Windows overlooking via Paisiello		2.7451	1*	0.09755
Rooms overlooking via Paisiello		1.2243	5	0.9475
Intensity of perceived sounds		0.63894	3	0.8875
Perception of traffic sounds		**18.153**	**4***	**0.001152**
Perception of technological sounds		8.4923	5	0.1311
Perception of anthropic sounds		4.1765	5	0.5243
Perception of natural sounds		3.7271	4*	0.4442
Soundscape quality		**11.889**	**3**	**0.007774**
Soundscape congruence		**10.5**	**3**	**0.01476**
Soundscape attributes		13.709	7	0.0566
Soundscape	Enjoyable	5.4343	5	0.3652
	Chaotic	4.8532	5	0.4341
	Interesting	1.7825	4*	0.7757
	Boring	5.547	5	0.3528
	Relaxing	6.1182	4*	0.1905
	Disturbing	**15.221**	**5**	**0.009457**
	Lively	3.2017	5	0.6689
	Monotonous	5.3131	5	0.3789
Landscape quality		1.4815	3	0.6865
Sound sensitivity		2.5753	3	0.4618

Table 23 - Pearson's chi-square test

Table 23 represents the Pearson's chi-square test of independence. In general, this type of test is one of the most useful statistics for testing hypotheses when the variables are nominal. Unlike most statistics, the Chi-square (χ^2) can provide information not only on the significance of any observed differences, but also provides detailed information on exactly which categories account for any differences found. With the data in table form, the researcher can proceed with calculating the $\chi 2$ statistic. In our case the hypotheses are:

H_0: a variable is independent on situation (ante and post)

H_1 (rejection p-value<0.05): variable depends on situation (ante and post)

The formula for calculating a Chi-Square is:

$$\sum \chi^2_{i-j} = \frac{(O-E)^2}{E}$$

Where O are the observed values an E the expected values. In the Chi-square statistic, the "expected" values represent an estimate of how the cases would be distributed if there were no situation effect. These values are calculated by multiplying each row and column total and dividing by the grand total. From the table above we note that four variable seems to be independent on situation (pre post). These variables are: "perception of

traffic sound", "soundscape quality", "soundscape congruence" and "disturbing" soundscape attribute. To better analyze whether the work carried out has brought improvements in terms of perception of sounds we use the variable "soundscape quality" which is dependent on situation as dependent variable in a regression model. With the use of regression models, we can establish if there are relationships between the response variable ("soundscape quality") and other covariates relating to perceptions of sounds or characteristics of the surrounding environment in the ante/post intervention periods.

ORDINAL LOGIT MODEL

First, we compare all the response values, of the covariates and the response variable, between the two periods by creating original variables with a value of 0 if the value has decreased; 1 if it has remained unchanged and 2 if it has increased.

Given the nature of the variables created, we choose to use an ordinal logit model. The ordered logit model is a regression model for an ordinal response variable. The model is based on the cumulative probabilities of the response variable: in particular, the logit of each cumulative probability is assumed to be a linear function of the covariates with regression coefficients constant across response categories. Let Y_i be an ordinal response variable with C categories for the i-th subject, alongside with a vector of covariates $\mathbf{x}_i$. A regression model establishes a relationship between the covariates and the set of probabilities of the categories $p_{ci} = Pr(Y_i = y_c|\boldsymbol{x}_i)$, *c*=1,…,*C*. Usually, regression models for ordinal responses are not expressed in terms of probabilities of the categories, but they refer to convenient one-to-one transformations, such as the cumulative probabilities $g_{ci} = Pr(Y_i \leq y_c|\boldsymbol{x}_i)$, *c*=1,…,C. The last cumulative probability is necessarily equal to 1, so the model specifies only *C–1* cumulative probability. An ordered logit model for an ordinal response Y_i with *C* categories is defined by a set of *C-1* equations where the cumulative probabilities are related to a linear predictor $\beta' x_i = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \ldots$ through the logit function:

$$logit(g_{ci}) = log\left(\frac{g_{ci}}{1 - g_{ci}}\right) = \alpha_c - \boldsymbol{\beta'}\boldsymbol{x}_i$$

The parameters α_c, called thresholds or cutpoints, are in increasing order ($\alpha_1 < \alpha_2 < \ldots < \alpha_{C-1}$). The vector of the slopes β is not indexed by the category index *c*, thus the effects of the covariates are constant across response categories. This feature is called the parallel regression assumption: indeed, plotting logit(g_{ci}) against a covariate yields *C–1* parallel line. In model above the minus before β implies that increasing a covariate with a positive slope is associated with a shift towards the right-end of the response scale, namely a rise of the probabilities of the higher categories [4]. In general, the cumulative probability for the category *c* is:

$$g_{ci} = \frac{e^{\alpha_c - \boldsymbol{\beta'}\boldsymbol{x}_i}}{1 + e^{\alpha_c - \boldsymbol{\beta'}\boldsymbol{x}_i}} = \frac{1}{1 + e^{-\alpha_c + \boldsymbol{\beta'}\boldsymbol{x}_i}}$$

The ordered logit model is also known as the proportional odds model because the parallel regression assumption implies the proportionality of the odds of not exceeding the *c*-th category $odds_{ci} = g_{ci}/(1 - g_{ci})$; in fact, the ratio of these odds for two units, say *i* and *j*, is $odds_{ci}/odds_{cj} = e^{\boldsymbol{\beta'}(\boldsymbol{x}_j - \boldsymbol{x}_i)}$, which is constant across response categories, because not depend on *c*.

In our case the resulting ordinal logit model is:

$$logit("soundscape\ quality"_{ci}) = \alpha_c - (\beta_1 * traffic\_sounds + \beta_2 * interesting\_soundscape + \beta_3 * nature\_dounds + \beta_4 * relaxing\_soundscape + \beta_5 * sensitivity\_sounds$$

qual_amb	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
traffico						
Unchanged	-7.047367	2.399337	-2.94	0.003	-11.74998	-2.344753
Yes	-8.004159	3.208891	-2.49	0.013	-14.29347	-1.714848
interessante						
Unchanged	5.320089	2.049402	2.60	0.009	1.303335	9.336843
Yes	1.914986	1.556173	1.23	0.218	-1.135057	4.96503
natura						
Unchanged	-.6013872	1.685393	-0.36	0.721	-3.904697	2.701922
Yes	9.055464	3.111493	2.91	0.004	2.957049	15.15388
rilassante						
Unchanged	4.754028	2.527349	1.88	0.060	-.1994857	9.707541
Yes	3.73245	2.311063	1.62	0.106	-.7971497	8.262049
sensibilita						
Unchanged	4.547256	2.190113	2.08	0.038	.2547141	8.839798
Yes	1.598098	1.349631	1.18	0.236	-1.047129	4.243325
/cut1	3.365244	2.201415			-.9494507	7.679939
/cut2	6.073346	2.42071			1.328842	10.81785

Table 24 - Results of the ordinal logit model

From the model above, we can see that, for the traffic_sounds variable who did not vary the response between the two periods or who responded that they heard less traffic in the post-intervention period tended to give a higher score on the soundscape quality than those who found a worsening in the traffic perception. Instead, for the nature sounds the model shows that who hear more the sounds of nature in the post-intervention period than those who hear them less tend to perceive a better soundscape quality. Looking at the characteristics of the "interesting" and "relaxing" environment, we note that in the first case those who find the environment interesting in the same way in the two periods compared to those who find it less interesting tend to perceive a better soundscape quality. While for the "relaxing" characteristic, those who find the relaxing environment in the same way or more relaxing in the second period compared to who find the environment less relaxing tend to perceive a higher soundscape quality. Finally, those who responded that they were sensitive to the environment in the same way tend to perceive a better soundscape quality than those who were less sensitive in the second period. So, from the model it emerges that for those who perceive between the two periods less noises considered annoying, such as those of traffic or perceive more sounds considered pleasant as those of nature, the perception of the surrounding sound environment is better.

5 Noise and traffic monitoring campaigns at receivers

5.1 Monitoring analysis

Although not foreseen in the original project proposal, in order to obtain an objective basis for the citizens evaluation at a façade level to be carried out in Action B5, a noise monitoring campaign at receivers has been carried out by VIENROSE and I-POOL.

This section reports the description and analysis of the data collected as a result of long-term phonometric noise measurement campaigns and traffic flow counting with control unit equipped with automatic radar traffic counting system showing the division into light and heavy vehicles.

Each monitoring campaign has had a bi-weekly duration and has been carried out at the pilot case of Paisiello street in Florence in the following phases:

1. Ante-operam campaign carried out by VIENROSE Period: 23rd June - 1st July 2021
2. I Post-operam campaign carried out by I-POOL Period: 17th - 28th September 2021
3. II post-operam campaign carried out by I-POOL Period: 21st - 30th November 2022

And in correspondence with the monitoring positions defined in Table 25.

ID position	Type of monitoring	Toponym
P01	Long-term (bi-weekly)	Paisiello street n.85
P02	Long-term (bi-weekly)	Paisiello street n.76 A.S.D. DLF Firenze

Table 25 - Monitoring positions

The P01 station is at the asphalt section designed under the LIFE E-VIA project, while the second one is at the traditional type of asphalt laid at the same time as the first one.

Figure 33 shows the planimetric location of the phonometric monitoring stations and of the traffic flows (contextual to the phonometric ones).

Figure 33 - Monitoring positions

5.2 Measurement systems

For the measurements the following measurement systems were used:

SYSTEM NO.1

PRECISION INTEGRATOR PHONOMETER 01dB type FUSION S.N. 11215, complying with the regulations IEC 651 – EN 60651 class 1 and IEC 804 – EN 60804;

PRECISION MICROPHONE WITH PREPOLARIZED CONDENSER 01dB type GRASS model 40 CE S.N. 233339, complying with the regulations EN61094-1/94 EN61094-2/93 EN61094-3/93 EN61094-4/95.

SYSTEM NO.2

PRECISION INTEGRATOR PHONOMETER 01 dB type BLUE SOLO S.N. 60982, complying with the regulations IEC 651 – EN 60651 class 1 and IEC 804 – EN 60804;

PRECISION MICROPHONE WITH PREPOLARIZED CONDENSER 01 dB type PRE21 S.N. 13936, complying with the regulations EN61094-1/94 EN61094-2/93 EN61094-3/93 EN61094-4/95 IEC 651 class 1 (imp.) and IEC 804.

For the memorization and the processing of the data was made use of the dedicated Software: dB Trait 5.5.

The technical data of automatic traffic flow detection systems (radar systems) are reported below:

Traffic monitoring device VIACOUNT II – VIA Traffic Controlling GmbH s.n. 11VZZ0018.

Traffic monitoring device VIACOUNT II – VIA Traffic Controlling GmbH s.n. 13VZZ0257.

For the memorization and the processing of the data was made use of the dedicated Software: ViaGraph vers. 4.00.09.

5.3 Measurement positions (phonometric monitoring)

The main information and the photographic contributes of the measurement positions used for the phonometric monitoring are shown in Table 26.

Measurement station	Description	Photo
P01	**Address:** Paisiello street n.85 **Height from the ground level:** 6.00 m **Distance from the road axis:** 8 m	
P02	**Address:** Paisiello street n.76 c/o A.S.D. DLF Firenze **Height from the ground level:** 6.00 m **Distance from the road axis:** 8 m	

Table 26 - Positions of phonometric monitoring

5.4 Measurement positions (detection of traffic flows)

The main information and photo contributions of the measurement stations used to detect traffic flows automatically using a traffic device with radar system are shown in Table 27.

Measurement station	Description	Photo
P01	**Monitoring dates:** 23 June-1st July 2021; 17th – 28th September 2021; 21st – 30th November 2022 **Reference road:** Paisiello street n.85	
P02	**Monitoring dates:** 23 June-1st July 2021; 17th – 28th September 2021; 21st – 30th November 2022 **Reference road:** Paisiello street n.76 c/o A.S.D. DLF Firenze	

Table 27 - Traffic flows detection stations

5.5 Monitoring results

In counting vehicles, which was done taking into account the distinction between light and heavy vehicles, heavy vehicles were normalized back to light vehicles for convenience by using a multiplication factor equal to 10.

The recorded traffic flows were used to weight the measured noise levels at the receptor during the three measurement campaigns.

A tabular summary of the results of the recorded traffic flows and phonometric is shown in Table 28.

P01 – LIFE E-VIA asphalt						
Scenario	**Traffic flows (n.)**	**Lnight (dBA)**	**Lden (dBA)**	**Scenario**	**ΔLnight (dBA) weighted** according to traffic flows	**ΔLden (dBA) weighted** according to traffic flows
Ante-operam	516	55,5	60,4	**Δ(Post-operam 1-Post-operam 2)**	**1,5**	0,6
Post-operam 1	325	49,1	57	**Δ(Ante-operam-Post-operam 2)**	-2,9	-0,8
Post-operam 2	930	55,2	62,2	**Δ(Ante-operam-Post-operam 1)**	**-4,4**	-1,4

Table 28 - Monitoring results P01

6 Conclusions

In the frame of LIFE E-VIA project an innovative low-noise asphalt that aims to reduce road traffic noise was laid down in a section of Paisiello street, the pilot case in Florence, in mid July 2021.
In the frame of Action B5, people's perception regarding noise was investigated in terms of the soundscape methodology aiming to assess the benefits of the re-pavement with the optimized asphalt and to involve the population. In particular, in order to assess the perception of soundscapes at different outdoor locations close to the pilot area, we organized and conducted a cycle of soundwalks. Additionally, sessions were organized to listen to audio recorded inside EVs and ICEVs as they passed over different types of asphalt, including the optimized one (Sub action B5.1). In order to collect additional subjective data on the acoustic comfort perceived inside an electric vehicle passing through the pilot street interviews were also organized inside an electric taxi. Finally, the submission of an ante-operam and a post-operam questionnaire to residents in the pilot street allow us to assess if and how (e.g. to what extent) the perception of soundscape from indoor location (residents' homes) changed after the intervention. All in all, these methods allowed us to evaluate outdoor and indoor soundscape perceptions and assess acoustic experiences inside electric vehicles and traditional vehicles passing through different type of asphalt pavements including the LIFE-EVIA optimized asphalt.
The analysis of subjective data collected during the soundwalks shows that among the three listening points located close to a road, the one located in the street parallel to the pilot area is evaluated as the less disturbing with lower traffic noise pollution, this can be explained by a lower level of traffic comparing to Paisiello street. However, a slight difference in terms of sound sources and soundscape perception also emerged comparing participants' evaluations of sounds environment at the site close to the section of the pilot street with the optimized asphalt with the one given to the soundscape at the section repaved with standard asphalt. The former was assessed as characterized by a lower level of traffic noise pollution, in particular, 16% of the subjects perceived traffic noise as «fair». In the latter case, all the subjects evaluate it as "high" or "very high", no one as "fair". These data suggest that the optimized asphalt may be a factor that played a major role in improving subjective traffic noise perception. This hypothesis is supported by the results concerning both: i) the assessment of audio recordings and ii) the evaluation of acoustic comfort inside the electric taxi passing through the stretch of the street repaved with the optimized asphalt. Indeed, 30% of the sample evaluated the quality of the soundscape inside an EV passing on the optimized asphalt as "good", compared to 10% who described as "good" the quality of the soundscapes recorded inside an ICEV and inside an EV passing on new but standard asphalt. Furthermore, 70% of subjects interviewed inside the electric taxi indicated the LIFE E-VIA optimized asphalt as the one with the best performance in terms of the perceived soundscape, compared to the new but standard asphalt and the worn asphalt.
In addition, the survey conducted through the distribution and collection of ante-operam and post-operam questionnaires to people living in the section of the street targeted by the intervention has demonstrated that the repaving has improved the quality of the soundscape and significantly reduced the perceived road traffic noise. As an illustration, according to 61% of the respondents to the post operam questionnaire traffic noise has decreased after the intervention. Indeed, the percentage of people who perceived traffic sound as "very high" and "high" significantly decreased in the post-operam period compared to the percentage observed in the period before the intervention. Concurrently, 77% of the respondents assessed the intervention as positive, in terms of reduction of road traffic noise perceived from home. Therefore, the results of the survey demonstrate the success of the project's action.

The results obtained in terms of the performance of the asphalt developed by the LIFE E-VIA project proved to be more than satisfactory in terms of reduction of noise levels at the receptor (4.4 dB(A) in terms of Lnight) and attenuation of performance over time (1.5 dB(A) after 16 months after paving).

References

[1] World Health Organization. *Environmental noise guidelines for the European region. World Health Organization.* Regional Office for Europe, (2018).
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[3] Schafer, R. M. *A Sound Education: 100 Exercises in Listening and Sound-Making.* Arcana Editions (1992).
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Appendix I -The Questionnaire for Soundwalks and audio recordings

LIFE/ENV/IT000201 LIFE E-VIA

THE PROJECT

Exposure data from the European Environment Agency demonstrate that more than 100 million EU citizens are affected by high noise levels negatively impacting human health. Traffic noise alone is harmful to the health of almost every third person in the World Health Organization European Region. 20% of Europeans are regularly exposed to night sound levels that could significantly damage health, especially in urban areas.

In this context, the LIFE E-VIA Project (Electric Vehicle noIse control by Assessment and optimization of tire / road interaction / Control of noise of electric vehicles through evaluation and optimization of the tire-asphalt interaction - www.life-evia.eu) intends to address the problem of noise pollution due to road traffic noise, focusing on a future scenario in which electric and hybrid vehicles will be a significant part of the traffic flow, and combine knowledge of the optimization of asphalts and tires in order to test an optimized solution for noise reduction in urban areas and optimize the Life Cycle Cost with respect to current best practices.

The Project, co-financed by the European Union through the Life programme, started in July 2019 and will end in January 2023. The project is coordinated by the Municipality of Florence and involves as partners the Mediterranean University of Reggio Calabria, Continental, Vie en.ro.se Ingegneria, University Gustave Eiffel and I-POOL.

THE QUESTIONNAIRE

The objective of this questionnaire is to collect data on the perception of the sound environment. In addition to some initial general questions, we kindly ask you to answer 8 questions relating to the perception of the soundscape at each listening point identified along the route. Your personal data will be treated as strictly confidential and the publication of the survey results will ensure the non-recognition of the responses. Please answer all questions in order, following the instructions provided.

PERSONAL INFORMATION

I1. **Age**: ☐ 18-25 ☐ 26-40 ☐ 41-55 ☐ 56-65 ☐ 66-75 ☐ >75

I2. **Gender**: ☐ Female ☐ Male

I3. **Education**: ☐ Primary School ☐ Middle School ☐ High School
☐ Bachelor or Master's Degree ☐ PhD

I4. **Occupation**: _____

I5. **City of residence**: _____

I6. **Nationality**: _____

I7. **Do you know/come to this place (via Paisiello)?**

☐ YES ☐ NO

I8. **If so, how often do you come to via Paisiello?**

☐ Everyday ☐ Once a week ☐ Twice a month ☐ Once a month ☐ Few times a year

I9. **If so, what is/are the reason/s?** *(you can select one or more answers)*

☐ Residence/home ☐ Residence of acquaintances ☐ Work ☐ Transit area to reach other destinations ☐ Leisure activities ☐ Shopping ☐ Other: …… (Please, specify)

I10. **How do you assess your sensitivity to sounds?** (Please tick one box)

0	1	2	3	4	5	6	7	8	9	10
Not at all										***Very High***

Initial excercises

Close sound:_____

Distant sound: _____

Pleasant sound_____

Unpleasant sound: _____

Natural/mechanical/anthropic sounds: _____

Sounds in motion: _____

Static sound: _____

POINT OF LISTENING N. 1

Q1. How do you assess the intensity of the following four types of sound in the soundscape around you?
(Please tick one box for each row)

Type of sound	*Very Low*	*Low*	*Fair*	*High*	*Very High*
Traffic (eg. Cars, motorcycles, clacson	☐	☐	☐	☐	☐
Mechanical/electrical sounds (eg. music, industries, sirens, construction)	☐	☐	☐	☐	☐
Anthropic sounds (eg. voices, laughter, children, step)	☐	☐	☐	☐	☐
Nature sounds (eg. wind, rustling leaves, birds)	☐	☐	☐	☐	☐

Q2. How do you assess the quality of the soundscape around you?

(Please tick one box)

0	1	2	3	4	5	6	7	8	9	10
Very Bad										***Excellent***

Q3. Do you think the soundscape around you is appropriate for this place?

(Please, tick one box)

Absolutely inappropriate	0	1	2	3	4	5	6	7	8	9	10	***Completely appropriate***

Q4. To what extent do you agree with the following statements about the soundscape around it?

(Please tick one box for each row)

The soundscape is:	**Strongly disagree**	**Disagree**	**Neither agree nor disagree**	**Agree**	**Strongly agree**
Enjoyable	☐	☐	☐	☐	☐
Chaotic	☐	☐	☐	☐	☐
Interesting	☐	☐	☐	☐	☐
Boring	☐	☐	☐	☐	☐
Relaxing	☐	☐	☐	☐	☐
Disturbing	☐	☐	☐	☐	☐
Lively	☐	☐	☐	☐	☐
Monotonous	☐	☐	☐	☐	☐

Q5. How do you assess the quality of the urban landscape around you?

(Please tick the box that best matches your opinion)

Very Bad	0	1	2	3	4	5	6	7	8	9	10	***Excellent***

LISTENING POINT N. 2

Q1. How do you assess the intensity of the following four types of sound in the soundscape around you?

(Please tick one box for each row)

Type of sound	*Very Low*	*Low*	*Fair*	*High*	*Very High*
Traffic (eg. Cars, motorcycles, clacson	☐	☐	☐	☐	☐
Mechanical/electrical sounds (eg. music, industries, sirens, construction)	☐	☐	☐	☐	☐
Anthropic sounds (eg. voices, laughter, children, step)	☐	☐	☐	☐	☐
Nature sounds (eg. wind, rustling leaves, birds)	☐	☐	☐	☐	☐

Q2. How do you assess the quality of the soundscape around you?
(Please tick one box)

0	1	2	3	4	5	6	7	8	9	10
Very Bad										***Excellent***

Q3. Do you think the soundscape around you is appropriate for this place?
(Please, tick one box)

Absolutely inappropriate	0	1	2	3	4	5	6	7	8	9	10	***Completely appropriate***

Q4. To what extent do you agree with the following statements about the soundscape around it?
(Please tick one box for each row)

The soundscape is:	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Enjoyable	☐	☐	☐	☐	☐
Chaotic	☐	☐	☐	☐	☐
Interesting	☐	☐	☐	☐	☐
Boring	☐	☐	☐	☐	☐
Relaxing	☐	☐	☐	☐	☐
Disturbing	☐	☐	☐	☐	☐
Lively	☐	☐	☐	☐	☐
Monotonous	☐	☐	☐	☐	☐

Q5. How do you assess the quality of the urban landscape around you?
(Please tick the box that best matches your opinion)

Very Bad	0	1	2	3	4	5	6	7	8	9	10	***Excellent***

LISTENING POINT N. 3

Q1. How do you assess the intensity of the following four types of sound in the soundscape around you?
(Please tick one box for each row)

Type of sound	*Very Low*	*Low*	*Fair*	*High*	*Very High*
Traffic (eg. Cars, motorcycles, clacson	☐	☐	☐	☐	☐
Mechanical/electrical sounds (eg. music, industries, sirens, construction)	☐	☐	☐	☐	☐
Anthropic sounds (eg. voices, laughter, children, step)	☐	☐	☐	☐	☐
Nature sounds (eg. wind, rustling leaves, birds)	☐	☐	☐	☐	☐

Q2. How do you assess the quality of the soundscape around you?
(Please tick one box)

0	1	2	3	4	5	6	7	8	9	10
Very Bad										***Excellent***

Q3. Do you think the soundscape around you is appropriate for this place?

(Please, tick one box)

Absolutely inappropriate	0	1	2	3	4	5	6	7	8	9	10	***Completely appropriate***

Q4. To what extent do you agree with the following statements about the soundscape around it?

(Please tick one box for each row)

The soundscape is:	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Enjoyable	☐	☐	☐	☐	☐
Chaotic	☐	☐	☐	☐	☐
Interesting	☐	☐	☐	☐	☐
Boring	☐	☐	☐	☐	☐
Relaxing	☐	☐	☐	☐	☐
Disturbing	☐	☐	☐	☐	☐
Lively	☐	☐	☐	☐	☐
Monotonous	☐	☐	☐	☐	☐

Q5. How do you assess the quality of the urban landscape around you?

(Please tick the box that best matches your opinion)

Very Bad	0	1	2	3	4	5	6	7	8	9	10	***Excellent***

LISTENING POINT N. 4

Q1. How do you assess the intensity of the following four types of sound in the soundscape around you?

(Please tick one box for each row)

Type of sound	*Very Low*	*Low*	*Fair*	*High*	*Very High*
Traffic (e.g. Cars, motorcycles, clacson)	☐	☐	☐	☐	☐
Mechanical/electrical sounds (e.g. music, industries, sirens, construction)	☐	☐	☐	☐	☐
Anthropic sounds (e.g. voices, laughter, children, step)	☐	☐	☐	☐	☐
Nature sounds (e.g. wind, rustling leaves, birds)	☐	☐	☐	☐	☐

Q2. How do you assess the quality of the soundscape around you?

(Please tick one box)

0	1	2	3	4	5	6	7	8	9	10
Very Bad										***Excellent***

Q3. Do you think the soundscape around you is appropriate for this place?

(Please, tick one box)

Absolutely inappropriate	0	1	2	3	4	5	6	7	8	9	10	***Completely appropriate***

Q4. To what extent do you agree with the following statements about the soundscape around it?
(Please tick one box for each row)

The soundscape is:	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Enjoyable	☐	☐	☐	☐	☐
Chaotic	☐	☐	☐	☐	☐
Interesting	☐	☐	☐	☐	☐
Boring	☐	☐	☐	☐	☐
Relaxing	☐	☐	☐	☐	☐
Disturbing	☐	☐	☐	☐	☐
Lively	☐	☐	☐	☐	☐
Monotonous	☐	☐	☐	☐	☐

Q5. How do you assess the quality of the urban landscape around you?
(Please tick the box that best matches your opinion)

Very Bad	0	1	2	3	4	5	6	7	8	9	10	***Excellent***

LISTENING POINT N.5

Q1. How do you assess the intensity of the following four types of sound in the soundscape around you?
(Please tick one box for each row)

Type of sound	*Very Low*	*Low*	*Fair*	*High*	*Very High*
Traffic (e.g. Cars, motorcycles, clacson	☐	☐	☐	☐	☐
Mechanical/electrical sounds (e.g. music, industries, sirens, construction)	☐	☐	☐	☐	☐
Anthropic sounds (e.g. voices, laughter, children, step)	☐	☐	☐	☐	☐
Nature sounds (e.g. wind, rustling leaves, birds)	☐	☐	☐	☐	☐

Q2. How do you assess the quality of the soundscape around you?
(Please tick one box)

0	1	2	3	4	5	6	7	8	9	10
Very Bad										***Excellent***

Q3. Do you think the soundscape around you is appropriate for this place?
(Please, tick one box)

Absolutely inappropriate	0	1	2	3	4	5	6	7	8	9	10	***Completely appropriate***

Q4. To what extent do you agree with the following statements about the soundscape around it?

(Please tick one box for each row)

The soundscape is:	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Enjoyable	☐	☐	☐	☐	☐
Chaotic	☐	☐	☐	☐	☐
Interesting	☐	☐	☐	☐	☐
Boring	☐	☐	☐	☐	☐
Relaxing	☐	☐	☐	☐	☐
Disturbing	☐	☐	☐	☐	☐
Lively	☐	☐	☐	☐	☐
Monotonous	☐	☐	☐	☐	☐

Q5. How do you assess the quality of the urban landscape around you?

(Please tick the box that best matches your opinion)

Very Bad	0	1	2	3	4	5	6	7	8	9	10	***Excellent***

AUDIO- RECORDINGS

Case 1

Q6: Imagine you are sitting inside a vehicle with an internal combustion engine and listening to the noise produced inside it while passing through a certain type of road pavement/asphalt. How do you assess the quality of the soundscape?

(Please tick the box that best matches your opinion)

Very poor	Poor	Acceptable	Good	Very good

Case 2

Q7: Imagine you are sitting inside an electric vehicle and listening to the noise produced inside it while passing through a certain type of road pavement/asphalt. How do you assess the quality of the soundscape?

(Please tick the box that best matches your opinion)

Very poor	Poor	Acceptable	Good	Very good

Case 3

Q8: Imagine you are sitting inside an electric vehicle and listening to the noise produced inside it while passing through a different type of road pavement/asphalt. How do you assess the quality of the soundscape?

(Please tick the box that best matches your opinion)

Very poor	Poor	Acceptable	Good	Very good

Case 4

Q9: Imagine you are sitting inside a vehicle with an internal combustion engine and listening to the noise produced inside it while passing through a different type of road pavement/asphalt. How do you assess the quality of the soundscape?

(Please tick the box that best matches your opinion)

Very poor	Poor	Acceptable	Good	Very good

Appendix II -The ante-operam questionnaire

LIFE/ENV/IT000201 LIFE E-VIA

THE PROJECT

Exposure data from the European Environment Agency demonstrate that more than 100 million EU citizens are affected by high noise levels negatively impacting human health. Traffic noise alone is harmful to the health of almost every third person in the World Health Organization European Region. 20% of Europeans are regularly exposed to night sound levels that could significantly damage health, especially in urban areas. The introduction of electric mobility is widely viewed as having the potential to reduce noise in urban areas, but the noise generated by tyres rolling on the road nevertheless needs careful study and further reduction. As emerged in Noise in Europe Conference (April 2017) and in the WHO guidelines published in October 2018, the increased stringency of EU at source standards needs to be balanced against other effective measures such as road surface and/or tyre improvements and urban planning measures as well. One of the solutions universally recognized as the best to reduce noise in urban areas, from both the point of view of noise and air quality, is the introduction of electric mobility.

Therefore, the project **LIFE E-VIA** (Electric Vehicle noIse control by Assessment and optimization of tyre/road interaction–www.life-evia.eu) intends to: - tackle noise pollution from road traffic noise focusing on a future perspective in which electric and hybrid vehicles will be a consistent portion of flow; - combine knowledge of road optimization and tyre development in order to test an optimized solution for reducing noise in urban areas and Life Cycle Cost with respect to actual best practices . The Project LIFE E-VIA, co-financed by the European Union through the Life programme, started in July 2019 and will end in January 2023. The project is coordinated by the Municipality of Florence and involves as partners the Mediterranean University of Reggio Calabria, Continental, Vie en.ro.se Ingegneria, University Gustave Eiffel and I-POOL.

THE SURVEY

The goal of this questionnaire is to collect data on the perception of the soundscape. In addition to some initial general questions, we kindly ask you to answer 10 questions related to the perception of the soundscape close to your home. Your personal data will be treated as strictly confidential and the publication of the survey results will ensure the non-recognition of the responses. Please answer all questions in order, following the instructions provided.

PERSONAL INFORMATION

I1. Age: ☐ 18-25 ☐ 26-40 ☐ 41-55 ☐ 56-65 ☐ 66-75 ☐ >75

I2. Gender: ☐ Female ☐ Male

I3. Education: ☐ Primary school ☐ Middle School ☐ High School ☐ Bachelor's Degree ☐ Ph.D. ☐ Master

I4. Occupation: _____

I5. City of Residence: _____

I6. Nationality: _____

D1. Does your home have windows overlooking via Paisiello? ☐ No ☐ Yes

D2. If so, which are the rooms that overlook via Paisiello?
(Make an X mark in the box for each room overlooking via Paisiello)

Room	*Overlooking via Paisiello*
Bedroom	☐
Single Bedroom	☐
Livingroom	☐
Kitchen	☐
Bathroom	☐
Other: …… (Please specify)	☐

D3. How do you assess the intensity of the following four types of sound in the soundscape around you?
(Make an X mark for each type of sound in the box that best matches your opinion)

Type of sound	*Very Low*	*Low*	*Fair*	*High*	*Very High*
Traffic (eg. Cars, motorcycles, clacson …)	☐	☐	☐	☐	☐
Mechanical/electrical sounds (es. music, industries, sirens, constructions…)	☐	☐	☐	☐	☐
Anthropic sounds (es. voices, laughter, children, steps…)	☐	☐	☐	☐	☐
Nature sounds (es. wind, rustling leaves, birds …)	☐	☐	☐	☐	☐

D4. How do you assess the quality of the soundscape around you?

(Please, tick the box that best matches your opinion)

0	1	2	3	4	5	6	7	8	9	10
Very Bad										***Excellent***

D5. Do you think the soundscape around you is appropriate for this place?
(Please, tick the box that best matches your opinion)

Absolutely inappropriate	0	1	2	3	4	5	6	7	8	9	10	***Completely appropriate***

D6. To what extent does it agree with the following statements about the sound environment around it??
(Please tick the box that best matches your opinion for each row)

The soundscape is:	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Enjoyable	☐	☐	☐	☐	☐
Chaotic	☐	☐	☐	☐	☐
Interesting	☐	☐	☐	☐	☐
Boring	☐	☐	☐	☐	☐
Relaxing	☐	☐	☐	☐	☐
Disturbing	☐	☐	☐	☐	☐
Lively	☐	☐	☐	☐	☐
Monotonous	☐	☐	☐	☐	☐

D7. How do you assess the quality of the urban landscape around you?
(Please tick the box that best matches your opinion)

Very Bad	0	1	2	3	4	5	6	7	8	9	10	***Excellent***

D8. Do you think that implementation of interventions for the reduction of noise could increase the value of your home? (Please tick the box that best matches your opinion)

Not at all	0	1	2	3	4	5	6	7	8	9	10	***Surely***

D9. Do you think that your health can be affected by the reduction of noise levels close to your home?
(Please tick the box that best matches your opinion)

Not at all	0	1	2	3	4	5	6	7	8	9	10	***Surely***

D10. How do you assess your sensitivity to sounds?
(Please tick the box that best matches your opinion)

Very low	0	1	2	3	4	5	6	7	8	9	10	***Very High***

Appendix III - The post-operam questionnaire

LIFE/ENV/IT000201 LIFE E-VIA

THE PROJECT

Exposure data from the European Environment Agency demonstrate that more than 100 million EU citizens are affected by high noise levels negatively impacting human health. Traffic noise alone is harmful to the health of almost every third person in the World Health Organization European Region. 20% of Europeans are regularly exposed to night sound levels that could significantly damage health, especially in urban areas. The introduction of electric mobility is widely viewed as having the potential to reduce noise in urban areas, but the noise generated by tyres rolling on the road nevertheless needs careful study and further reduction. As emerged in Noise in Europe Conference (April 2017) and in the WHO guidelines published in October 2018, the increased stringency of EU at source standards needs to be balanced against other effective measures such as road surface and/or tyre improvements and urban planning measures as well. One of the solutions universally recognized as the best to reduce noise in urban areas, from both the point of view of noise and air quality, is the introduction of electric mobility.

Therefore, the project **LIFE E-VIA** (Electric Vehicle noIse control by Assessment and optimization of tyre/road interaction– www.life-evia.eu) intends to: - tackle noise pollution from road traffic noise focusing on a future perspective in which electric and hybrid vehicles will be a consistent portion of flow; - combine knowledge of road optimization and tyre development in order to test an optimized solution for reducing noise in urban areas and Life Cycle Cost with respect to actual best practices . The Project LIFE E-VIA, co-financed by the European Union through the Life programme, started in July 2019 and will end in January 2023. The project is coordinated by the Municipality of Florence and involves as partners the Mediterranean University of Reggio Calabria, Continental, Vie en.ro.se Ingegneria, University Gustave Eiffel and I-POOL.

THE SURVEY

The goal of this questionnaire is to collect data on the perception of the soundscape. In addition to some initial general questions, we kindly ask you to answer 12 questions related to the perception of the soundscape close to your home. Your personal data will be treated as strictly confidential and the publication of the survey results will ensure the non-recognition of the responses. Please answer all questions in order, following the instructions provided.

PERSONAL INFORMATION

I1. Age: ☐ 18-25 ☐ 26-40 ☐ 41-55 ☐ 56-65 ☐ 66-75 ☐ >75

I2. Gender: ☐ Female ☐ Male

I3. Education: ☐ Primary school ☐ Middle School ☐ High School ☐ Bachelor's Degree ☐ Ph.D. ☐ Master

I4. Occupation: _____

I5. City of Residence: _____

I6. Nationality: _____

D1. Does your home have windows overlooking via Paisiello? ☐ No ☐ Yes

D2. If so, which are the rooms that overlook via Paisiello?
(Make an X mark in the box for each room overlooking via Paisiello)

Room	*Overlooking via Paisiello*
Bedroom	☐
Single Bedroom	☐
Livingroom	☐
Kitchen	☐
Bathroom	☐
Other: …… (Please specify)	☐

D3. How do you assess the intensity of the following four types of sound in the soundscape around you?
(Make an X mark for each type of sound in the box that best matches your opinion)

Type of sound	*Very Low*	*Low*	*Fair*	*High*	*Very High*
Traffic (eg. Cars, motorcycles, clacson …)	☐	☐	☐	☐	☐
Mechanical/electrical sounds (es. music, industries, sirens, constructions…)	☐	☐	☐	☐	☐
Anthropic sounds (es. voices, laughter, children, steps…)	☐	☐	☐	☐	☐
Nature sounds (es. wind, rustling leaves, birds …)	☐	☐	☐	☐	☐

D4. How do you assess the quality of the soundscape around you?
(Please, tick the box that best matches your opinion)

0	1	2	3	4	5	6	7	8	9	10
Very Bad										***Excellent***

D5. Do you think the soundscape around you is appropriate for this place?
(Please, tick the box that best matches your opinion)

Absolutely inappropriate	0	1	2	3	4	5	6	7	8	9	10	***Completely appropriate***

D6. To what extent do you agree with the following statements about the soundscape around you?
(Please tick the box that best matches your opinion for each row)

The soundscape is:	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Enjoyable	☐	☐	☐	☐	☐
Chaotic	☐	☐	☐	☐	☐
Interesting	☐	☐	☐	☐	☐
Boring	☐	☐	☐	☐	☐
Relaxing	☐	☐	☐	☐	☐
Disturbing	☐	☐	☐	☐	☐
Lively	☐	☐	☐	☐	☐
Monotonous	☐	☐	☐	☐	☐

D7. How do you assess the quality of the urban landscape around you?
(Please tick the box that best matches your opinion)

Very Bad	0	1	2	3	4	5	6	7	8	9	10	***Excellent***

D8. To what extent has the noise of traffic you perceive changed in the past months?
(Please tick the box that best matches your opinion)

Increased					***Stable***	***Decreased***				
Very much		fairly		slightly		Slightly		Fairly		Very much
0	1	2	3	4	5	6	7	8	9	10

D9. How do you assess the effects of the re-paving of via Paisiello with the new asphalt on the traffic sound you perceive from your home?
(Please tick the box that best matches your opinion)

Negative					***Irrelevant***	***Positive***				
Very much		fairly		slightly		Slightly		Fairly		Very much
0	1	2	3	4	5	6	7	8	9	10

D10. Do you think that the implementation of a low-noise asphalt has increased the value of your home?
(Please tick the box that best matches your opinion)

Not at all	0	1	2	3	4	5	6	7	8	9	10	***Surely***

D11. Do you think that your health can be improved by the recent reduction of noise levels close to your home?
(Please tick the box that best matches your opinion)

Not at all	0	1	2	3	4	5	6	7	8	9	10	***Surely***

D12. How do you assess your sensitivity to sounds?

(Please tick the box that best matches your opinion)

Very low	0	1	2	3	4	5	6	7	8	9	10	***Very High***

7 Annex - Calibration certificates for the measurement systems used

Azienda USL Toscana sud est
Servizio Sanitario della Toscana

Laboratorio di Sanita' Pubblica
Area Vasta Toscana Sud Est
U.O. Igiene Industriale
Laboratorio Agenti Fisici
Strada del Ruffolo - 53100 Siena
Tel 0577 536097 - Fax 0577 536754

Centro di Taratura LAT 164
Calibration Centre
Laboratorio Accreditato di Taratura
Accredited Calibration Laboratory

ACCREDIA
L'ENTE ITALIANO DI ACCREDITAMENTO

LAT 164

Membro degli Accordi di Mutuo Riconoscimento EA, IAF e ILAC

Signatory of EA, IAF and ILAC Mutual Recognition, Agreements

CERTIFICATO DI TARATURA LAT164 FA1580_22
Certificate of Calibration

- data di emissione *date of issue*: **18/01/2022**
- cliente *customer*: **VIE.EN.RO.SE. Ingegneria Srl**
  Via Belfiore, 36
  50144 Firenze (FI)
- destinatario *receiver*: **c.s.**

Si riferisce a *referring to*

- oggetto *item*: **Fonometro**
- costruttore *manufacturer*: **01 dB**
- modello *model*: **Solo Blu**
- matricola *serial number*: **60982**
- data di ricevimento oggetto *date of receipt of item*: **17/01/2022**
- data delle misure *date of measurements*: **17/01/2022**
- registro di laboratorio *laboratory reference*: **1448**

Il presente certificato di taratura è emesso in base all'accreditamento LAT N. 164 rilasciato in accordo ai decreti attuativi della legge n. 273/1991 che ha istituito il Sistema Nazionale di Taratura (SNT). ACCREDIA attesta le capacità di misura e di taratura, le competenze metrologiche del Centro e la riferibilità delle tarature eseguite ai campioni nazionali ed internazionali delle unità di misura del Sistema Internazionale delle Unità (SI).
Questo certificato non può essere riprodotto in modo parziale, salvo espressa autorizzazione scritta da parte del Centro.

This certificate of calibration is issued in compliance with the accreditation LAT N° 164. granted according to decrees connected with Italian law No. 273/1991 which has established the National Calibration System. ACCREDIA attests the calibration and measurement capability, metrological competence of the Centre and the traceability of calibration results to the national and international standards of the International System of Units (SI).
This certificate may not be partially reproduced, except with the prior written permission of the issuing Centre.

I risultati di misura riportati nel presente Certificato sono stati ottenuti applicando le procedure citate alla pagina seguente, dove sono specificati anche i campioni o gli strumenti che garantiscono la catena di riferibilità del Centro e i rispettivi certificati di taratura in corso di validità. Essi si riferiscono esclusivamente all'oggetto in taratura e sono validi nel momento e nelle condizioni di taratura, salvo diversamente specificato.
The measurement results reported in this Certificate were obtained following the calibration procedures given in the following page, where the reference standards or instruments are indicated which guarantee the traceability chain of the laboratory, and the related calibration certificates in the course of validity are indicated as well. They relate only to the calibrated item and they are valid for the time and conditions of calibration, unless otherwise specified.

Le incertezze di misura dichiarate in questo documento sono state determinate conformemente alla Guida ISO/IEC 98 e al documento EA-4/02. Solitamente sono espresse come incertezza estesa ottenuta moltiplicando l'incertezza tipo per il fattore di copertura *k* corrispondente ad un livello di fiducia di circa il 95%. Normalmente tale fattore *k* vale 2.
The measurement uncertainties stated in this document have been determined according to ISO/IEC guide 98 and ioa EA-4/02. Usually, they have been estimated as expanded uncertainty obtained multiplying the standard uncertainty by the coverage factor k corresponding to a confidence level of about 95%. Normally, this factor k is 2.

Direzione tecnica
(Approving Officer)

Azienda USL Toscana sud est
Servizio Sanitario della Toscana

Centro di Taratura LAT 164
Calibration Centre
Laboratorio Accreditato di Taratura
Accredited Calibration Laboratory

ACCREDIA
L'ENTE ITALIANO DI ACCREDITAMENTO

LAT 164

Membro degli Accordi di Mutuo Riconoscimento EA, IAF e ILAC

Signatory of EA, IAF adl ILAC Mutual Recognition, Agreements

Laboratorio di Sanita' Pubblica
Area Vasta Toscana Sud Est
U.O. Igiene Industriale
Laboratorio Agenti Fisici
Strada del Ruffolo - 53100 Siena
Tel 0577 536097 - Fax 0577 536754

CERTIFICATO DI TARATURA LAT164 FA1580_22
Certificate of Calibration

Di seguito, vengono riportate le seguenti informazioni:
In the following, information is reported about:

- la descrizione dell'oggetto in taratura (se necessaria);
description of the item to be calibrated (if necessary);

Oggetto:	**Fonometro**		Costruttore:	**01 dB**		
Modello:	**Solo Blu**		N. Serie:	**60982**		
Canale oggetto del Test:	**1**		Versione del Firmware:	**V1.401 2726 01107**		
Oggetto:	**Microfono**		Costruttore:	**01 dB**		
Modello:	**MCE 212**		N. Serie:	**75274**		
Preamplificatore	Costruttore:	**01 dB**	Modello:	**PRE21 S**	Matricola:	**13936**
Manuale di Istruzioni:	✓ P101-TNUT-134-CNOT1390		Data Pubblicazione:	**05/10/2004**		
☐ da sito web:			Data Download:			

Calibratore utilizzato:	Costruttore:	**Bruel & Kjaer**	Modello:	**4231**	Matricola:	**2713443**
Estremi certificato di taratura n.		**LAT068 47211-A**				Data:**01/06/2021**

- l'identificazione delle procedure in base alle quali sono state eseguite le tarature;
technical procedures used for calibration performed;

I risultati di misura riportati nel presente Certificato sono stati ottenuti applicando le procedure N.Macro Processo 02 Taratura Rev1 – PR0A1_Fonometri IEC 61672 ed 1 _rev5
The measurement results reported in this Certificate were obtained following procedures N. N.Macro Processo 02 Taratura Rev1 – PR0A1_Fonometri IEC 61672 ed 1 _rev5

- una dichiarazione che identifichi in quale modo le misure sono metrologicamente riferibili;
a statement identifying how the measurements are metrologically traceable;

La catena di riferibilità ha inizio dai campioni di riferimento PL_1 Keysight 34401A sn.SG53001544 – PL_2 B&K4228 sn.1798921 – PL_3B&K4180 sn. 1863691
Traceability is through reference standards. PL_1 Keysight 34401A sn. SG53001544 – PL_2 B&K4228 sn.1798921 – PL_4 B&K4226 sn. 1899881 muniti di certificati validi di taratura rispettivamente PL_1 1-1471823792-1 – PL_2 21-0639-02 – PL_4 21-0639-03
validated by certificates of calibration PL_1 1 1-1471823792-1 – PL_2 21-0639-02 – PL_4 21-0639-03

- il luogo di taratura (se effettuata fuori dal Laboratorio);
site of calibration (if different from the Laboratory);
Non previsto

- le condizioni ambientali e di taratura;
calibration and environmental conditions;

Temperatura:	23,6	°C ± 0,3 °C
Umidità:	26,2	% ± 2,5 %
Pressione:	1003,01 hPa ± 0,15 hPa	

Centro di Taratura LAT 164
Calibration Centre
Laboratorio Accreditato di Taratura
Accredited Calibration Laboratory

LAT 164

Membro degli Accordi di Mutuo Riconoscimento EA, IAF e ILAC

Signatory of EA, IAF adi ILAC Mutual Recognition, Agreements

Laboratorio di Sanita' Pubblica
Area Vasta Toscana Sud Est
U.O. Igiene Industriale
Laboratorio Agenti Fisici
Strada del Ruffolo - 53100 Siena
Tel 0577 536097 - Fax 0577 536794

CERTIFICATO DI TARATURA LAT164 FA1656_23
Certificate of Calibration

- data di emissione *date of issue*	30/01/2023
- cliente *customer*	VIE.EN.RO.SE. Ingegneria S.r.l. Via Belfiore, 36 50127 Firenze (FI)
- destinatario *receiver*	c.s.

Si riferisce a
referring to

- oggetto *item*	Fonometro
- costruttore *manufacturer*	01 dB
- modello *model*	Fusion canale esterno
- matricola *serial number*	11215
- data di ricevimento oggetto *date of receipt of item*	27/01/2023
- data delle misure *date of measurements*	30/01/2023
- registro di laboratorio *laboratory reference*	1525

Il presente certificato di taratura è emesso in base all'accreditamento LAT N. 164 rilasciato in accordo ai decreti attuativi della legge n. 273/1991 che ha istituito il Sistema Nazionale di Taratura (SNT). ACCREDIA attesta le capacità di misura e di taratura, le competenze metrologiche del Centro e la riferibilità delle tarature eseguite ai campioni nazionali ed internazionali delle unità di misura del Sistema Internazionale delle Unità (SI). Questo certificato non può essere riprodotto in modo parziale, salvo espressa autorizzazione scritta da parte del Centro.

This certificate of calibration is issued in compliance with the accreditation LAT N° 164, granted according to decreas connected with Italian law No. 273/1991 which has established the National Calibration System. ACCREDIA attests the calibration and measurement capability, metrological competence of the Centre and the traceability of calibration results to the national and international standards of the International System of Units (SI). This certificate may not be partially reproduced, except with the prior written permission of the issuing Centre.

I risultati di misura riportati nel presente Certificato sono stati ottenuti applicando le procedure citate alla pagina seguente, dove sono specificati anche i campioni o gli strumenti che garantiscono la catena di riferibilità del Centro e i rispettivi certificati di taratura in corso di validità. Essi si riferiscono esclusivamente all'oggetto in taratura e sono validi nel momento e nelle condizioni di taratura, salvo diversamente specificato.
The measurement results reported in this Certificate were obtained following the calibration procedures given in the following page, where the reference standards or instruments are indicated which guarantee the traceability chain of the laboratory, and the related calibration certificates in the course of validity are indicated as well. They relate only to the calibrated item and they are valid for the time and conditions of calibration, unless otherwise specified.

Le incertezze di misura dichiarate in questo documento sono state determinate conformemente alla Guida ISO/IEC 98 e al documento EA-4/02. Solitamente sono espresse come incertezza estesa ottenuta moltiplicando l'incertezza tipo per il fattore di copertura *k* corrispondente ad un livello di fiducia di circa il 95%. Normalmente tale fattore *k* vale 2.
The measurement uncertainties stated in this document have been determined according to ISO/IEC guide 98 and toe EA-4/02. Usually, they have been estimated as expanded uncertainty obtained multiplying the standard uncertainty by the coverage factor k corresponding to a confidence level of about 95%. Normally, this factor k is 2.

Direzione tecnica
(Approving Officer)

Centro di Taratura LAT 164
Calibration Centre
Laboratorio Accreditato di Taratura
Accredited Calibration Laboratory

LAT 164

Membro degli Accordi di Mutuo Riconoscimento EA, IAF e ILAC

Signatory of EA, IAF ad ILAC Mutual Recognition, Agreements

Laboratorio di Sanita' Pubblica
Area Vasta Toscana Sud Est
U.O. Igiene Industriale
Laboratorio Agenti Fisici
Strada del Ruffolo - 53100 Siena
Tel 0577 536093 - Fax 0577 536754

CERTIFICATO DI TARATURA LAT164 FA1656_23
Certificate of Calibration

Di seguito, vengono riportate le seguenti informazioni:
In the following, information is reported about:

- la descrizione dell'oggetto in taratura (se necessaria);
description of the item to be calibrated (if necessary);

Oggetto:	**Fonometro**		Costruttore:	**01dB**		
Modello:	**Fusion canale esterno**		N. Serie:	**11215**		
Canale oggetto del Test:	esterno		Versione del Firmware: **2.46**			
Oggetto:	**Microfono**		Costruttore:	**GRAS**		
Modello:	**40CE**		N. Serie:	**233339**		
Preamplificatore	Costruttore:	**01dB**	Modello:	**PRE22**	Matricola:	**1605084**
Manuale di Istruzioni: ✓			Data Pubblicazione: **D01131 June 2016**			
☐da sito web:			Data Download:			
Calibratore utilizzato:	Costruttore:	**Brüel & Kjær**	Modello:	**4231**	Matricola:	**2713443**
Estremi certificato di taratura n.		**LAT068 47211/A**				Data:**01/06/2021**

- l'identificazione delle procedure in base alle quali sono state eseguite le tarature;
technical procedures used for calibration performed;

I risultati di misura riportati nel presente Certificato sono stati ottenuti applicando le procedure N.Macro Processo 02 Taratura Rev1 – PR0A1_Fonometri IEC 61672 ed 1 _rev5
The measurement results reported in this Certificate were obtained following procedures N. N.Macro Processo 02 Taratura Rev1 – PR0A1_Fonometri IEC 61672 ed 1 _rev5

- una dichiarazione che identifichi in quale modo le misure sono metrologicamente riferibili;
a statement identifying how the measurements are metrologically traceable;

La catena di riferibilità ha inizio dai campioni di riferimento PL_1 Keysight 34401A sn.SG53001544 – PL_2 B&K4228 sn.1798921 – PL_3B&K4180 sn. 2541524
Traceability is through reference standards. PL_1 Keysight 34401A sn. SG53001544 – PL_2 B&K4228 sn.1798921 – PL_3 B&K4180 sn. 2541524
muniti di certificati validi di taratura rispettivamente PL_1 LAT051 C12229A2F0 – PL_2 22-0650-02 – PL_3 22-0650-01
validated by certificates of calibration PL_1 LAT051 C12229A2F0 – PL_2 22-0650-02 – PL_3 22-0650-01

- il luogo di taratura (se effettuata fuori dal Laboratorio);
site of calibration (if different from the Laboratory);
Non previsto

- le condizioni ambientali e di taratura;
calibration and environmental conditions;

Temperatura:	21,9	°C ± 0,3 °C
Umidità:	31,9	% ± 2,5 %
Pressione:	997,9	hPa ± 0,15 hPa