LIFE Project Number

LIFE18 ENV/IT/000201

Final Report

Covering the project activities from 01/07/2019[1] to 31/01/2023

Reporting Date[2]

31/03/2023

LIFE PROJECT NAME or Acronym

LIFE E-VIA

Data Project

Project location:	Florence (Italy)
Project start date:	01/07/2019
Project end date:	31/01/2023
Total budget:	€ 1,797,030.00
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(%) of eligible costs:	55%

Data Beneficiary

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[1] Project start date
[2] Include the reporting date as foreseen in part C2 of Annex II of the Grant Agreement

1. Table of contents

2. List of key-words and abbreviations

Keywords:

Close-proximity noise, CNOSSOS-EU, crumb rubber, driving behavior, dynamic stiffness, noise, electric vehicles, EV fleet, friction, low-noise asphalt concretes, low-noise pavement, microphone array, motor noise, noise perception, noise prediction, noise sources, optimized tyres, pass-by noise, psycho-acoustics, rolling noise, rubberised asphalt concrete, sound absorption, soundscape, surface texture, tyre-road noise, vehicle noise emission, very thin asphalt concrete.

Abbreviations:

AVAS	Acoustic Vehicle Alerting System
BEV	Battery Electric Vehicle
CPB	Controlled Pass-By
CAE	Computer-Aided Engineering
CNOSSOS-EU	European Common Noise Assessment Methods
CPB	Controlled Pass-By
CPX	Close-ProXimity
CR	Crumb Rubber
CRS	Constant Rolling Speed
DAC	Dense Asphalt Concrete
EAA	European Environment Agency
EC6	Continental EcoContact 6
END	Environmental Noise Directive
ETD	Estimated Texture Depth
ETRTO	The European Tyre and Rim Technical Organisation
EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicle
GPP	Green Public Procurement
HEV	Hybrid Electric Vehicle
HWR	Height-Width-Ratio
ICE	Internal Combustion Engine
ICEV	Internal Combustion Engine Vehicle
ISO	International Organization for Standardization
LI	Load Index
MPD	Mean Profile Depth
MTD	Mean Texture Depth
NVH	Noise Vibration Harshness
OE	Original Equipment
P	LIFE E-VIA prototype road surface
PCR	LIFE E-VIA prototype road surface with crumb rubber
PHEV	Plug-in Electric Vehicle
RPM	Rounds Per Minute
SL	Standard Load
SMA	Stone Mastic Asphalt
SPL	Sound Pressure Level
SRTT	Standard Reference Test Tyre
UNECE	United Nations Economic Commission for Europe
VTAC	Very Thin Asphalt Concrete
WHO	World Health Organisation
SUV	Sports Utility Vehicle
XL	Extra Load

3. Executive Summary (maximum 2 pages)

More than 100 million EU citizens are affected by high noise levels negatively impacting human health (EAA). As indicated during the Noise in Europe Conference (2017) and in the WHO guidelines (2018), an increased adoption of effective measures such as road surface and/or tyre improvements and urban planning measures is necessary.
The specific **LIFE E-VIA project objectives** are:
1) To reduce noise for roads inside very populated urban areas through the implementation of a mitigation measure aimed at optimizing road surfaces and tyres of EVs. Two road surfaces, at least 5 different EV types, one reference ICE Vehicle (ICEV) and at least 3 types of tyres per vehicle type (including tyres specifically designed for EVs) will be tested.
2) To estimate the mitigation efficiency and potential of tyres, pavements and traffic at a higher and comprehensive level: a Life Cycle Analysis (LCA) and a Life Cycle Cost Analysis (LCCA) will be performed to demonstrate the individual and synergistic efficiency of pavement surfaces, tyres and vehicles (including the comparison between internal combustion vehicles, mixed traffic, and EV traffic).
3) To contribute to EU legislation effective implementation (EU Directives 2002/49/EC and 2015/996/EC), providing rolling noise coefficients within the Common Noise Assessment Method (CNOSSOS-EU), specifically tuned for EVs.
4) To contribute to national and Italian regional policies, issuing guidelines about use and application of the methodology output of the project.
5) To raise people's awareness of noise pollution and health effects explaining the opportunities provided by EVs through specific dissemination and promotional events, also investigating people perception regarding noise in terms of soundscape methodology and involving them in noise data acquisition.
6) To demonstrate and promote sustainable road transport mobility (electric), reducing noise emission by 5 dB(A) at receivers roadside and achieving also CO2 emissions reduction (21%), based on the Italian context and the concerned literature.
7) To encourage low-noise surfaces implementation in further EU and extra-EU scenarios, demonstrating durability and sustainability, through in-depth LCA&LCCA.

The main **obtained and quantified achievements**, are:
1. L_{CPX} measurements have been carried out during four sessions throughout the project's duration. The last measurement session gave the following results for the E-VIA pavements: Using 50 km/h as the reference speed, 90.4 dBA (with 1 dBA uncertainty) for the reference pavement and 89.3 dBA (with 0.9 dBA uncertainty) for the E-VIA pavement that includes crumb rubber, giving a further environmental advantage in the recycle and reuse of exhausted tyres. Ageing effects were observed in subsequent testing sessions.
2. CPB measurements were carried out by IPOOL for obtaining a comparison of the performance of vehicles and tyres combination, turning out to be very useful in terms of noise emission. Due to the fact that the traditional and the E-VIA pavements were one after the other, passages could be measured consecutively reducing the error space, weather conditions and repeatability. In wide band, the E-VIA pavement turned out to be 2.1 dB(A) less noisy that the reference pavement.
3. According to acoustic measurements carried out at receivers roadside about one year after the intervention implementation, a reduction of 4.4 dB(A) in terms of Lnight (in the night period from 10 p.m. to 6 a.m.) has been measured. About 16 months after the pilot intervention realization, a new noise measurement campaign has been carried out in order to verify asphalt performances overtime. Between the second and the third noise measurement campaign, a difference of 2.9 dB(A) in terms of Lnight was still measured.

4. In terms of qualitative perception of the new soundscape determined by the pilot intervention in Florence, 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 stretch with standard asphalt. Also, 70% of the interviewees inside the electric taxi indicated the optimized asphalt as the one with the best performance in terms of acoustic comfort, compared to new but standard asphalt and the worn one. Survey administered to residents living in the street section repaved with the optimized asphalt demonstrate that the intervention improved the quality of the soundscape and reduced the perceived traffic noise: according to 61% of the respondents traffic noise has decreased after the intervention and 77% assessed the intervention as positive from an acoustic point of view.
5. At the end of the project, about 2000 people have been positively affected by the reduction of noise in the pilot area. Results and effects, measured during the project, will be modelled for the estimation in future applications. Additional analysis based on the Life Cycle Assessment approach suggested that the LIFE E-VIA solutions reduce the DALY (Disability-adjusted life years) by 33%.
6. The noise optimized tyre for electric vehicles led to a reduction of rolling noise of 0.8 dB(A) under typical urban driving conditions on a variety of road surfaces, at a different number of speeds, and using a number of different test vehicles. Especially good results were obtained with the two LIFE E-VIA surfaces tested in Nantes, highlighting the combined efficiency of the LIFE E-VIA solutions. The very good noise performance of the LIFE E-VIA tyre is combined with a very balanced and competitive portfolio of non-noise related performances.
7. CO_2 reduction with electric cars use in the mitigated area, i.e. 3 tons CO2 reduction per year (where the contribution of tyres was taken into account in terms of about 2 g/km). The evaluated target is less ambitious than expected, due to the fact that over the years 2019-2022 the increase of the number electric vehicles in Italy has followed a quite unsatisfactory trend. This is the main reason of the occurred deviation. Several specific actions have been organised to promote electric market and raise awareness (events and stands dedicated to the project, lessons to students, distributed materials, etc.).

The main **obtained outputs** are:
1. Development/testing/optimization of a new methodology for the prediction of the noise emitted by tyres in contact with the proposed quiet asphalt with the aim to optimize them in the future for a growing number of electric vehicles; adapting quiet pavements to the evolution of the car fleet by optimizing them from the acoustic point of view to reduce the exposure to noise where the transit speed determines an ineffective use of the electric motor due to the presence of rolling noise
2. New optimized road surface able to enhance performances of EVs, compliant with low-noise EUGPPC: improved environmental solutions (new quiet tyres for electric cars tested) capable of being widely taken up by the society in general and by the economy in particular.
3. New noise emission model for electric cars, helping EU legislation implementation.
4. New testing framework to develop surfaces for mixed fleets with increasingly electric and hybrid vehicles proportion.
5. During the project duration, the obtained outcomes have been presented in periodic occasion, e.g. Eurocities meetings; moreover, EV mobility, good behaviours and noise awareness will continued to be promoted after the project's conclusion to promote and support electric and sustainable mobility.

A summary of main achievements carried out by the project in the reporting period is made available hereinafter:

1. Technical reports on preparatory actions dealing with literature review on EVs and their noise emission, track design focusing on quiet pavement technologies and their performance over time, design or performance requirements for a holistic low noise tyre for EV applications. All reports are available at https://life-evia.eu/documents/ (Actions A1-A2-A3).
2. Design of prototype pavement mixtures including volumetrics, materials and surfaces textures (Action B1).
3. Laying of the prototype pavement in Nantes (Action B2).
4. Pass-by measurement campaigns carried out on 6 different road surfaces and 8 different vehicles tested, including 7 EVs and 1 ICEV (Action B2).
5. Implementation of the two asphalt sections in the Florence pilot case (via Paisiello), including 150 m with traditional asphalt and 150 m with E-VIA asphalt (Action B3).
6. Four measurement sessions (CPX, Impedance tube, the Extended surface method and CPB for the acoustic characterization, 3D surface texture and mechanical impedance measurements) have been carried out to evaluate the morphological and mechanical properties of the pilot site and initial targets have been achieved (Action B4).
7. Carrying out of soundwalks concurrently with interviews on electric taxi (with 80 participants) and of ante and post-operam interviews with 56 residents of the pilot street, demonstrating the effectiveness of the realized interventions also from the point of view of people's perception. A long-term ante and post-noise monitoring campaign was also carried out (not foreseen in the original proposal) which permitted to evaluate the ante and post (short and long-term) noise levels at receivers (Action B5).
8. Quantification of the acoustic performance of new EV tyres and new road surface to provide knowledge and tools to public administrations. In particular, measurements on the test tracks in Florence have been used to calculate specific CNOSSOS rolling noise coefficients, besides a road surface correction factor (Action B6).
9. Compared to the Continental EcoContact 6 205/55 R16 91V reference tyre, the LIFE E-VIA tyre demonstrated very good noise performance which is combined with a very balanced and competitive portfolio of non-noise related performances. The very good performance levels of the reference tyre could be maintained, if not slightly improved (Action B7).
10. Evaluation of project's indicators and KPIs (Action C1).
11. A specific LCC and LCA analysis has been carried out (Action C2).
12. Several scientific papers, project's noticeboards, presentations at national and international congresses, project's events and stands, press conferences, brief articles on national and local newspapers have been object of the dissemination strategy (Actions D1-D2).

4. Introduction (maximum 2 pages)

LIFE E-VIA projects focuses on the **environmental problem** related to noise exposure in urban areas mainly due to road traffic. In fact, noise exposure data from the European Environment Agency (EEA) 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 WHO European Region. 20% of Europeans are regularly exposed to night sound levels that could significantly damage health, especially in urban areas. 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.

In the world, there are more than 3 million EV (after November 2017) and International Energy Agency data indicate that there will be more than 125 million (until 220 million) in 2030, exceeding 50% of cars sold. With the progress of modern Internal Combustion Engines (ICE), tyre/road noise dominates after 40 kph for steady-speed traffic. This threshold is even lower for EVs with strongly reduced engine noise, thus leading to a higher relative contribution of tyre/road noise to the overall exterior vehicle noise. Similar effects can also be observed for the contribution of the tyre rolling resistance to the vehicle's energy consumption. This affects the emission of CO_2 and air pollutants, and the achievable mileage which is crucial for the public acceptance of EVs. Thus, for the changed requirements of EVs there is a need for in-depth investigations of tyre/road interaction. Last but not least, even for the application of the Directive 2002/49/EC, the coefficients to apply the CNOSSOS model (Directive 996/2015/EC) to new traffic spectra and new vehicles (including EV) are completely missing.

The specific **project objectives** are:

1) To reduce noise for roads inside very populated urban areas through the implementation of mitigation measures aimed at optimizing road surfaces and tyres of EVs. Two road surfaces, at least 5 different EV types, one reference ICE Vehicle (ICEV) and at least 3 types of tyres per vehicle type (including tyres specifically designed for EVs) will be tested.

2) To estimate the mitigation efficiency and potential of tyres, pavements and traffic at a higher and comprehensive level: a Life Cycle and Life Cycle Cost Analysis will be performed to demonstrate the individual and synergistic efficiency of pavement surfaces, tyres and vehicles.

3) To contribute to EU legislation effective implementation, providing rolling noise coefficients within the Common Noise Assessment Method (CNOSSOS-EU).

4) To contribute to national and Italian regional policies, issuing guidelines about use and application of the methodology output of the project.

5) To raise people's awareness of noise pollution and health effects explaining the opportunities provided by EVs through dissemination and promotional events, also investigating people perception regarding noise and involving them in noise data acquisition.

6) To demonstrate and promote sustainable road transport mobility, reducing noise emission by 5 dB(A) at receivers' roadside and achieving also CO2 emissions reduction (21%), based on the Italian context and the concerned literature.

7) To encourage low-noise surfaces implementation in further EU and extra-EU scenarios, demonstrating durability and sustainability, through in-depth LCA&LCCA.

The main **expected achievements**, including related **environmental benefits**, are:

1. Reduction of noise levels are expected for the sake of citizens health, for EV and ICEV, with pavements/tyres having life cycle costs comparable to those of standard road surfaces and tyres. Regarding reduction of CPX noise levels at 50kph, for the surface-OPTIMIZED track (action B3, track 2), a L_{CPX} below 87 dBA is targeted with respect to the «comprehensive» criterion for low noise pavements of the EUGPPC, and for reference track 1, a L_{CPX} below 90 dBA is expected («core» criterion of EUGPPC). In comparison with the common old existing

pavements (old DACs), this implies a higher noise reduction at the source (at least 3 to 4 dBA) than the simple substitution by a common new dense-graded pavement (at least 2 dBA). Regarding Lden and Lnight, the proposed mitigation action should lead to a reduction of at least 5 dBA at receivers living at road side.
2. At the end of the project, about 2000 people are going to be positively affected by the reduction of noise (Lden/Lnight reduction of at least 5 dB(A)), in the pilot area. A quantification of health benefits in terms of Disability-Adjusted Life Year (DALY) reduction will be provided.
3. CO_2 reduction with electric cars use in the mitigated area, i.e. 29 tons CO2 reduction per year (where the contribution of tyres was taken into account in terms of about 2 g/km). Specific actions are intended to promote electric market and raise awareness.
The applied **methodology** consists in:
- An initial recognition about the state of the art concerning EVs and their noise emission, compared to ICEV, Quiet pavement technologies and their performance over time, for urban areas and EV, Tyre role in the new context of EV and ICEV.
- Selection of mixtures (volumetrics, materials, and surface texture), for the tracks to be constructed in France (prototypal area) and Italy (pilot case), to minimize noise from EV.
- Selection of the optimal road surface for the specific context of EV fleet and tyres and construction of a test track in the prototypal area in Nantes and verification of optimization criteria regarding noise with several types of tyres
- Implementation of the prototypal pavement in the pilot area in Florence
- Running track efficiency tests in the pilot area, including the evaluation of noisiness of EV/ICEV for different tyres in terms of overall noise and tyre/road noise, providing information in terms of actual performance and potential in future fleets scenarios, testing different tyres for a subsequent “close-to-market” use.
- Application of the soundscape holistic approach to evaluate the performance of EV vs. ICEV in the newly built scenario
- Evaluation of EV noise emissions, in order to populate an EV noise model according to 2015/996/EC directive, CNOSSOS-EU model. Rolling noise coefficients for EVs will be estimated for the local fleet.
- Actual development and building of EV tyres which are designed to give an optimal holistic relation between low exterior noise and other key performances.
All these steps will be supported by dissemination, monitoring, managing and LCA/LCC activities.
Expected longer term results are:
- in terms of EU environmental policy and legislation concerning noise, the development of a new emission model for EVs, together with introduction of coefficients for rolling noise for CNOSSOS-EU prediction model and the adoption of Project's method and guidelines as regional/national standard.
- in terms of replicability and transferability, activities such as replication of solution for low-noise surfaces tested in pilot area in at least 3 project-based action plans, EV festival and events replication, distribution of two new tyres in the market, replication and transferability of CR-based pavements.
Regarding the **possible integration with other EU policies**, LIFE E-VIA project outcomes will contribute to lead positive health effects for densely populated areas. This includes benefits by referring to: Noise-induced hearing loss; Cardiovascular effects; Psychological impacts; Stress; Annoyance; Children physical development and Cognitive development; Effects on animals, based on the relationship between CPX and noise levels.

5. Administrative part (maximum 1 page)

Regarding the **project management process**, the LIFE E-VIA project is managed by the Project Manager (PM) from FIRENZE who have responsibility for technical aspects and relations with the EC. The PM structure is then developed in order to face the unforeseen difficulties, allowing flexibility and dialogue between the different parts of the staff. An administrative management staff (AMS) is appointed for the reporting and administrative management between FIRENZE and the associated beneficiaries. A general coordinator for dissemination and communication activities (GCDC) is established. The PM, together with the AMS and the GCDC, constantly interfaces with the general monitoring unit (GMU). The whole Project Management Staff (PMS) interacts with the Steering Committee and the Scientific Committee, with the Technical and Administrative associated beneficiaries units and the Project impact monitoring unit (PIMU). The Coordinating Beneficiary assures that periodic recalls are made to partners, in case delays in documentation sending occur. An online repository has been set up and managed by Coordinating Beneficiary, where all the documents provided by the partners are collected and organized in dedicated folders.

The project partnership is formed by public and private bodies with proven experience in European projects and the specific role that each of them assumes in the project. Moreover, the expertise of each partner is complementary to that of the others in order to effectively achieve the project objectives. Specifically, FIRENZE has a long-term experience in EU-funded projects. It has been involved in several projects tackling smart cities opportunities and sustainable mobility issues. It promotes several initiatives to enhance electric vehicle use and to raise people's awareness of pollution due to traffic. UNIRC combines its commitment to research and teaching; DIIES group focuses on quiet pavements, surface texture, pavement-tyre interaction, acoustics, measurement issues, and LCA/LCC. VIENROSE is one of the leading technical companies in Italy working in acoustics and environmental engineering with UNI EIFFEL expertise in noise control and noise reduction. It is also specialized in soundscape research and application and in activities involving people in events focused on acoustics and in organising such events. IPOOL is a spin-off society of National Research Council, CNR in Pisa. It offers highly qualified services in R&D of analytical and instrumental technologies for industrial and environmental processes. It has a several years experience in CPX method of low-noise road surfaces made with rubber from end-of-life tyres (ELTs). UNI-EIFFEL is a major player in EU research on city and territories, transportation, and civil engineering. It conducts applied research and expert appraisals in the fields of transport, infrastructure, natural hazards and urban issues with the aim of improving the living conditions of citizens and, more widely, promoting the sustainable development of societies. CRD develops pioneering technologies and services for sustainable and connected mobility of people and their goods. Founded in 1871, the technology company offers safe, efficient, intelligent and affordable solutions for vehicles, machines, traffic and transportation.

The only amendment requested, formally submitted within June 2020, concerned the merging of the “Institut Français des Sciences et Technologies des Transports, de l’Aménagement et des Réseaux” (IFSSTAR) and the “Université Paris-Est Marne-la-Vallée” to become the «Université Gustave Eiffel» (EIFFEL) with a new PIC number (897556521). The staff involved in the LIFE E-VIA project has not changed in comparison with the proposal (only former IFSTTAR employees have been involved in the project).

No particular problems neither significant deviation from the work plan have been encountered during the project lifetime. Communication with EASME (CINEA) and Monitoring Team have been held regularly and have concerned explanations from the administrative and technical point of view and the KPI definition and monitoring.

6. Technical part (maximum 25 pages)

6.1. Technical progress, per Action

Action A1 – Electric vehicles and their noise emission

Foreseen start date: 1st July 2019 Actual start date: 1st September 2019
Foreseen end date: 31st January 2020 Actual end date: 31st March 2020

The literature review foreseen under Action A1 was piloted by UNI EIFFEL in collaboration with VIENROSE which complemented the work regarding noise perception of EVs. The work performed provides solid bases and methodological recommendations regarding the implementation of the LIFE E-VIA project, specifically for the optimisation of tyre/road noise reduction in the context of a growing EV fleet in urban area.

EV fleet and distribution: As a main output of A1 for implementation actions, the current BEV models dominating the European market have helped in orienting the selection of BEVs for acoustic tests planned in the tyre-pavement coupling study on UNI EIFFEL reference test track in Nantes (France) within action B2.

Changes of driving behaviour: Technical features of EVs infer changes in the driving behaviour, namely the limited vehicle range, the availability of regenerative braking and a set of different sensations arising when driving EVs. A1 report recommends considering specificities of driving behaviour in the characterisation of tyre/road and vehicle noise emission during the tests on the prototype and on the pilot area, respectively within implementation actions B2 and B4. This entails considering variable speed in addition to constant speed driving.

Specificities of EV noise sources: Existing studies found that for EVs tyre/road noise exceeds propulsion noise at speeds above 30 km/h, sustaining the need for low noise tyres and quiet road surfaces for noise reduction, including in urban areas. This meets one of the main objectives of the LIFE E-VIA project. However, the literature review pointed out a lack of information on tyres, pavement types and/or background noise of the test sites to solidly substantiate results. Measurement campaigns planned in implementation action B2 of LIFE E-VIA shall tackle these difficulties in several ways.

Perception of noise from EVs: An increasing number of EVs involves positive effects in terms of noise reduction and perception. As an outlook of A1 action, investigations on human response, including soundwalks and interviews, seem crucial and will be performed in action B5 by VIENROSE.

EVs in the noise predictions models: The majority of road traffic noise prediction models only refer to conventional vehicles and do not mention electric vehicles. Separation of propulsion and rolling noise is a challenge on these latter vehicles. A1 report points out these difficulties and solutions shall be considered in actions involving low speed measurements.

The results of the preparatory action A1 are in full agreement with the foreseen action description. All the aspects mentioned in the project's proposal have been addressed with effective collaboration between the involved partners. Regarding time schedule, the delivery of the final report on action A1, which was planned on 31/03/2020, has been delayed for several contextual reasons. First at the very beginning of the project the staff effort was concentrated on the experimental campaign of sub-action B2.1 in August and September 2019 (the latter finally postponed for bad weather conditions). Thus, the effective starting date on A1 action regarding literature review was actually on the 1st of September 2019. Then, the staff was loaded again in February and March 2020 for the second stage of the experimental campaign within sub-action B2.1, which was finally postponed due to Covid19 outbreak. Second, the working conditions due to Covid19 made the finalisation of the work within A1 even harder. The draft report was partly completed on 31/03/2020 and the final report was validated on 12/06/2020. We consider that this delay had no main impact on other implementation actions.

Action A2 – Quiet pavements technologies and their performance over time

Foreseen start date: 1st July 2019 Actual start date: 1st July 2019
Foreseen end date: 31st January 2020 Actual end date: 31st March 2020

In Action A2 UNIRC gathers and structures available references in the pursuit of the following actions (mainly B1 and C2), UNI EIFFEL and IPOOL provides advice, support and references for tyre-pavement interaction and for noise-related issues respectively. Main deliverable: Report Actions A2 (03/2020, Del. 4.2). This action aims at providing the best scientific and practical bases to design the tracks including in-lab tests (preliminary tests). Emphasis is going to be given to Crumb Rubber-added solutions because of their perspectives as per the current literature. To this aim, for each solution, this action focused on: Acoustic and non-acoustic performance and durability; Corresponding mixture composition (quantities, typology), volumetric characteristics, and their evolution over time; Corresponding agency and user costs; Pertaining to raw materials and processes involved and their impact on environmental indicators; Research and industrial areas and elements to enhance the formula/processes in the pursuit of improving their noise-related and overall characteristics. Their compatibility and perspectives when analysed in terms of 2015/996/EC directive, CNOSSOS-EU mod and when compared to the transition from the actual spectrum of traffic to a new scenario in which EVs will be an outstanding percentage. Preliminary in-lab tests were made: the airflow resistance was measured using the apparatus Norsonic Nor1517A (purchased under the project), by applying the alternating airflow method in accordance with UNI EN ISO 9053-1:2019. A careful study of pavement solution (including crumb-rubber solutions) in the literature was carried out. The acoustic durability of different types of bituminous mixtures was considered. The main characteristics related to basic properties (such as air voids, AV) were considered. For each mixture, a tentative array of non-acoustic performance (e.g., in-lab permeability) was derived. Mixture composition was derived. This involved aggregate mixture and gradation crumb rubber type, size and quantity. A study of literature was made to evaluate agency and user costs. In particular, for user cost, it is noted that they include three main categories: Value of Time (VOT), Vehicle Operating Costs (VOC), and Accident Costs (AC). The following points have been analysed in term of environmental impact: the emissions measured during mixture production, component emissions in pavement mixtures, and Kg CO2 equivalent values for mixtures production. At the end, using the data collected, the results for a friction course were obtained. According to the literature, there is still room for improving the performance of crumb rubber added bituminous mixtures. Indeed, crumb rubber treatment (prior to the mixing stage), crumb rubber percentage/gradation, and crumb rubber function have a certain potential. It is noted that when dealing with dry process, rubber swelling represents a tangible issue: this can be limited through the pre-treatment of rubber (see "Room for improvements"). The hierarchical structure of noise quantification according to EU 2015/996 builds on having the steady traffic flow noise depending on traffic flow and single vehicle (see "Quiet pavements and EU approach"). The following conclusions were drawn:

1) The choice of a pavement is going to affect: $\alpha_{i,m}$ (the spectral correction in dB at reference speed vref for category m (1, 2 or 3) and spectral band i (octave band from 125 to 4000 Hz)) and β_m (the speed effect on rolling noise reduction).

2) EV percentage and type could affect: propulsion noise coefficients $A_{P,i,m}$ and $B_{P,i,m}$ and, to a certain extent, deviations related to the driving conditions ($\Delta L_{WP,acc,i,m}$ and $\Delta L_{WP,grad,i,m}$).

Acoustic and non-acoustic performance have been analysed, together with the concerned costs, and six classes of solutions have been selected. For a detailed description, please cf. Technical Report Action A2 deliverable on the project website: https://life-evia.eu/.

To select the mixes UNIRC analysed many solutions (pavement, bituminous mixtures), based on acoustic and non-acoustic performances.
At the beginning, more than 150 mixes were selected spanning from dense-graded to gap-graded ones. Their characteristics and impacts were analysed.
Preliminary tests were carried out.
To select the mixes following characteristics and parameters have been considered:

- Acoustic response (as-built and over time)
- Expected life by referring to mechanistic properties
- Permeability
- Friction.

The following main criteria were followed to select the mixtures:

- Having an expected life far from 0
- Having an ENDt value sufficiently low
- Having satisfactory characteristics for the remaining properties.

Based on the above the following mixtures were selected.

	Acronym	END_t (dB)	MPD (mm)	AV (%)	BPN
1	AC6	0.7	0.72	11.7	≥60
3	SUP	1.2	0.92	8.2	≥60
4	OG4	2.9	1.79	17.4	≥55
6	GAP	0.7	0.95	6.9	≥55
10	SM6	1.7	0.8	7.6	≥60
11	SM6*	2.4	1.04	3.7	≥60
12	AC6*	2.2	1.1	7.4	≥60
13	SM8	1.7	0.9	7.3	≥60
19	ISO	0	0.5	4	≥60

Selected mixtures

The main volumetric and functional parameters were derived.
The mixtures AC6, ISO, and GAP resulted in the best noise-related parameters. To this end, also the ENDt indicator was used.

Action A3 - Tyre role in the context of EV and ICEV

Foreseen start date: 1st July 2019 Actual start date: 1st August 2019
Foreseen end date: 31st March 2020 Actual end date: 31st July 2020

This action is reported in the project deliverable report *A3: Tyre role in the context of EV and ICEV* (Del. 4.3). A3 was carried out predominantly by CRD with additional support from UNI-EIFFEL. The late start of the action is related to the project start during summer vacation season, and the encountered delay in finishing the action was caused by work stoppages related to the circumstances surrounding the Covid 19 pandemic. A3 was concluded slightly below the estimated budget.. Action A3 main objective is the identification of the role of the tyre in the context of EV vs. ICE vehicles with respect to rolling noise and related target conflicts, for example with respect to rolling resistance.
In accordance with the project proposal this task was broken down in several sub-steps, details for which can be found in the mentioned report:

1. Preparation of a market overview of representative EVs to identify properties which can have a direct or indirect influence on the choice of tyre and the relevant tyre performances such as noise or rolling resistance. This was accompanied by a literature study which focused on identifying the most important of these parameters in the context of a change from ICEV to EV. Based on this, tyre load, tyre torque, and tyre dimensions were identified as the most important parameters which might change going from ICEV to EV.
2. The data collected in the previous step was then compared to the corresponding characteristics for classical ICE vehicles to classify the extend of the influence of the identified differences on the target performances. It was found that compared to ICEVs, tyre loads will be 10 % to 20 % higher for comparable EVs. Linked to this is an expected increase in inflation pressure for the tyre. This increase in tyre load, however, is in most cases well within the load bearing capacity of the tyre so that the tyre load index does not need to be increased. Regarding tyre torque, no definite conclusion could be drawn due to a lack of specific data and a large influence of driver behaviour and electronic control systems on this property. It was nevertheless concluded that it is highly likely that higher tyre torques are to be encountered on EVs. With respect to typical tyre dimensions no general trend towards previously uncommon tyre sizes was observed for EVs.
3. These findings were then used to assess the requirements of an EV optimized tyre with respect to noise on the one hand, and characteristics such as rolling resistance and wet grip on the other hand. It was concluded that these target conflicts are best solved by an approach which focuses on the tread pattern layout of the tyre. Compared to other measures like compound or construction, pattern changes can have a major impact on tyre/road noise both under free rolling and torque conditions while being mostly rolling resistance neutral. The impact of pattern changes on wet grip will be considered at each development stage. The suitability of this approach was shown by an initial set of measurements and simulations which focused on the tyre behaviour under different torque, load and inflation pressure conditions.
4. Based on all previous steps a requirement book for the holistic EV-noise optimized to be developed in action B7 was defined.
5. Finally, a strategy for the development of a tyre fulfilling this requirement book in action B7 was presented.

The requirements for the development of a holistic, noise optimized EV tyre in action B7 which have been derived in A3 Action are summarized in the following Table.

Property	Value	Comment
Tyre dimensions	205/55 R16	
Load index	91 SL / 94 XL	Corresponding to 615 kg / 670 kg
Speed symbol	H (max. speed 210 km/h)	Minimum requirement
Tyre load	400 kg	Based on median EV weight in Compact segment
Inflation pressure	Based on LI and tyre load.	In accordance with [16].
Vehicle/road inclination	Representative angle (-1.5° to -2.5°)	
Rolling conditions	Free and under torque	
Noise performance	Excellent exterior noise performance on an EV operating under urban driving conditions up to 50 km/h.	Special focus on performance on noise optimized road surface property to be developed in B1/B2. Good performance up to 80 km/h.
Rolling resistance	R117 compliant, Label class A	
Wet grip	R117 compliant Label class B	Class A if achievable
Other performances	R30 and R177 compliant	

Summary of the requirement book for the holistic development of a noise optimized EV tyre action B7

Action B1 - Track design

Foreseen start date: 1st October 2019 Actual start date: 1st September 2019
Foreseen end date: 31st March 2021 Actual end date: 31st March 2021 (31 January 2023, according to CINEA request to revise the Report)

B.1 aims at selecting mixtures (materials, and surface texture), for the tracks to be constructed in France and Italy, in order to minimize noise from EV, taking into account the synergy with actions B.2. This action i) benefits from actions A.1, A.2, A.3; ii) gives the instructions for B.2 prototype; iii) uses B.2 results; iv) gives the instructions for the pilot area in Florence (B.3). Consequently, it basically starts after the actions Ai and ends before B.3.
Regarding sub-action B1.1, data gathering was carried out. Based on data gathering (B1.1 - data gathering initially from A1, A2, and A3), in B1.2, two types of mixtures (with and without crumb rubber, nominal maximum size of about 6mm) were designed and partly validated through experiments. At the end of B1.2, UNIRC delivered the first internal report (July-August 2020), used by University of G. Eiffel, to construct the proving ground in Nantes, France. In B1.2 the first internal report was issued and delivered to EIFFEL.
Sub-action B1.3 refers to data gathering from UNI EIFFEL that refer to Nantes prototype (during and after B2). This phase in in progress and it is undergoing delays due to the pandemic.
Sub-action B1.4 refers to data gathering from IPOOL tests (during and after B2). This phase is in progress.
Sub-action B1.5 refers to the final design and support to track construction (during and after B2, and before B3). By means of B1.5, B3 is carried out and led by FI. As a part of B1.5 (Final design and support to track construction -during and after B2, and before B3), UNIRC started to draft the second internal report (B15 for B3), where it was expected to receive the pertaining information from the other partners including the ones that were supposed to test the proving ground in Nantes. To this end, due to the pandemic, delays occurred, but in the meanwhile, the exchange of information between UNIRC and FI, aiming at B3 construction, received a great impulse. In October-November 2020, the first draft of the second internal report was sent by UNIRC to FI, in order to start the bid process. The level of details was modified due to the fact that the tests from Nantes were delayed by the pandemic.
As a corrective action, the B1-to-B3 report (second internal report above) was drafted in more general terms.

Conclusion and results:
Based on A2 mixtures, based on tests carried out and under the assumption that in the pilot case traffic is low, temperatures are not too high, and bitumen has a satisfactory softening point (high), two mixtures were derived, namely mixture 1 and mixture 2.

- Mixture 1, close to the AC6 mixture selected in A2 with CR=0% with a 6.4% of bitumen (with respect to the total mix), with minor risks of bitumen excess.
- Mixture 2, with CR=1.9% with a 6.0% of bitumen (with respect to the total mix), with minor risks of bitumen excess.

Action B2 – Tyre-pavement coupling study and prototype implementation

Foreseen start date: 1st July 2019 Actual start date: 1st July 2019
Foreseen end date: 30th September 2021 Actual end date: 13th May 2022

Action B2 was focused on tyre/road interaction in the specific context of growing EV fleet. The main goal was to help in selecting the optimal combination of road surface and tyre in order to reduce noise in urban area, prior to the implementation of the pilot test section in Florence (Italy) within Action B3. Action B2 mainly consisted of gathering experimental data on the

reference test track of UNI EIFFEL in Nantes (France). Action B2 activities started at the very beginning of the LIFE E-VIA project in July 2019 and lasted up to the end of 2021. The final version of the deliverable was published in May 2022. Action B2 was piloted by UNI EIFFEL with contributions of UNIRC, CRD and IPOOL. It was composed of four sub-actions:

- B2.1 - *Acoustical characterisation of EVs on existing tracks* (UNI EIFFEL);
- B2.2 - *Construction of the B1-based prototype test section* (UNI EIFFEL, UNIRC);
- B2.3 - *Characterisation of the B1-based prototype test section* (UNI EIFFEL, IPOOL);
- B2.4 - *Selection of optimised EV tyres* (UNI EIFFEL, CRD).

Sub-action B2.1 started at the beginning of the project and consisted in the acoustical characterisation of a set of EVs on six different existing road surfaces of UNI EIFFEL reference test track in Nantes. Tests included source characterisation by means of a microphone array located on the roadside and standard CPB noise measurements at usual urban speeds. Different real driving conditions have been considered, i.e., constant speed, acceleration and deceleration conditions. As expected for EVs, at constant speed tyre/road noise dominates sound emission. At 50 km/h, the difference between the quietest and the loudest test sections varies from 4.8 dB(A) to 7.9 dB(A) depending on EV model. While deceleration tests in energy recovery mode leads to little difference with pass-by at constant speed, pass-by in full acceleration tests with EVs have shown a large noise increase, often exceeding 5 dB(A). This increase comes from the driving wheel area, involving both rolling noise under torque effect and motor noise contributions. It was also found that the ranking of road surfaces remains quite unchanged under acceleration. These results emphasise the stake of the road surface selection for reducing noise emission from EVs. The combination of sound absorption properties and low texture levels leads to the highest noise reduction. These results provide reference acoustical data for EVs in order to help in the mix design of the optimised road surface developed within Action B1. They also offer support data to action B6 dealing with the improvement of CNOSSOS-EU model for EVs.

Sub-action B2.2 was conducted from February to September 2020. This action was dedicated to the construction of a 57 m long by 8 m wide prototype of low-noise road surface on UNI EIFFEL reference test track. Based on the main outputs of action B1, two VTAC 0/6 test sections of the same grading curve were laid. They differ by the addition of 1.9 % of CR in one of the mixes. A call for tender was published in June 2020 and 4 companies were consulted by UNI EIFFEL. Only one company (Colas) applied for building the prototype and was selected. The construction of the prototype was performed in September 2020 without major difficulty, using classical laying procedure in road construction. The test section without CR was named P, while the other with CR was named PCR. The controls after construction have shown the conformity of the grading curve and of the bitumen content for both test sections. The evaluated thickness and air-void content were also compliant. The measured MTD was rather low on both test sections (average value of 0.51 mm for P and 0.42 mm for PCR). This sub-action made the prototype road surface available for extensive physical and acoustic characterisation. It provided feedback for action B1 and prior to full-scale construction of the low-noise test section in the pilot area in Florence (Italy) within action B3.

Sub-action B2.3 dealt with the characterisation of the prototype test section. It started after its construction in September 2020 and ended in June 2021. Regarding road surface properties influencing tyre/road noise, quite low MPD and surface texture levels were measured for both prototype test sections P and PCR. The sound absorption of both test sections is also weak, while their dynamic stiffness remains close to a conventional asphalt concrete. Regarding skid resistance, the ETD values confirm the low macro-texture of P and PCR, but the friction coefficient and its evolution with polishing of the road surface are very satisfactory. Pass-by

noise measurements with EVs show that P and PCR test sections are among the quietest road surfaces, with an average noise reduction around 4 dB(A) at 50 km/h, by comparison with a reference DAC 0/10 test section. CPX measurements confirm this good noise performance for the prototype test section, with a noise reduction around 3 dB(A) at 50 km/h for a standard commercial tyre. The noise reduction with the SRTT tyre (ISO 11891-3) amounts to 1.7 dB(A) for P and 2.4 dB(A) for PCR. Both prototype test sections meet the Core criterion of the European GPP for a low-noise pavement, fixing the CPX noise level at 50 km/h below 90 dB(A). This result complies with the objectives of the project. All in all, apart from the SRTT tyre, test section P without CR is on average 0.6 dB(A) quieter than test section PCR. The series of tests carried out provides a comprehensive assessment of the prototype for further LIFE E-VIA project activities.

Sub-action B2.4 focused on the acoustical characterisation of six different tyre versions, namely V1 to V6, developed by CRD within action B7. The dimension of the tyres was 205/55 R16 and the tyre versions mainly differed from each other by the tread pattern design. Pass-by noise measurements conforming regulation UNECE R51.03 were performed in autumn 2021. The tyres were fitted on two different vehicles, one EV and one ICEV. With these tyres, test section PCR turns out to be systematically around 0.5 dB(A) quieter than test section P. Taking tyre version V1 as a reference, the tyre version V2 is the quietest. The noise reduction may exceed 1.5 dB(A) with the EV under strong acceleration, but otherwise it does not exceed 1 dB(A) in the usual driving situations. Apart from tyre version V2, there was no major definite advantage observed for the other tested cases. Four tyre versions of the set were also tested by the CPX method on the prototype test sections and on further existing road surfaces. P and PCR are among the quietest road surfaces, with a noise reduction from the reference DAC 0/10 between -4.2 dB(A) and -5.8 dB(A). Test section PCR is generally quieter than P, with a difference up to 1.1 dB(A). The results of sub-action B2.4 are then used for the final optimisation of the EV tyre by CRD within action B7, prior to further testing on the pilot area in Florence.

Conclusion and results:

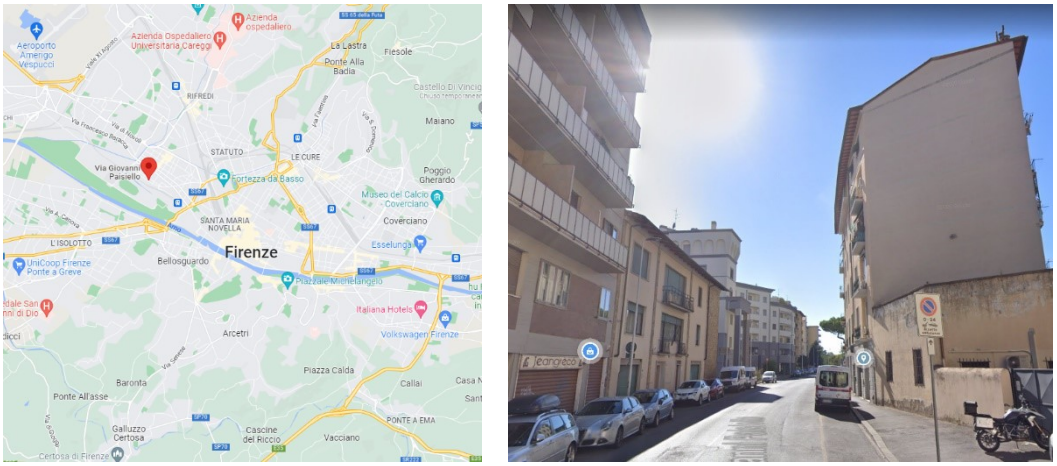
The results of the implementation action B2 agree with the foreseen action description. All the aspects mentioned in the project's proposal have been addressed with effective collaboration between the involved partners. Regarding time schedule, final report on action B2 was delivered about 6 months after the foreseen date (30/11/2021). This is due to several contextual difficulties. The first difficulty was the availability of the reference test track in Nantes and its coincidence with proper weather conditions for noise measurements. Then, some experimental campaigns were postponed later in 2020 due to the Covid-19 pandemic and shutdown of UNI EIFFEL campus during spring 2020. This also explains 2 months shift in the prototype construction which was initially planned in July 2020. The experimental campaign of sub-action B2.3 was also postponed due to unfavourable weather conditions and the second wave of the Covid-19 pandemic in autumn 2020, limiting the experimental activities, especially the coming of IPOOL in Nantes for CPX test on the prototype, finally done in June 2021. Nevertheless, all tests planned within action B2 have been achieved and have led to essential conclusions in due time for subsequent actions of the project.

Action B3 – Pilot area: Implementation

Foreseen start date: 1st April 2020 Actual start date: 1st April 2020
Foreseen end date: 31st January 2023 Actual end date: 31st January 2023

Action B3, leaded by FIRENZE, is of crucial importance because it refers to the interventions' implementation in the pilot area of the LIFE E-VIA project (Sub-Action B3.1) and it allows the subsequent fulfilment of Actions B4, B5, B6 and following ones.
Starting from summer 2020, a reflection about the appropriateness regarding the choose of the project pilot street has been made in order to evaluate if alternative pilot cases were possible. In fact, the Municipality of Florence wants to carry out the tests concerning the new pavement in an area as densely populated as possible where the intervention is feasible. As a consequence, it has been decided to change the pilot street from Michelucci to Paisiello street which is located in the central-west area of the city of Firenze and is a populated and busy street. Specific motivations which led to this decision, and which are mainly related to the suitable characteristics of Paisiello street with respect to Via Michelucci are reported hereinafter:

1) Two-way travel without significative curves
2) Significant population density of the area
3) Busy road due to traffic toward the city center
4) Close to public offices (Regional Agency for Environment Protection and Metropolitan)
5) Close to the most relevant park in Florence (Cascine)
6) Close to one of the most important interventions of urban requalification (ex Manifattura Tabacchi) with new dwellings, primary school, fashion school (University)



Paisiello street - source Google maps 2022

The intervention was included in the authority's planning for road maintenance for the year 2021. The design mix prepared by UNIRC (Action B1) and tested in Nantes by UNIEIFFEL (Action B2) was previously supplied to the company Endiasfaldi, a producer of bituminous conglomerates, which carried out tests and then produced the required mix.
The construction related procedures have been structured and timely planned according to the following:

- Preparation of technical documents: September 2020
- New mixture definition (technical minimum requirements actions B1 e B2). Included as specification in the tender documents: December 2020
- Tender and award notice published: March 2021
- Winner legal documents received: June 2021
- Implementation: mid July 2021

The work was then carried out between 12 and 16 July 2021 by the AVR company, which laid 150 linear metres of traditional asphalt and 150 linear metres of project asphalt.
Subsequently, on 16 July 2021, Laboratorio Sigma srl carried out core drilling tests to verify the correspondence between the laid asphalt (grain size, bitumen percentage, porosity, etc.) and the planned asphalt, obtaining excellent results both according to objective (Action B4, B5) and subjective (Action B5) measurements and evaluations.

Progress of work and final result

No delays have occurred for the current action. Reports on B3 Tender specification definition and about the implementation in the pilot area have been delivered with a minor delay by FIRENZE in collaboration with VIENROSE not entailing any delay in the timely implementation of the pilot case.

Pilot case has been definitively implemented according to the project proposal.

Action B4 - Track efficiency tests in the pilot area

Foreseen start date: 1st July 2020 Actual start date: 1st July 2020
Foreseen end date: 30th September 2022 Actual end date: 31st January 2023

Action B.4 "Track efficiency tests in the pilot area" aims to test the new road surfaces laid in Paisiello Street, Firenze, and to provide useful results to characterize the emission from Electrical Vehicles (EV). In order to achieve this result, the study has been divided into two sub-actions as follows:

Sub-action B4.1 – B1-road surface characterization
Acoustical performances are tested by IPOOL according to the Close Proximity method CPX, ISO 11819-2, the Impedance Tube method (IT), ISO 13472-2 and the Extended Surface method (ES), ISO13472-1.

Road surface properties are evaluated By UNI EIFFEL using a 3D texture scanning technique (3DTX), providing the Mean Profile Depth (MPD) and the one third-octave band texture spectra according to ISO standards 13473-1 and 13473-4. The mechanical properties of the layings are monitored by UNI EIFFEL with the parameter of dynamic stiffness thanks to a mechanical impedance measurement (MI).

Sub-action B4.2 – Acoustical characterization of EVs
EVs emission are acoustically characterized by IPOOL according to the standard Controlled Pass By CPB performed at typical urban speed and directly in the urban environment. While an SPB measurement should be preferable, EVs are still at the time of the project not diffused enough in the circulating car fleet to allow it. Therefore, a fleet composed of very common brands and models of EVs, such as, Nissan Leaf, Hyundai Ioniq, Tesla Model 3, and a Nissan NV200 is studied. Additionally, two set of designed tyres, tested previously by Continental, were measured using the same model of vehicle (Nissan Leaf). The obtained data is then analysed and used as input for Action B6. The measurements are carried on for a year after the laying of the pavements, repeating tests according to Table 1 in order to provide not only a characterization of the Pilot Area, but also to study ageing effects from a holistic acoustical approach. Every test reported was conducted at by night-time after closure of the street to traffic.

Measurement sessions and testing performed

Meas. Session	Test performed
1 - October 2021	TX, MI, IT, ES, CPX, CPB
2 - February 2022	IT, ES, CPX, CPB
3 - July 2022	IT, ES, CPX, CPB
4 - October 2022	IT, ES, CPX, CPB

Non-Acoustical tests
Both the 3D surface texture and the mechanical impedance measurements were carried out during the first session in October 2021 by UNI EIFFEL. Two areas were chosen, in Paisiello Street intersections, one for the Reference R and another for the E-VIA PCR pavements, also used for the CPB method measurement positions.
The 3D texture was characterized using the system described in E-VIA Report of Action B2. For both tested sections, four successive scans were measured in the wheel path of the acoustical

test vehicles on the side of the CPB measurement microphone position, centred on its longitudinal position.
The data allowed the extraction of the Mean Profile Depth (MPD) and the one third-octave band texture spectra. The MPD values of P and PCR amount respectively to 0.42 mm and 0.60 mm, while they were respectively 0.30 mm and 0.39 mm within action B2.
The measurement principle of the dynamic stiffness is described in E-VIA Report of Action B2 and is performed with an impact hammer delivering an input force, an impedance head measuring the direct force and the direct acceleration at the impact location and an accelerometer measuring the transfer acceleration at a certain distance from the impact point. Five different spots were tested, located in the middle of the test section, centred around the CPB microphone position for the test section and spaced by 2 meters.

Acoustical absorption tests
Impedance tube and Extended Surface methods were used to obtain the acoustical absorption of the pavement. The two techniques allow to evaluate different sound field geometry conditions, as the tube uses a plane wave centered on a small spot and the other system uses a spherical wave and samples a circular surface with a radius of approximately 1.3 m. Both systems were used to sample the two pavements in three points along one of the wheel paths and the center of the lane, thus providing knowledge on the laying homogeneity and the behaviour of its different parts in term of asphalt wear.
The Extended Surface allows for a wider frequency range than the Impedance tube, with results for third octave bands ranging from 250 Hz to 4 kHz for the former and from 200 Hz to 1800 Hz for the latter. Nevertheless, on the overlapping range the two instruments showed similar absorption values, in the range of 0.1 to 0.25 for both pavements. The E-VIA one presented initially a slightly higher absorption value, perhaps due to its higher porosity. Both pavements showed degradation on this parameter, reaching a similar value around 0.05 in the tube's frequency range.

Acoustical emission tests
CPX and CPB measurements were performed to evaluate the pavement and the wheel-surface interaction as a noise source. The CPX technique allows the evaluation of the noise produced near the contact zone between the wheel and the pavement, with a continuous acquisition that is analysed to provide a level indication for discrete sections along all the road tracts. The CPB on the contrary is a fixed-point evaluation, with microphones placed 7.5 m from the center of the lane over which the measured vehicle travelled by. With this method is then possible to evaluate the emission of the road as a linear source. A prediction of the expected L_{CPX} and its ageing under the Pilot Area conditions was calculated from the mixture project properties in the case of the new crumb rubber pavement that was laid in the test tracks in Nantes. This evaluation provided a good approximation of what was then measured in Paisiello Street.

CPX requirements are described in the GPP standard, establishing a reference for future public tenders when a low noise emission pavement is necessary: achieving an L_{CPX} below 90 dB(A) at 50 km/h at the laying guarantees the objective. Both the Reference P and the E-VIA PCR pavements reached the goal, respectively with L_{CPX} values of 89.8 dB(A) and 87.6 dB(A). The stricter limit of 87 dB(A) could not be fully reached by the E-VIA pavement, but it must be pointed out that it lays in the confidence interval of the measurement.

CPB measurements, requiring essentially an obstacle free environment around the measuring points, posed a challenge for the tests in the urban environment. The presence of road bumpers, used to reduce travelling speed and providing a safer crossing for pedestrians, was a major

problem in both the execution of the measurements and their analysis. A new data elaboration technique was then developed to allow the evaluation of the acoustical emissions from the passages, avoiding unwanted contributions other than the vehicle. Results were then used as an input for Action B6.

Action B5 - Soundscape analysis

Foreseen start date: 1st November 2019 Actual start date: 1st February 2020
Foreseen end date: 31st January 2022 Actual end date: 31st December 2022

The action is split into 3 sub-actions that were performed by VIENROSE.

Sub-action B5.1 - Soundwalks and interviews in the pilot area (VIENROSE)

The following activities were carried out in the frame of sub-action B5.1:

(i) soundwalks with five listening points, with the aim of assessing the participants' perception of environmental noise;

(ii) binaural listening of four audio recordings to assess the perceived soundscape inside a vehicle.

An ad hoc questionnaire was developed for the participants to fill in during the experiences. The soundwalks were organized in the area surrounding the project pilot street and were carried out after the project intervention (Action B3), from April to November 2022 and involved a total of 80 participants.

Soundwalks itinerary (5 listening points)

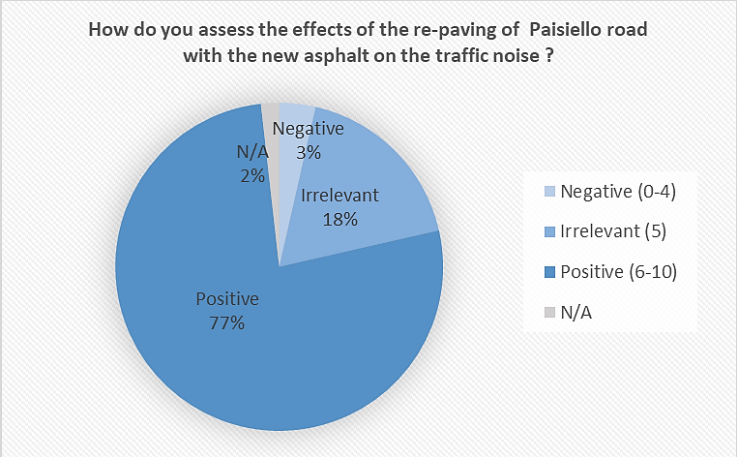
The analysis of data collected through the survey shows that the listening point of the soundwalk's itinerary located on the sidewalk of the section repaved with the optimized asphalt (n.2) is considered slightly better in terms of soundscape quality and traffic noise pollution than the one located at the section of the street with repaved with a standard asphalt.
In addition, four different binaural recordings were carried out inside an ICEV or an EV while driving on specific stretches of the pilot road with different asphalt (old, normal, optimized). Participants were asked to listen these recordings with binaural headphones and answer to specific section of the questionnaire.

Listening sessions were organized right after each soundwalks experience with the same sample 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.

Binaural recordings and listening sessions

Sub action B5.2 - Interview in the pilot road on an electric vehicle "taxi" (VIENROSE)
Interviews on an electric taxi (a Nissan Leaf rent to carry out the experience) were organized to assess participants (a total of 80 subjects) perception of the soundscape while passing, as taxi passengers, through the following sections of the pilot area: 1) section with optimized asphalt, 2) with new but standard asphalt, 3) with worn asphalt. 70% of the interviewed subjects indicated the optimized asphalt as the one with the best performance in terms of acoustic comfort.

Sub-action B5.3 - Ante and post-operam interviews with residents (VIENROSE)
As regards Sub-action B5.3 it was foreseen to carry out an interview campaign with a semi-random sample of at least 100 people to be identified on electric bus lines whose route involved the passage on different types of asphalt (old, normal, optimized). In the new pilot street, selected after the approval of the proposal, no bus lines are present; consequently, the typology of survey foreseen for the original pilot case was modified. In particular, instead of carrying out the survey on electric busses, ante and post-operam questionnaires have been designed and submitted to residents of Paisiello street to evaluate soundscape perception before and after the intervention.
The total number of ante-operam *questionnaires distributed between the* 7th and the 9th of July 2021 was 92 of which 56 were returned and analysed. 101 post-operam questionnaires were delivered between the 15th and the 17th of September 2021 of which 56 were returned and analysed. A quantitative analysis of collected data was performed encompassing a descriptive statistical analysis and the application of the Pearson's Chi-squared test. Results shows that after the realization of the interventions: i) the intensity of traffic noise has decreased; ii) the quality of the soundscape has improved; iii) the appropriateness of the soundscape with the urban context has improved. Also, a significant majority of respondents (77%) positively assessed the effects of the re-paving with the optimized asphalt.



Assessment by residents of the intervention effects

The deliverable Action B5 - Report on Soundscape analysis due on 4/2022, was concluded on 15/12/2022. The conclusion of the action was delayed mainly because of the COVID pandemic, for precautionary reasons we decided to postpone the organization of soundscapes walks to April-September 2022 instead of concluding them by January 2022. This delay did not affect the progress of the other project activities.

Although not foreseen in the original project proposal, in order to obtain an objective basis for the citizens evaluation at a façade level, a long-term ante and post-noise monitoring campaign has been carried out. Moreover, a long-term noise monitoring campaign has been carried out after about 16 months from the asphalt laying. Two monitoring positions have been defined: one in the road section interested by the optimized asphalt (150 m) and the other in the road section interested by a new standard asphalt (150 m). The ante-operam campaign was carried out by VIENROSE from June 23rd to July 1st 2021. The first post-operam campaign was carried out by IPOOL from 17th to 28th September 2021, and the second one was performed by IPOOL from 21st to 30th November 2022.

	LIFE E-VIA Asphalt	New but standard asphalt
	Lnight	Lnight
Leq (ante-post)	4,4	1,5
Leq (post-post_long term)	2,9	0,3

Results of monitoring campaigns

The results show a significative noise level reduction immediately after the laying and especially in terms of Lnight with the LIFE E-VIA asphalt, although slightly lower than expected, while the benefit reduction in the long-term is in line with the sector-specific literature. Results obtained for the traditional asphalt show its reduced performances from the acoustic point of view with respect to the LIFE E-VIA one.

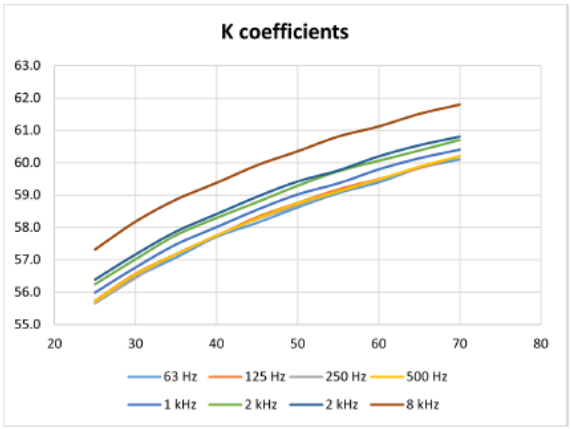
Action B6 - Evaluation of EV noise emissions

Foreseen start date: 1st July 2020 Actual start date: 1st July 2020
Foreseen end date: 30th September 2022 Actual end date: 31st January 2023

The work carried out in action B6 used as input the measurements taken in B4 action in the pilot area, located in Paisiello street in Florence. Such measurements concern the assessment trough CPB method of the electric vehicles acoustic emission using four different vehicles (Nissan Leaf, Nissan NV200, Hyundai Ioniq e Tesla Model 3) with different tyres in two different kind of pavements, the first of which have been considered as reference pavement (RP), instead the second is made by Crumb Rubber (CR pavement) and has been used for the assessment of the contribution due to the deviation from the standard conditions.
Results obtained in the different sub-actions are reported:

1) In Sub-Action B6.1 the SEL (total energy of the passage event), SEL_{speed} (the energy integration within a temporal window adjusted by the time the vehicle travels a segment of the road) and L_{max} are calculated from the acquisition of in situ pressure levels.

2) Sub-action B6.2 deals with the guidelines for the CNOSSOS coefficients estimation to use for calculating the sound power emitted from an electric vehicle under standard conditions. In particular, the K coefficient has been calculated in function of the speed in the 63 Hz-8kHz frequency range as the difference between the sound emission power of a vehicle ($LWR, i, m = A_{R,i,m} + B_{R,i,m} * \log(\frac{V_m}{V_{ref}}) + \Delta LW_{R,i,m}$), calculated according to the UE Directive 996/2015 and the equivalent sound pressure level (Leq) at the measuring point corresponding to the passage of an hourly vehicle, obtained by software simulation using the SoundPlan 8.2 software.



K coefficients for CNOSSOS coefficients estimation

For the calculation of the coefficients *AR,I* and *BR,i* regarding electric vehicles, the hourly levels corresponding to the passing of an electric vehicle have been estimated with two different processes, the sought after coefficients will be then calculated by minimizing the difference the differences between the two processes. The first process is executed starting from the K coefficient calculated in Sub-Action B6.1 and from 1, while the second consists in the direct analysis of the measurements taken in situ.

3) Sub-action B6.3 is concerned with the estimation of CNOSSOS coefficients to use for calculating the variation in sound power emission due to different pavements.
Difference between Reference Pavement and Crumbed Rubber Pavement calculated from

measurement coefficients fit is reported in the following table.

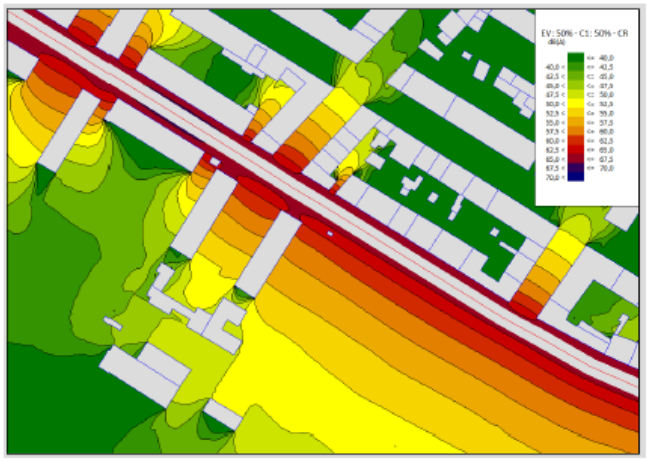
CNOSSOS Coefficients	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	Broad Band
25	-1.9	-2.0	-1.2	0.1	1.1	1.3	0	-1.2	-0.6
30	-2.0	-2.1	-1.3	0.1	1.1	1.2	-0.1	-1.3	-0.6
35	-2.0	-2.1	-1.3	0	1.0	1.2	-0.2	-1.4	-0.7
40	-2.1	-2.2	-1.4	-0.1	0.9	1.1	-0.2	-1.4	-0.8
45	-2.1	-2.3	-1.4	-0.1	0.9	1.1	-0.3	-1.5	-0.8
50	-2.2	-2.3	-1.5	-0.2	0.8	1.0	-0.3	-1.5	-0.9
55	-2.2	-2.3	-1.5	-0.2	0.8	1.0	-0.4	-1.6	-0.9
60	-2.3	-2.4	-1.6	-0.2	0.8	1.0	-0.4	-1.6	-0.9
65	-2.3	-2.4	-1.6	-0.3	0.7	0.9	-0.4	-1.6	1.0
70	-2.3	-2.4	-1.6	-0.3	0.7	0.9	-0.5	-1.7	1.0

CNOSSOS coefficients

4) Sub -actions B6.4 shows the results of the modelling of electric vehicles in various scenarios with different percentages of electric vehicles flow, starting from the coefficients calculated in B6.2 and B6.3.
The simulations carried out in the test area have been made available in tabular and graphic form, in which several scenarios have been made, to hypothesize what could be the impact on urban roads due to progressive increase in electric mobility compared to traditional.

ID scenario	Vehicles per hour	% ICEVs	% Evs	Pavement
1	500	100%	0%	Reference
2	500	50%	50%	Reference
3	500	0%	100%	Reference
4	500	100%	0%	Crumbed Rubber
5	500	50%	50%	Crumbed Rubber
6	500	0%	100%	Crumbed Rubber

Scenarios considered in simulation



Example of scenario (Scenario n. 5, CR pavement, 50% electric vehicles)

Action B7 - Holistic performances of tyres

Foreseen start date: 1st July 2019	Actual start date: 1st October 2019
Foreseen end date: 31st January 2023	Actual end date: 31st January 2023

B7 was carried out by CRD with additional support from UNI-EIFFEL. The late start of the action was related to the project start during summer vacation season and a focus on general project administration and action A3 in the early months of the project. Related to the Covid-19 pandemic some delay was encountered in the 2020 activities. However, this delay could be made up and the action was finished as planned. Besides depending on input from action preparatory A3 at early stages of the B7, at later stages also measurement data from B2 and B3 which was obtained by UNI EIFFEL and IPOOL was used in the action.

The objective of action B7 was the development of a holistic low-noise optimised tyre for EVs operating in cities. To account for special characteristics of EVs, the noise optimisation not only considered pass-bys at constant speed. A particular focus was also laid on improving exterior noise under torque. While good pass-by noise performance should especially be achieved on the two LIFE E-VIA road surfaces, the development aimed at achieving a robust performance on different road surfaces and under different operating conditions.

At the same time, for a safe, ecological and economical driving every tyre must fulfil several other requirements besides exterior noise. Performances such as wet grip, rolling resistance, and wear affect safety, fuel efficiency (i.e. attainable mileage for EVs) and the environmental impact of the tyre. Some of these characteristics are also directly linked to the customer acceptance of the final product. Many of the required performances are linked by the physical and chemical properties of the tyre such as construction, rubber compound, contour or tread pattern. Because of this, these performances cannot be seen isolated, indeed there are many target conflicts where an improvement in one area will lead to a decreased performance in another area. Because of this a holistic tyre development approach was used which accounts for all required performances simultaneously.

The development process used CRD's extensive internal know-how in tyre development. It followed the company's well-established tyre development processes involving extensive state-of-the-art simulations to minimize development costs. Based on the outcome of action A3, the Continental EcoContact 6 205/55 R16 91V was chosen as reference tyre. It is representative for a premium brand summer tyre for the European market with focus on economical, ecological and safe driving. With already good noise, fuel efficiency and wet grip performance this tyre sets high targets for the development of the LIFE E-VIA tyre. Based on a target conflict analysis focusing on the interaction between exterior noise and other requirements, most importantly wet grip, it was concluded that a realistic goal for the achievable pass-by tyre noise reduction would be between 0.5 dB(A) and 1.5 dB(A).

In an iterative development process consisting of three development loops, one of which was purely virtual, existing, validated technologies were combined in a smart and novel way to develop the holistic noise optimized EV tyre. Besides by extensive simulations, the performance of the tyre was evaluated by a large number of measurements. Indoor drum noise with and without torque and on different road surfaces were carried out in CRD's NVH laboratories. Constant speed and accelerated pass-bys were carried out on different road surfaces at CRD's test track, UNI EIFFEL's test track in Nantes (linked to action B2), and by IPOOL at the site of the LIFE E-VIA repaving activities in Florence (action B3). Finally, rolling resistance and wet grip performance was evaluated at CRD's R&D facilities following the requirements of the EU tyre label Regulation EC 1222/2009.

Depending on road surface, under urban conditions a constant speed pass-by noise reduction of up to 0.3 dB(A) to 0.8 dB(A) was observed for the final tyre. Under torque conditions this increases a to 1.0 dB(A) reduction. For the L_{urban} metric which combines the effect of constant

and accelerated driving under urban conditions the previous results combine to give a reduction of 0.8 dB(A). During the noise tests, the robustness of the provided noise optimisations was proven by relatively consistent noise reductions on a variety of road surfaces, at a different number of speeds, and using several different test vehicles. Especially good results were obtained with the LIFE E-VIA noise optimised road surfaces with and without crumb rubber, highlighting the combined efficiency of the LIFE E-VIA solutions. These results align very well with the noise reductions which were expected from the action.

The very good noise performance of the LIFE E-VIA tyre was combined with a very balanced and competitive portfolio of non-noise related performances. For the most important criteria the already very good performance levels of the reference tyre could be maintained, if not slightly improved. Especially, there was no negative impact on rolling resistance and wet grip performance, and even an expected increase in milage, which highlights the ecological, economical and safe design of the final tyre. In view of this, the final LIFE E-VIA tyre can be declared a successful implementation of a sustainable, holistic low noise optimized EV tyre for urban applications, thus fulfilling the planned outcome of the action.

Assessing the importance of the new insights which were gained during the tyre development the focus should mostly not be on the technical side. As stated previously, the development did not develop new technical solutions, instead existing, validated technologies were combined in smart and novel ways. The long-term value of action B7 in this regard is related to the know-how and new processes which were created to optimise noise in a holistic way for EV applications. For another application, e.g. an all-season tyre, none of the technical solutions used here might be usable due to, for example, safety requirements related to driving on ice and snow. However, the knowledge and development processes used in action B7 will highly likely still be of use in such a situation.

Moreover, a fundamental gain in knowledge was achieved from a series of investigations on the influence of measurement conditions on accelerated pass-bys. As already stated, noise under acceleration is more important for EVs, especially in urban environments. However, while controlled pass-by (CPB) measurements at constant speed have been used for decades, and thus are well understood, the procedures for accelerated pass-by measurements are still quite new. This means that there is limited knowledge on how these types of measurements are affected by variations in test conditions, test vehicle, etc. To close this gap at least partially, action B7 also looked at how accelerated pass-by tests are affected by the conditions which are prevailing when the test is conducted.

Firstly, it was found that it is not possible to consider tyre and vehicle independent of each other. Quite contrary, they need to be considered as one combined system for accelerated pass-by measurement purposes. Secondly, the sound pressure level change in comparison to free rolling depends to a large extent on environmental conditions, in particular the air temperature, and the road surface. Extending the type of accelerated measurement to include indoor drum tests with torque, it was also observed that not only can relative differences between, but also the ranking of, tyres change, when comparing indoor versus outdoor measurement results.

As the noise optimisation part of the tyre development is still highly dependent on both indoor and outdoor measurements these are highly relevant findings. One the one hand, within the development process it needs to be assured that the right type of testing under the right conditions is used to assure that results from accelerated noise tests are both relevant to the development goals, and comparable between different development loops (e.g. assuring that the same test vehicles are used). On the other hand, the large influence of operating conditions on the sound pressure level (SPL) under torque is not limited to testing only. The same variations will be observed under real life driving. Thus, the development process needs to guarantee that a robust reduction of tyre/road noise can be achieved under the diverse traffic and operating conditions which are encountered for driving in urban environments.

Action B8 – Replicability and Transferability

Foreseen start date: 01st July 2020	Actual start date: 01st July 2020
Foreseen end date: 31st December 2020	Actual end date: 31st January 2023

The LIFE E-VIA project has a high perspective of sustainability. Specifically, each partner took on specific tasks based on its own configuration and existing and potentially expandable contact networks. Results obtained for each aspect are reported.

RT1) LOW-NOISE SURFACES

As part of the ordinary road maintenance programs, asphalts of the same type as those tested in the LIFE E-VIA project will be used to repave infrastructures with similar characteristics to those of Paisiello street. These works, planned for the year 2022, have been postponed to 2023 due to urgent work on the rehabilitation of underground utilities. More than 25000 m^2 of asphalt with technical characteristics analogous to those of the E-VIA project will be laid in Florence in 2023. Official documentation has been provided proving the founding allocation.

Moreover, a spin off was proposed at the department DIIES of UNIRC. The extract of the Department Council Minutes No. 103 of 20/7/2021has been provided.

RT2) FESTIVALS AND EVENTS REPLICATION

The LIFE E-VIA PROJECT has been presented in the Eurocities Environment Forum of Oslo 23-25 October 2019 (21 cities participating) by FIRENZE and VIENROSE.

RT3) FOLLOW UP MARKET ORIENTED

A market analysis has been made by UNIRC, considering asphalt/road market according to asphalt components (e.g., bitumen, aggregates, and additives), asphalt plants, crumb rubber and tyres, road works firms and vehicle brands.

The novelty for tyres achieved in the project is in the target-oriented integration of existing technologies which was used to achieve the desired noise and target conflict performances. One enabler for this smart integration was the additional know-how which was gained on how to incorporate accelerated pass-by noise testing into the tyre development process in the best way. The other enabler was the adaption of development processes to the special requirements of the holistic noise optimised EV tyre. In action B8 scenarios for the exploitation of both of these two enablers for tyre development processes were evaluated by CRD.

For the accelerated pass-by noise testing it was concluded that a significant business risk is created from the additional measurement uncertainties which are introduced by the accelerated pass-by noise testing. It was concluded that testing conditions, especially in terms of used test vehicle and meteorological conditions, need to be tightly controlled to minimise the risk of failing target approvals due to test variations. In view of this a particular focus was laid on the measures and best-practises which are needed to minimise the impact of test variations. With respect to adaptations of the tyre development process the first point which was investigated for the exploitation concept was how to properly account for accelerated pass-by noise during the tyre development design, simulation and test phases. It was shown that a robust and efficient noise prediction during the development process is possible by simple adaptations to existing hybrid prediction tools. It was also investigated what would be needed to assure coherent test results throughout a multi-year development project.

Moreover, two separate Close-to-market questionnaires, one on the new asphalt developed by partner UNIRC and one on the tyres optimized by CRD coordinated by FIRENZE and VIENROSE, were filled. In each questionnaire, indications were given about the innovation of the developed products, maturity and competition of the market, assessment.

RT4) CNOSSOS IMPROVED DATA BASE FOR STRATEGIC NOISE MAPPING

The database of CNOSSOS coefficients for EVs has been implemented by IPOOL. The coefficients were processed and tested on Paisiello street and will be used in the action plans, as the switch to electric vehicles will certainly be used in the action plans of several managers of public transport, particularly in agglomerations.

RT5) 3 PROJECT-BASED ACTION PLANS

Life E-VIA asphalt was proposed by VIENROSE in the Noise action plan of the Comune of Inzago (MI) and has already been laid and tested in three road sections and as a standard reference for the Piano Triennale di Bonifica dell'inquinamento acustico of Regione Lombardia.

RT6) CR-BASED PAVEMENTS

In the context the LIFE SNEAK project in which FIRENZE, UNIRC and VIENROSE are partners, optimised asphalts are being tested in urban areas where the presence of vibrations is relevant. Three dissemination events are planned within the LIFE SNEAK during which Ecopneus (partner) will also promote the results of the E-VIA project, in which the optimised asphalt laid in the pilot area contained a part of recycled rubber powder.

The Deliverable concerning the "B8 Report containing Replicability and Transferability plan" has been delivered by the end of the project. It also contains an Annex on the Exploitation & business plan delivered by UNIRC. The Deliverable "B8 Technology exploitation plan for the transfer of EV tire noise optimization technology into the market by CRD" has been delivered by the end of the project as well.

Action C1 – Monitoring of the impact of the project actions

Foreseen start date: 1st July 2019 Actual start date: 1st July 2019
Foreseen end date: 31st January 2023 Actual end date: 31st January 2023

Action C1 is strictly related to the definition and monitoring of the environmental performance indicators and of the Key project Indicators (KPI). It is managed by FIRENZE with contributions from all partners.
Regarding the environmental performance indicators, after initial adjustments the validity of the categories and targets defined in the project proposal has been confirmed. The monitoring of indicators has been regularly carried out, periodically asking responsible partners about indicators' values updating in correspondence to specific monitoring periods.
Concerning the KPI, several email communications and also some videoconferences have taken place between the Project monitor, FIRENZE and VIENROSE (supporting partner) in order to define the indicators and validate them. KPIs have finally been updated on the dedicated webtool, while finalized project indicators are reported below.

Indicator name	Parameter	Expected value at the project end	Actual value at the project end	Motivations
Reduction of greenhouse gas emissions (GHG)	CO_2 [t/y]	29	3	For greenhouse gas emission, it is noted that, for example, over the years 2019-2022, the increase of the number electric vehicles in Italy has followed a quite unsatisfactory trend. This is the main reason of the deviation.
Air quality and emissions	PM reduction [g/y]	4000	400	The evaluated results illustrate that the reduction of PM due to decrease in the use of diesel cars is just at the beginning of a cycle. Over the last years the decrease in the number of diesel cars has been unsatisfactory and lower than predicted. This is the main reason of the deviation.
Waste management	Tyres [t/y] Landfill saved [m^3]	2.4 200	0.2 15	The addition of high quantities of crumb rubber, CR, to the mixture was not possible to the negative consequences in terms of swelling and increase of the viscosity of the asphalt binder. This explains the reduction in terms of both tons per year and in terms of cubic meters of landfills saved.
Reduced resource consumption	Mineral aggregates [t/y]	0.1	0.04	Even if multiple interventions are scheduled, the reduction in the use of crumb rubber as an additive in the bituminous mixture has caused the consequent reduction in the figure that refers to the "reduced resource consumption".

Communication, dissemination, awareness raising	Entities/individuals made aware [n.] Website visits [n.] People changing behaviour [n.]	20000 70000 2000	150000 12576 100	Value related to people made aware has been obtained considering 80 visitors to the LIFE E-VIA stand at Expomove, 100 students involved in awareness lessons addressing also the project, 200 residents of via Paisiello who received informative letters about the project and the survey initiative, and the 1% of followers of 31 webpages/websites* which published news about the project, 80 participants to the soundwalks who have been informed about the project, 70 (online and in presence) participants to the final event, participants to congresses where the project has been presented. Calculation of website visits has been made in the frame of Action C1 by VIENROSE, by monitoring website statistics made available by Google Analytics. The number of people changing behaviour has been estimated considering that about 200 residents of Paisiello street have been informed about the project and the potentialities of EV. Added to these are all those who have attended presentations about the project and participated in events organized by it whose awareness of electric vehicles has been stimulated.
Noise performance indicators	Lden/Lnight [dBA] L_{CPX} [dBA] People positively affected [n.]	-5 <90 2000	-1.4/-4.4 87 ± 1.5 2000	Values for Lden, Lnight and CPX have been obtained according to measurements carried out in Actions B4 and B5. Number of people positively affected (e.g. residents) has been confirmed also in view of the pilot street change.
Soundscape improvement	Perception improvement of a noise-optimised asphalt with respect to a traditional one [%] Perception and comfort improvement of an EV with respect to a ICEV [%]	50 50	50 50	These targets have been achieved according to questionnaires submitted and analysed in the frame of Action B5.
Noise-related health effects reduction	% HSD % RR hypertension % RR myocardial infarction	From 21 to 15 From 2,1 to 1,9 14	From 8,3 to 6 Reduction of 9% From 1,00433	HSD reduction has been obtained according to the Position paper on dose-effect relationships for night-time noise. http://ec.europa.eu/environment/noise/pdf/positionpaper.pdf RR hypertension has been estimated according to the study "Cardiovascular effects of environmental noise: research in Sweden" by Bluhm, G. and Eriksson, C. https://pubmed.ncbi.nlm.nih.gov/21537104/, considering a reduction of about 1.4 dB(A) Lden.

	% HA	25	to 1,00048 From 10,7 to 9,4	The Exposure-response function for myocardial infarction made available by EAA Technical report No 11/2020 has been used. For HA the Position paper on dose response relationships between transportation noise and annoyance http://ec.europa.eu/environment/noise/pdf/noise_ expert_network.pdf (accessed January 2007) has been used.

With regard to both environmental performance indicators and KPI, a specific and additional contribution, with respect to what was foreseen in the project proposal, was provided by VIENROSE partner. In fact, on a trimester basis a Report on website design and statistics on visits is prepared and uploaded on the project website (https://life-evia.eu/documents/). The Report is structured in the following sections: after a fixed paragraph about the specific of the project website, its architecture and managing procedures, the periodic (trimestral) website statistics are reported since September 2019 to 31st January 2023 according to data provided by the Google analytics application, after the creation of a dedicated email address linked to the Project's website.
Report on Action C1 has been delivered by 31st January 2023.

In conclusion:
- Life environmental performance indicators have been regularly monitored
- KPI webtool have been filled and constantly updated
- Report on statistics about website visits has been regularly provided on a trimester basis
- Report on Action C1 (Del. 31) has been delivered

Action C2 – Life cycle analysis (LCA) and life cycle costing (LCC)

Foreseen start date: 1st July 2019 Actual start date: 1st July 2019
Foreseen end date: 31st December 2022 Actual end date: 31st January 2023

In the context of action C2 (C.2: Life cycle analysis (LCA) and life cycle costing (LCC) - For LCA, several papers were published. The internal costs and external costs were considered, as well as the durability of acoustic performance. The main scenarios considered were as follows: Scenario 1. Via Paisiello road with texture-optimised pavement. 2. Scenario close to via Paisiello with traditional friction course, without crumb rubber. When analysing the scenarios above the data provided by tests and analyses were asked, including B4, B5, B6, and C1. By referring to the replication plan, which implies consequences to LCA/LCC-related items, these consequences were considered.
For indicators, traditional (e.g., Global Energy Requirement, GER, in terms of Mj/m2 and Carbon Footprint, CF, in terms of $gCO_2eq/m2$) were considered together with more specific ones (e.g., DALY). The main results were discussed, pointing out the main consequences in terms of construction, maintenance and rehabilitation, as well as circular economy, where waste reduction is addressed. Specifically:

1) In the LIFE E-VIA scenario, the **total emissions of GWP** generated from cradle to gate are about 7.6 kg $CO2_{eq}/m^2$. The most impactful stage is "production". This step accounts for about 85% of the total GWP. 13.5% of emissions are generated during the transportation phase and only 1.5% is linked to construction activities while in the REFERENCE scenario GWP is marginally lower than 7.6 kg $CO2_{eq}/m^2$ and the impact of the different phases is approximately the same as the LIFE E-VIA scenario (84.5% production phase, 14% transportation phase, and 1.5% construction stage). The comparison between the scenarios shows that the LIFE E-VIA solution allows recording a 4% increase in GWP, when compared with the traditional friction course.
2) Also in terms of **energy consumption**, the production stage is the most impactful. Obtained results show higher values for the LIFE E-VIA scenario. This is due to the fact that the production phase and the transportation stage in the LIFE E-VIA scenario include an additional process which is the crumb rubber production/transportation to the mixing plant. In particular, the energy associated with the production of RARX is about 17 MJ/m^2, this value was estimated on the basis of the energy required for the production of 1 ton of RARX.
3) To quantify the **human health impacts** the reference unit is the DALYs (Disability-adjusted life years). This unit is recommended by the WHO (World Health Organization) and is defined as the "loss of the equivalent of one year of full health. DALYs for a disease or health condition are the sum of the years of life lost due to premature mortality and the years lived with a disability due to prevalent cases of the disease or health condition in a population". In the LIFE E-VIA the calculation was limited to the YLDs (years lived with a disability) and the assessment of the impacts of road traffic noise was carried out as suggested by Piao et al.. In the first year of use of the LIFE E-VIA friction course, human health impacts of noise assessment are estimated to be 0.248 DALY, which means about 90 life days less in the year. For the REFERENCE scenario, HI is 0.3 DALY which means about 119 life days less in a year (assuming the same noise-impacted area close to the case study street). These results suggest that the LIFE E-VIA reduced the DALY by 33%.

The economic benefits deriving from adopting the new asphalt solution build on many aspects, including the following:

- a higher expected life of the pavement (+15%), which implies a lower impact on user cost, and air pollution related to maintenance and rehabilitation. Overall this implies light economic benefits (0.01€/sm/year), despite the higher initial cost (with respect to common asphalt technologies).
- Economic benefits for the dwellers living close to the road (health-related and property-related). This corresponds to an appreciable economic benefit (0.55 euros per square meter of pavement per year of life). These economic benefits involve a number of important factors including benefits in terms of house cost and health-related benefits.

In other terms, dweller life is better (which corresponds to an important benefit and positively affects citizen perception), while the same municipality does not undergo any increases in budget per year.

In terms of business opportunities with new technology, thanks to Via Paisiello implementation and thanks to the expected replications also in other regions, it is envisaged that the diffusion of this new technology will promote new industries related to the production of treated crumb rubber. Indeed, modifying the crumb rubber prior to its introduction into the mixture can benefit the mixture's volumetric properties and the mechanistic ones. This explains why in some European countries (e.g., Spain) there are industries that treat crumb rubber for pavement applications. Already during the project, many firms expressed interest towards this pavement technology and further replications are expected also outside Tuscany. Setting up and improving the supply chain from end-of-life tyres to recycling appear strategies that are better than discarding tyres into landfills or stockpiles (legally forbidden, but still common) or recovering a somehow little part of tyre energy by burning the tyres (e.g., about 15% of the energy spent is recovered, cf. also Valentini and Pegoretti, 2022, https://doi.org/10.1016/j.aiepr.2022.08.006). These factors are now perceived by people as well as the corresponding economic opportunities are noted. This refers to the process that allows deriving crumb rubber (as well as other components) from end-of-life tyres. This process involves initial investments but many economic entrepreneurs are interested to develop industries because of the final cost of the treated crumb rubber. Indeed, at the moment, treated crumb rubber cost is similar to the cost of asphalt binder (about 1 €/kg) and this makes such an investment quite promising.

From the analyses above, the industrial development of supply chains to derive treated crumb rubber from end-of-life tyres merges as a clear, tangible perspective. It is envisaged that this process is a matter of a few years more than a long-term perspective.

Action D1 - Information and awareness raising activities

Foreseen start date: 1st July 2019 Actual start date: 1st July 2019
Foreseen end date: 31st January 2023 Actual end date: 31st January 2023

At the project's beginning the **Dissemination plan** (Del. D1) has been drafted by VIENROSE, shared with partners and definitively agreed, together with the structure of a **Dissemination photo album**. Both documents have been regularly updated by VIENROSE, by asking partners to provide news and materials both related to Action D1 and D2. Moreover, after the first Monitoring Visit, it has been requested to VIENROSE to produce a more detailed description of the plan. As a consequence, the document titled "Communication and dissemination strategy" has been drafted within September 2020 and attached to the Mid Term Report. Finally, the official Project logo has been produced by VIENROSE and consequently adopted in all technical reports, presentations and other products or materials. The LIFE E-VIA **website** (https://life-evia.eu/) has been activated since 31st December 2019 (Del. D3). The website design has been commissioned to an external company, while the structure definition and the managing is directly in charge of VIENROSE and it is carried out by a back-end service for which three people have been trained. After the first Monitoring Visit, it was agreed with the Project's monitor to add a "FAQs" and a "Stakeholders" folder for the Networking activities. The website structure will be maintained for three years after the project conclusion and updated with information about dissemination events and possible papers. VIENROSE has been also in charge of the regular materials collection from all partners and uploading and constant updating of the website. Moreover, every three months VIENROSE has drafted a report about website statistics (see Action C1) as an additional project report. During the project duration, 13 **noticeboards** in English language have been produced (Del. 18) together with 6 noticeboards in French (Del. 21), 6 noticeboards in German (Del. 22) and 8 noticeboards in Italian (Del. 23) by all partners. All noticeboards (https://life-evia.eu/documents/) have been exposed during official meetings and events organised by the project. A **press release** (https://life-evia.eu/news/articles-published-in-april-2021-about-life-e-via-project/) has been published by FIRENZE about the pilot case implementation and two **interviews** have been given by VIENROSE during the project final event (https://life-evia.eu/deliverables/id_11_press-conferences/). Regarding the open contest for students "MusicAlert", although postponed due to the COVID-19 pandemic and to the fact that high schools in Calabria have been locked down several times, has been organised by UNIRC with the A. Volta high school in April 2022 (https://life-evia.eu/news/contest-results-on-electric-vehicle-acoustic-signals/). 2 leaflets have been produced and distributed respectively in Expomove 2021 and 2022 events.

Leaflet, MusicAlert open contest, Noticeboard

The video about the prototype construction and during the pass-by noise measurement of EVs on the reference test track in Nantes has been produced (Del. 9). The Layman's report (Del. 35) has been issued by VIENROSE. All dissemination products have been published and are available for free on the project website.

(Projects funded under the Call 2014 onwards must use this format)

Action D2 - Technical dissemination activities to stakeholders

Foreseen start date: 1st July 2019 Actual start date: 1 July 2019
Foreseen end date: 31st January 2023 Actual end date: 31st January 2023

Regarding the promotion of project results among policymakers, FIRENZE and VIENROSE have participated to the EUROCITIES meeting in Oslo during the Environment Forum in October 2019 (https://life-evia.eu/event/eurocities-environment-forum/ about 40 participants); FIRENZE participated also to the EUROCITIES meeting held online during the Environment Forum in April 2021. On both occasions a presentation about LIFE E-VIA has been given. Regarding the publication of technical/scientific articles and presentations, the achieved targets are the following:
2019 – A keynote speech was given by UNIRC in the EAI SmartCity 360° 2019 International Summit holed in Braga (Portugal) in December (https://life-evia.eu/event/eai-smartcity-360-of-international-summit-2019/ about 60 participants) and a presentation was made by VIENROSE at the 9th International FKL Symposium in Lecce (Italy) in October (https://life-evia.eu/event/9th-international-fkl-symposium-the-lost-sounds-rediscovered-by-the-students-of-the-schools-that-participated-in-the-inad-2019-initiative/ about 35 participants).
2020 – 1 paper was published by UNIRC for peer-reviewed open access journal Sustainability (Del.20a); 1 paper was presented by UNI-EIFFEL at the JTAV 2020 Congress in Ille de France (https://life-evia.eu/event/journees-techniques-acoustique-et-vibrations-jtav-2020/ about 70 participants), 1 paper was submitted by UNIRC at the 11th International Conference "Environmental Engineering" (ENVIRO); 1 paper was submitted to the 20th international conference IEEE Mediterranean Elettronical Conference (MELECON) by UNIRC; 1 paper was presented online by FIRENZE and VIENROSE at the Forum Acusticum Congress; 1 chapter was prepared for the Book "New Metropolitan Perspectives" by UNIRC.
2021 – 1 presentation of the project was made online during the IYS2020-2021 Steering Committee meeting in January (https://life-evia.eu/event/iys2020-steering-committee-meeting/ about 15 particIpants); 1 paper was published by UNIRC for peer-reviewed open access Noise Mapping journal (Del. 20b); 1 paper was published by UNI-EIFFEL in the open access top ranked Noise Mapping journal (Del. 15); 1 paper was presented online by VIENROSE, UNIRC and FIRENZE at the Italian Acoustic Association Congress (foreseen in 2020 when, due to Covid-19, the Congress was not organised) in May (about 100 particpants); 1 presentation was made by CRD at the European Tire and Rim Technical Organisation (ETRTO) in May (about 50 participants); 1 presentation was made online by UNI-EIFFEL at the French "Journées Techniques Acoustique et Vibrations" (JTAV2021) (about 60 participants); 1 abstract was sent by UNIRC to the 11th International Conference on the Bearing Capacity of Roads, Railways and Airfields (BCRRA); two papers were presented online at the ICSV27 Congress by VIENROSE and FIRENZE (about 80 participants each); 1 presentation was given in Vienna by CRD at the Annual Meeting of the German Acoustical Society (DAGA 2021) in August (about 80 participants); 1 paper was presented online by UNIRC and IPOOL at the Euronoise 2021 Congress (about 70 participants); 1 webinar titled "Mobilità elettrica e asfalti a bassa emissione di rumore: il progetti LIFE E-VIA e altri contributi" was organised by project partners in May 2021 (https://life-evia.eu/event/workshop-electric-mobility-and-low-noise-asphalts-the-life-e-via-project-and-other-contributions/ about 130 participants); 2 presentations were given by FIRENZE and UNIRC and 1 stand dedicated to the project was managed by FIRENZE and VIENROSE at the International Conference on Sustainable Mobility in Florence/online in October (about 50 participants); 1 presentation was given online by FIRENZE at the "Urban heat island and noise: our not so invisible enemies" webinar (https://life-evia.eu/event/life-heatland-workshop/ about

50 participants); more than 20 brief articles were published on Italian magazines mainly concerning the LIFE E-VIA pilot case (https://life-evia.eu/news/articles-published-on-italian-journals-in-october-2021/; https://life-evia.eu/news/articles-published-in-april-2021-about-life-e-via-project/); 1 lesson was held by CRD at the University of Applied Science in Hanover in June.
2022 – 1 article about the EV Festival referring to the LIFE E-VIA project was published on ANSA online magazine in October (Del. 16) together with a brief article about replication interventions in Florence in December; 1 promotional video about the project pilot case implementation was issued by FIRENZE (Del. 26); 1 abstract was presented by UNIRC at the 11th International Conference on the Bearing Capacity of Roads, Railways and Airfields (BCRRA); 1 paper was presented by CRD at the Annual Meeting of the German Acoustical Society (DAGA 2021) in Stuggart in March (about 80 participants); 1 presentation was given by UNI-EIFFEL at CFA 2022 in Marseille in April (about 80 participants); 1 paper was presented by VIENROSE at the Italian Acoustic Association Congress in Matera in May (https://life-evia.eu/event/48th-aia-national-conference-matera-25-27-may-2022/ about 80 participants); 1 paper was presented by UNI-EIFFEL, UNIRC and IPOOL to RAR 2022 in Malaga in June; 3 papers were presented at the Internoise 2022 Congress held in Glasgow in August: 1 by UNIRC, 1 by CRD and UNI-EIFFEL, 1 by UNI-EIFFEL (https://life-evia.eu/news/networking-activity-structured-session-on-tyre-road-noise-at-internoise-2022/ about 80 participants); 1 presentation was made by VIENROSE at Tecniacustica congress in Elche in November (about 50 participants); proceedings of the final event, organised in the frame of Expomove 2022 event, have been made freely accessible via the project website (Del. 37); 1 presentation was given online by FIRENZE and VIENROSE at the COSCI&Costa conference in April (about 40 participants); FIRENZE participated to the Festival Europa Agorà in May in Florence, disseminating video materials and brochures to visitors (https://life-evia.eu/event/festival-europa-agora-firenze/ about 100 participants); 1 presentation was given by VIENROSE during a study day organised by the Order of Engineers of the Province of Florence (https://life-evia.eu/event/study-day-immissioni-in-ambito-urbano/ about 80 participants).

Stand at Expomove 2021

JTAV Congress 2020

Festival d'Europa 2022

2023 – 1 Open Source Article on peer-reviewed international journal for dissemination of the obtained results by UNI-EIFFEL is going to be published in the Romanian Journal of Transport Infrastructure, volume 11 (2022) no.2 (Del. 19b); 1 Open Source Article titled "Adjusted Controlled Pass-By (CPB) method for urban road traffic noise assessment" has been published by IPOOL on Sustainability journal (answers to reviewers sent); 1 Article titled "CNOSSOS-EU coefficients for electric vehicle noise emission" has been sent for review to Applied Acoustics journal by IPOOL; 1 Article titled "Road pavements' dynamic stiffness measurements by means of impact hammer in a non-resonant configuration" has been published (with Editor) on Construction and Building Materials journal; 1 Article on "Influence

on dynamic stiffness of crumb rubber introduction in pavements" is under preparation by IPOOL and UNIRC.
All available materials about the above-mentioned activities all dealing with LIFE E-VIA are available for free on the project website. The Workshop in Reggio Calabria was held both in digital and in person modality on 11 October 2021: technical presentations were given by partners and are available on the project website (Del. 24) and also students involved in the MusicAlert contest were involved. Since the beginning of the Project all partners have activated and maintained networking activities, especially with the LIFE+15 NEREIDE, LIFE+15 MONZA and LIFE+16 CLOWN projects. Specifically, the absorption measurement method with a similar Adrienne system able to detect also the phenomenon of water planning and developed within the LIFE+2015 NEREIDE project has been used in the framework of action B2. Moreover, FIRENZE and VIENROSE took part in the final event of the LIFE+2015 MONZA project and published updating about recently published papers on the LIFE E-VIA website. Due to the spread of the COVID-19 pandemic, the national and annual congress of the Acoustical Society of Italy 2020 has been postponed to 2021 when VIENROSE and FIRENZE participated. VIENROSE and FIRENZE will participate to the final event of the LIFE+16 CLOWN project in April 2023 with a presentation about the LIFE E-VIA project.

Networking activities with mentioned LIFE projects will be maintained also after the project conclusion and possibly new networking exchanges will be established with additional EU projects that will start in the next period.

16 additional scientific papers have been presented in national / international congresses (Del. 36) together with additional 8 presentations. 2 additional Articles have been published on scientific journals.

Action E1 – Coordination, Monitoring and project management

Foreseen start date: 1st July 2019 Actual start date: 1st July 2019
Foreseen end date: 31st January 2023 Actual end date: 31st January 2023

Responsible partner for Action E1 is FIRENZE and the other partners have been involved in carrying out the action. Regarding sub-action E1.1, since the kick-off meeting the Project Management structure and related members have been defined. The Project Manager – PM from FIRENZE has responsibility for technical aspects and relations with the EC. PM structure is developed to face the unforeseen difficulties, allowing flexibility and dialogue between the different parts of the staff, especially involving Steering Committee and Scientific Committee and strengthening the decision making, by relating to General Monitoring Unit (GMU), Project Impacts Monitoring Unit (PIMU) and Technical and administrative associated beneficiaries units. An administrative management staff (AMS) is appointed for the reporting and administrative management between FIRENZE and the associated beneficiaries. A general coordinator for dissemination and communication activities (GCDC) is established.
Concerning period meetings, the kick-off meeting was held on September 20th 2019 in Florence. FIRENZE participated to the LIFE 18 ENV and GIE Welcome meeting in Brussels in November 2019. A general internal meeting and the first monitoring meeting were held respectively on 20 and 21 February 2020 in Florence. Second, third and fourth monitoring visits were held online or in mixed mode on 11-12 May 2021, 25 February 2022 and 5 December 2022. Other internal Project meetings were held in digital mode in 2020 on 28 July and 23 October, in 2021 on 5 March, 14 April and 11 October, in 2022 on 20 July.
The final event (M13) was successfully organised on 7 October 2022 concurrently with and in the frame of the Expomove Congress. More than 100 people participated to the final event for which both a scientific seminar and a stand dedicated to the project were organised and set-up.
Regarding sub-action E1.2, mainly four activities have been carried out:
1- Preparation of the project Monitoring Protocol (Del.2).
2- Initial and Intermediate Monitoring consisting in six-monthly verifications of administrative and financial documentation.
3- Technical monitoring which has been regularly carried out. As a tool for punctual progress monitoring, monthly reports of the activities are regularly collected and stored.
4- Final Monitoring consisting in the collection of Self Monitoring Forms from partners and calculation of GO/NO GO indicators for each concluded action.
Communications with partners have been mainly managed by email or videoconferences. FIRENZE has created a digital repository in which all Project documentation is collected. Although the monitoring protocol was formalized with delay (March 2020), the activities were carried out according to the schedule. Regarding the Milestones, the Kick-Off Meeting date has been respected and the scheduled deadline relating to the drafting and signing of the Monitoring Protocol was respected, albeit with a slight delay.


Final event

Action E2 – After LIFE Plan

Foreseen start date: 1st October 2022	Actual start date: 1st October 2022
Foreseen end date: 31st January 2023	Actual end date: 31st January 2023

Responsible partner for Action E2 is FIRENZE and the other partners have been involved in carrying out the action. Action E2 provides the development of a strategy for the communication and dissemination of the project results and the dissemination of knowledge acquired after the end of the same.
The After-LIFE Plan of the project, after the Introduction, the list of partners and the summary of key project's achievements, is essentially divided into two technical and dissemination activities that the partners of the LIFE E-VIA project are in planning to start and those ones that have already been started and which, in any case, will be completed in the period following the end of the project and specifically:
Technical activities
- **Laying of the new pavement in additional sites of the Municipality of Florence.** More than 25,000 m^2 of asphalt with technical characteristics analogous to those of the E-VIA project will be laid in Florence in 2023.
- **3 project-based action plans**. Vienrose will propose the use of the optimised asphalt proposed by the LIFE E-VIA project to its customers, for whom 6 contracts have already been awarded for the IV round of updating of the agglomerations' Action Plans.
- **Cnossos improved data base for strategic noise mapping.** The implemented database and the coefficients for electric vehicles and asphalt, processed and tested on Via Paisiello, will be used in the IV Round of Action Plans.
- A **Fourth monitoring campaign** will be performed by VIENROSE/IPOOL (2024) to estimate the efficiency of pavements after 3 years of surfaces laying
- **CPX/CPB monitoring campaign**. A yearly monitoring campaign will be performed by UNI-EIFFEL to estimate the efficiency of pavements in the prototypal test section.
- **Possible future development of tyre product lines**: for possible future tyre development processes, CRD will exploit both of two main enablers deriving from the project activities: the additional know-how gained during action B7 on how to incorporate accelerated pass-by noise testing into the tyre development process in the best way and the adaption of development processes to the special requirements of the holistic noise optimised EV tyre.
Dissemination activities
- Maintainance of the project website. The LIFE E-VIA project website will be maintained until 2025 (three years after the project's conclusion).
- **Organization of an event to disseminate LIFE E-VIA results**. FIRENZE will continue to promote EV mobility and to improve good behaviours and noise awareness.
- **Presentation of results during Eurocities meetings**. Being Florence a member of Eurocities, training and awareness raising among cities will be guaranteed.
- Presentation of results during conferences and workshops. The presentation of results is already foreseen in 4 conferences after the project's conclusion.
- Presentation in scientific journals. The publication of three papers is foreseen just after the project's conclusion.
- Dissemination via ARPATNEWS. ARPAT has already being involved in the dissemination phase; news and project updates, as well as results in the after life period will be disseminated through the agency website.
- 3 initiatives for disseminating results of CR-low noise pavements with Ecopneus. They will be planned in the frame of the LIFE SNEAK project where some partners are the same of the LIFE E-VIA.

6.2. Evaluation of Project Implementation

Please evaluate the following aspects of the project:

– Methodology applied

The overall applied methodology has worked properly, during the whole project's duration. In particular, a good interaction has been envisaged between the units and committees defined under Action E1 in terms of deadline respecting and fair and full coverage of tasks. Moreover, the timely collection of the Monthly Report from each partner and the continuous exchanges among them allows a proper monitoring of the effective actions' implementation and, in case of possible delays, allow to take a rapid corrective action. Also, regarding the management of financial documentation, after some clarifications provided by the Coordinating Beneficiary to partners in terms of correct filling of templates, it is correctly collected on a semester basis and stored in a dedicated online repository.

– Compare the results achieved against the objectives and expected results foreseen in the proposal and described in section 4: clearly assess whether the objectives were met and describe the successes and lessons learned. This could be presented in a table, which compares through quantitative and qualitative information the actions implemented in the frame of the project with the objectives and expected results in the revised proposal:

Action	Foreseen in the revised proposal	Achieved	Evaluation
A1	**Objectives:** Literature review on EVs and their noise emission **Expected results:** • A1 report Guidelines for subsequent actions	A1 report achieved, including guidelines for actions B2, B4, B6.	Although delayed regarding the initial time schedule, the preparatory action was useful for implementation actions of the project. State of the art considering a wide scope of parameters affecting noise is one of the first of its kind in the field of noise emission of EVs. The state of the art that was carried out is one of the first of its kind in the field since it considers a wide scope of parameters affecting noise emissions. This provided solid bases and methodological recommendations for the subsequent implementation actions of the project.

A2	**Objectives**: Providing the best scientific and practical bases to design the tracks, including in-lab tests. **Expected results**: • Preliminary tests data • A2 report focusing on quiet pavement technologies and their performance over time.	Preliminary tests were carried out. The report A2 was successfully edited.	At the end of Action A2, mixes were selected based on many characteristics, including: - Acoustic response (as-built and over time) - Expected life by referring to mechanistic properties - Permeability - Friction. The objectives were met.
A3	**Objectives**: Identification of the role of the tyre in the context of EV vs. ICE vehicles with respect to rolling noise and related target conflicts, for example with respect to rolling resistance. **Expected results**: a report describing the changed requirements on a holistic low-noise tyre going from ICEV to EV applications. Definition of a requirement book and a development strategy for such a tyre which then will be used in B7.	Based on data analysis, the report incl. requirement book and the development strategy has been issued.	The Action has been finished with a small delay but with all objectives reached as planned. The requirements for the development of a holistic, noise optimized EV tyre in action B7 concerning e.g. tyre dimension and load, acoustic performance, were identified
B1	**Objectives:** Selecting mixtures (volumetrics, materials, and surface texture), for the tracks to be constructed in France and Italy, to minimize noise from EV, taking into account the synergy with actions B2 and B3. **Expected results**: • A durable reduction of noise. • B1 report that focuses on mixtures, gradations and types (and quantities) of aggregates, crumb rubber, asphalt binder, further components, and process-related recommendations.	Two types of mixtures were designed and validated through a plane of experiments. The report B1 was issued.	This action makes a contribution to the majority of the objectives. It affects objective 1 of the project because noise reduction is crucial in LCA and in LCC assessments. The objectives were met.
B2	**Objectives:** **B21** - Acoustical characterization of EVs on existing tracks **B22** - Construction of a B1-based test track prototype **B23** - Characterization of the B1-based prototypal test section **B24** - Selection of optimized EV tyres	• Measurement campaign performed on 6 existing road surfaces for 7 EV models and 1 ICEV at constant speed, in full acceleration and in	• CPB noise levels differences at constant speed 50 km/h on existing test sections range between 4.8 dBA and 7.9

	Expected results: • Microphone array and CPB noise tests of EVs on different existing road surfaces in real driving conditions • A 50m-long by 8m-large prototypal test section on UNI EIFFEL reference test track • Characterization of the prototype (road surface characteristics, CPB and microphone array tests for a selection of EVs, CPX noise including SRTT tyres) • CPB and CPX noise tests for carved prototype tyres delivered by CRD on the prototypal test sections and further standard road surfaces •	regenerative deceleration • Prototype construction in September 2020, 57m-long by 8m-large on UNI EIFFEL reference test track in Nantes, two different mixes of VTAC 0/6 (PCR with CR and P without CR) • 3D surface texture, sound absorption, friction and mechanical impedance measured on P and PCR • Pass-by tests for 3 EVs on P and PCR at constant speed, acceleration and deceleration • CPX tests with SRTT tyre done by IPOOL on P and PCR test sections Technical demonstrators of tyres delivered by CRD (1 set of reference tyres V1 and 5 other tyre sets V2 to V6 with variations of tread pattern) and tested according to UNECE on P and PCR and by the CPX method (including 6 existing test sections)	dBA, depending on EV model • Noise increase for ISO surface in the order 5 dBA in acceleration compared to constant speed • Prototype construction is conforming with the proposal in terms of dimensions and composition. It includes 2 versions of B1-based low-noise road surface as foreseen in the proposal • CPB noise levels at constant speed 50 km/h on prototype test sections P and PCR are 3.9 dBA to 4.7 dBA quieter than the reference DAC 0/10 • CPX overall noise levels at 50 km/h for P and PCR meet the Core criterion of GPP for a low-noise pavement (L_{CPX} < 90 dBA with SRTT tyres) and PCR close to the more stringent comprehensive criterion of GPP (L_{CPX} < 87 dBA with SRTT tyres) • Variation between tyre versions for an EV are less than 1 dBA at constant speed and up to 1.5 dBA at full acceleration • For CPX noise level at 50 km/h with tyres V1 to V6, P and PCR among the

			quietest road surfaces, PCR is up to 1.1 dBA quieter than P and noise reduction relative to tyre V1 is up to -0.6 dBA on PCR for V2 and -1 dBA on P for V4
B3	**Objectives**: To test the new prototype pavement in a densely populated area of the city **Expected results**: • definition of a reference track about 150 m long, complying with the "core" criterion for low-noise pavement of the EU GPP Criteria for Road Design, Construction and Maintenance, 2016 • implementation of a surface-optimized track, about 150 m long, crumb rubber added, complying with the "comprehensive" criterion of the EUGPPC above, i.e., L_{CPX}<87 dB(A) at 50 kph. • B3 Report	The construction procedures (e.g. Tender definition and assignment) were timely planned and carried out. The pilot area was successfully implemented. B3 report was compiled	The pilot street originally foreseen in the proposal (Michelucci Street) was replaced with Paisiello street, with similar characteristics to the previous one but at the same time with repaving needs that fit well with the project timeline.
B4	**Objectives**: Test of the new road surfaces laid in the Pilot Area of Via Paisiello in Florence and to carry out all measurements necessary to Action B6. The overall objective entails the use of a broad range of measurement systems: CPX, Impedance tube, the Extended surface method and CPB for the acoustic characterization, 3D surface texture and mechanical impedance measurements to evaluate the morphological and mechanical properties of the site. **Expected results**: ● to obtain measurements with all the mentioned systems on the Florence test track. ● Repetition of the acoustical testing during a year after the pavement laying in four total measurement sessions. • Report of Action B4.	All the expected testing has been carried out during the four scheduled sessions. More specifically, acoustic tests were performed during all the sessions, while non-acoustic ones in the first after pavement laying. Besides. tests allowed the continuous development of the instrumentation involved and the definition of new measurement approaches. Action B4 Report has been completed.	Besides the performed efficiency tests, an important outcome obtained is the optimization of the CPX data post-processing developed during this and B6 Actions. Interesting and detailed data on pavement early ageing in urban settings has been acquired, which will lead to further research in the field. The Action successfully provided good quality input data for Action B6.
B5	**Objectives**: evaluate how people's perception about the soundscape changes in relation to the implementation of the	Regarding Sub-Action B5.1, because of organizational issues, it was decided to carry out	Alongside the analysis of citizens' acoustic perceptions

	new pilot pavement and the interaction with EVs. **Expected results:** • design and submission of different version of a questionnaire during three events: Soundwalks and interview during the EV Festival (B5.1); Interview in the pilot road on an electric "taxi" (B5.2); Interview on EV concerning different road pavements (B5.3). • B5 report	soundwalks concurrently with interviews on electric taxi (Sub-Action B5.2). Regarding Sub-Action B5.3, it was originally foreseen to carry out interviews with citizens on busses concerning different road pavements. However, due to the change in the pilot road this objective was modified and ante and post-operam interviews with 56 residents of the pilot street have been carried out. Data collected during surveys, soundwalk experiences and interviews on the electric taxi were analysed and presented in the B5 Report. A long-term ante and post-noise monitoring campaign was also carried out (not foreseen in the original proposal) which permitted to evaluate the ante and post (short and long-term) noise levels at receivers.	based on soundscape approach, showing a positive assessment of the intervention, this action contributes to people involvement thanks to their participation to surveys, soundwalk experiences and interviews. With reference to sub-actions B5.1 and B5.2 a target of 80 participants was achieved (instead than 150), due to Covid-19 reasons and difficulties in involving people in such experiences. The achieved noise reduction, measured through long-term ante and post-noise monitoring campaign at receivers, demonstrates the effectiveness/good performance of the LIFE E-VIA asphalt.
B6	**Objectives**: Quantifying the acoustic performance of new EV tyres and new road surface to provide knowledge and tools to public administrations. In particular, measurements on the test tracks in Florence shall be used to calculate specific CNOSSOS rolling noise coefficients, besides a road surface correction factor. **Expected results**: ● CNOSSOS related parameters for EV and tested pavements. ● Analysis on the acquired data, requiring optimized acquisition software and analysis software. ● Pilot Area noise mapping scenarios for the evaluation of EV impact. ● Report of Action B6.	All the expected results were reached, expressed in both Action B6 Report and the Guidelines.	Extremely positive results were obtained in the Pilot Area evaluation with scenarios of massive EV introduction. Even if the dataset used in the CNOSSOS 5th vehicle category definition is not completely representative of actual future electric mobility scenarios, given the fast evolution it's undergoing, these are indicative of what it can be expected in a few years.

	• Guidelines about the use and application of the methodology output, leading to Project replication as an urban planning tool.		
B7	**Objectives**: Action B.7 aims at developing a holistic low noise EV tyre for urban applications. Besides the focus on low noise, the target conflicts noise/rolling resistance and noise/wet grip shall be solved at a high level to support a reduction in greenhouse gas emissions and improve market acceptance. **Expected results**: • The action will result in holistic noise optimized EV tyres, and a report which is due at the end of the project.	Compared to the Continental EcoContact 6 205/55 R16 91V reference tyre and depending on road surface and operating conditions, for urban driving pass-by noise reduction of up to 1.0 dB(A) was observed for the final LIFE E-VIA tyre. For the L_{urban} metric which combines the effect of constant and accelerated driving under urban conditions the reduction is 0.8 dB(A). The very good noise performance of the LIFE E-VIA tyre is combined with a very balanced and competitive portfolio of non-noise related performances. The very good performance levels of the reference tyre could be maintained, if not slightly improved. Noise under acceleration is of special importance for EVs. However, for historic reasons there is limited knowledge on how accelerated pass-by measurements are affected by variations in test conditions, test vehicle, etc. To close this gap at least partially, action B7 also looked at how accelerated pass-by tests are affected by the conditions which are prevailing when the test is conducted. It was found that it is not possible to consider tyre and vehicle independent of each other, they need to be considered as one combined system for accelerated pass-by measurement purposes. Moreover, the SPL	The Action has been finished as planned and with all objectives reached as planned. The achieved noise reduction is within the expected range and the holistic nature is assured by the well-balanced target conflicts. Assessing the importance of the new insights which were gained during the tyre development there is no new single individual technical solution which is responsible for the good tyre performance. The development combined existing, validated technologies in in smart and novel ways. The long-term value of action B7 in this regard is related to the know-how and new processes which were created to optimise noise in a holistic way for EV applications. Fundamental for future tyre development is the knowledge which was gained in the investigations on accelerated pass-by noise testing. The noise optimisation part of the tyre development is still highly dependent on indoor and outdoor

		change in comparison to free rolling depends on environmental conditions like air temperature, and the road surface. Compared to indoor drum tests with torque it was also observed that ranking and relative differences between tyres can change between these indoor and outdoor tests.	measurements. Within the development process it needs to be assured that the right type of testing under the right conditions is used to guarantee that results from accelerated noise tests are relevant to the development goals. Also, the large influence of operating conditions on the SPL under torque is not limited to testing only. The same variations will be observed under real life driving. Thus, the development process needs to guarantee that a robust reduction of tyre/road noise can be achieved under the diverse traffic and operating conditions which are encountered for driving in urban environments.
B8	**Objectives:** Action B.8 addresses the replication and transferability of the solution tested in the pilot case (Action B3) **Expected Results:** • B8 Report containing Replicability and Transferability plan • B8 Technology exploitation plan for the transfer of EV tyre noise optimization technology into the market by CRD	Replication of solution tested in the pilot area is planned in 2023, for an extension beyond that envisaged in the project proposal. Festivals and event replication: E-VIA has been presented in the Eurocities Environment Forum of Oslo 23-25 October 2019. 21 cities participating. Follow-up market oriented: An exploitation plan and a temptative business plan have been implemented by CRD and UNIRC respectively. The CNOSSOS database is implemented and the coefficients for electric vehicles and asphalt have been found, processed and tested on Via Paisiello.	Although some of the objectives of this action will be realised after the end of the project, commitments, including financial ones, have already been made, as evidenced by the documents attached to the B8 action report. All objectives planned during the project have been completed

		Replication of the solution tested in the pilot area. This replication goal, expected after the end of the project, was actually anticipated by VIENROSE: 1) In the Noise action plan of the Comune of Inzago (MI) and has already been laid and tested in three road sections. 2) As a standard reference for the Piano Triennale di Bonifica dell'inquinamento acustico of Regione Lombardia. Replication and transferability of project output is guaranteed by three dissemination events planned within the LIFE SNEAK project: in all these events Ecopneus will also promote the results of the E-VIA project, in which the optimised asphalt laid in the pilot area contained a part of recycled rubber powder	
C1	**Objectives:** to progressively verify that Implementation actions (actions B) are carried out according to the project objectives and that the quantitative expected results are actually achieved. **Expected results:** providing values for project performance indicators and KPI. C1 report.	Life environmental performance indicators have been regularly monitored. KPI webtool have been filled and constantly updated. Report on statistics about website visits has been regularly provided on a trimester basis (additional contribution, not foreseen in the project proposal) Report C1 was delivered	Expected values concerning the core indicators of the project e.g. Noise performance indicators, Soundscape improvement, Noise-related health effects reduction (regarding hypertension) were achieved.
C2	**Objectives**: This action aims to evaluate tracks efficiency from a comprehensive point of view, including soundscape components (B5), thus achieving objective 6 of demonstrating the durability and effectiveness through LCA. **Expected results**: C2 report that focuses on understanding, investigating, and assessing from a quantitative point of	Data from materials/processes were basically gathered by UNIRC. The paper 'Energy and Environmental Life Cycle Assessment of Sustainable Pavement Materials and Technologies for Urban Roads' by F.G. Praticò, M. Giunta, M. Mistretta	This action makes a contribution to the majority of the objectives. It affects objective 1 of the project because noise reduction is crucial in LCA and in LCC assessments. The objectives were met.

	view, the potential environmental impacts for the LIFE E-VIA pavement system.	and T. M. Gulotta, was published. The report C2 is about to be achieved.	
D1	**Objectives:** Spreading information and raising awareness about project activities to the general public and to stakeholders. **Expected results**: • Dissemination Plan; • Project website; • Layman's report; • 15 noticeboards in EN; 5 in IT; 5 in FR; 5 noticeboards in GE; • 3 press conferences; • 1 radio campaign; • Participation to 2020/2021/2022 editions of INAD; • Organization of "MusicAlert" open context; • Video on prototype construction.	The LIFE E-VIA website has been activated since December 2019. 33 noticeboards in beneficiaries' languages were issued and exposed during official meetings and events organised by the project. A press release was published about the pilot case and two interviews were given. The Dissemination plan, the Layman report were issued, and a student contest took place in April 2022. The video on prototype construction was made available online.	The objectives were met and project progress and results were successfully spread to different target groups through multiple channels. The number of issued noticeboards has been higher than the target one
D2	**Objectives:** dissemination activities to stakeholders **Expected results:** • Participation to Eurocities meetings • 17 different scientific papers to be presented in congresses; 3 articles for open access (OA) journals; 2 OA articles on peer reviewed international journals; 1 article in an OA top ranked journal • Organization of 4 events • Networking activities • 1 promotional video and 1 article for local magazines • Proceedings of Final Event in Florence and of the student contest	Foreseen publication of scientific papers has been achieved and events were organized counting on a significant number of participant stakeholders. Networking activities with LIFE+15 NEREIDE, LIFE+15 MONZA and LIFE+16 CLOWN projects were carried out. Foreseen deliverables were issued. Additional papers were published, and additional activities have been organised.	The objectives were successfully met effectively contributing to the dissemination of project mission, activities and results to national and international stakeholders
E1	**Objectives:** Ensure effective and timely monitoring of the project. **Expected results:** • six general meetings including the kick-off one • Establishment of scientific, steering • Monitoring protocol • Final report	Period meetings and technical monitoring were regularly carried out. The final event was successfully organized in the frame of the Expo move meeting (Florence) with more than 100 participants. Deliverables were issued (Monitoring protocol and final report)	The foreseen activities and monitoring were carried out according to the schedule ensuring smooth project progress. Due to the spread of the Covid-19 pandemic some meetings have been held in digital mode

E2	**Objectives:** This action refers to the elaboration of a strategy for the communication of the Project results and knowledge after its end. **Expected results:** After LIFE and exploitation plan	The action provides the after-Life strategy, presented in a ad hoc plan	The activities were completed on schedule and partners agreed on specific actions for the dissemination of acquired knowledge after project end.

- Indicate which project results have been immediately visible and which results will only become apparent after a certain time period.
  Project results that are already visible are hereinafter listed:
  a. Technical reports on preparatory actions dealing with literature review on EVs and their noise emission, track design focusing on quiet pavement technologies and their performance over time, design or performance requirements for a holistic low noise tyre for EV applications. All reports are available at https://life-evia.eu/documents/ (Actions A1-A2-A3).
  b. Design of prototype pavement mixtures including volumetrics, materials and surfaces textures (Action B1).
  c. Laying of the prototype pavement in Nantes (Action B2).
  d. Pass-by measurement campaigns carried out on 6 road surfaces and 8 different vehicles tested, including 7 EVs and 1 ICEV (Action B2).
  e. Definition of the tender document for the road pavement to be implemented in the pilot case in Florence (Action B3).
  f. Implementation of the two asphalt sections in the Florence pilot case (via Paisiello), including 150 m with traditional asphalt and 150 m with E-VIA asphalt (Action B3).
  g. Four measurement sessions (CPX, Impedance tube, the Extended surface method and CPB for the acoustic characterization, 3D surface texture and mechanical impedance measurements) have been carried out to evaluate the morphological and mechanical properties of the pilot site and initial targets have been achieved (Action B4).
  h. Carrying out of soundwalks concurrently with interviews on electric taxi (with 80 participants) and of ante and post-operam interviews with 56 residents of the pilot street, demonstrating the effectiveness of the realized interventions also from the point of view of people's perception. A long-term ante and post-noise monitoring campaign was also carried out (not foreseen in the original proposal) which permitted to evaluate the ante and post (short and long-term) noise levels at receivers (Action B5).
  i. Quantification of the acoustic performance of new EV tyres and new road surface to provide knowledge and tools to public administrations. In particular, measurements on the test tracks in Florence have been used to calculate specific CNOSSOS rolling noise coefficients, besides a road surface correction factor (Action B6).
  j. Compared to the Continental EcoContact 6 205/55 R16 91V reference tyre, the LIFE E-VIA tyre demonstrated very good noise performance which is combined with a very balanced and competitive portfolio of non-noise related performances. The very good performance levels of the reference tyre could be maintained, if not slightly improved (Action B7).
  k. Evaluation of project's indicators and KPIs (Action C1).
  l. A specific LCC and LCA analysis has been carried out (Action C2).

m. Several scientific papers, project's noticeboards, presentations at national and international congresses, project's events and stands, press conferences, brief articles on national and local newspapers have been object of the dissemination strategy (Actions D1-D2).

Results which will be more evident after the project's conclusion an in the immediately subsequent years will be the ones related to replication and possible further market development of the two project's products (asphalt and tyres optimized for noise and for EVs).

- Describe the results of the **replication efforts**.
  Replication efforts are made in the following main actions:
  1. More than 25,000 square meters of asphalt with technical characteristics analogous to those of the E-VIA project will be laid in Florence in 2023.
  2. The CNOSSOS database is implemented and the coefficients for electric vehicles and asphalt have been found. The coefficients were processed and tested on Via Paisiello and will be certainly used in the action plans, as the switch to electric vehicles will certainly be used in the action plans of several managers of public transport, particularly in agglomerations.
  3. The proposal of the use of the LIFE E-VIA asphalt in the Action Plan of additional cities has been reached already during the project duration. In fact, the Life E-VIA asphalt was proposed by VIENROSE in the Noise action plan of the Comune of Inzago (MI) and has already been laid and tested in three road sections. Moreover, it has been adopted as a standard reference for the *Piano Triennale di Bonifica dell'inquinamento acustico* of *Regione Lombardia*.
  4. The promotion of the CR-based initiatives will be guaranteed by the fact that Ecopneus is a partner in the LIFE SNEAK project together with the Municipality of Florence, the University of Reggio Calabria and Vienrose. In this context, optimised asphalts are being tested for urban areas where the presence of vibrations is relevant. Three dissemination events are planned within the LIFE SNEAK project: in all these events Ecopneus will also promote the results of the E-VIA project, in which the optimised asphalt laid in the pilot area contained a part of recycled rubber powder.

- Indicate the effectiveness of the dissemination activities and comment on any major drawbacks.
  Despite difficulties encountered due to the spread of Covid-19 and persistence of limitations during the project's duration, the dissemination activity has been progressing very well. Despite some activities could not been carried out to the above-mentioned motivations, additional activities have been foreseen (e.g., the online webinar dedicated to the project, lessons to students in Germany, participation on invitation to conferences of other EU projects, etc.). All partners are participating in events outside the project where the achieved results of the project are illustrated. Several papers about the project have been published on distinguished scientific journals (and additional ones will be published after the project's conclusion) and several posts have been published on social media giving news about the project, together with brief articles on local and national newspapers. Finally, the project website, has constantly up-to-date news. Positive feedbacks about the effectiveness of the carried-out dissemination activities are also collected according to website statistics.
- Policy impact

The main policy target achieved relates to the contribution made to the reduction of noise in urban areas, in compliance with the Environmental Noise Directive 2002/49/EC (END) and with a view to contributing, with concrete solutions, to the problem denounced by the World Health Organization by the European Environment Agency (EEA) and related to the exposure of more than 100 million European citizens to high levels of noise, with even serious consequences on their health. The LIFE E-VIA project has demonstrated the ability that an innovative asphalt has in reducing noise levels at receivers, with particular reference to the Lnight parameter (reduction of 4.4 dB on receivers façade). Nonetheless, the noise optimized tyre for electric vehicles developed by LIFE E-VIA led to a reduction of rolling noise of 0.8 dB(A) under typical urban driving conditions. The very good noise performance of the LIFE E-VIA tyre is combined with a very balanced and competitive portfolio of non-noise related performances. Especially, no negative impact on rolling resistance and wet grip performance occurred, and even an expected increase in milage, which highlights the ecological, economical and safe design of the final tyre.

At policy level, achieved results will facilitate the process of noise mitigation planning, being the proposed noise mitigation intervention a cost-effective solution.

Moreover, pending the implementation of emission database for EVs for a wider implementation of the CNOSSOS model referred to in Directive 996/2015 to be mandatorily adopted in the 2021/2022 noise mapping round, the END had recommended interim noise calculation methods and the determination of coefficients to apply the CNOSSOS model to new traffic spectra and new vehicles (e.g., PHEV, EV) which are completely missing. In this framework, the noise measurements carried out for different EVs in Florence and Nantes have permitted, in various conditions of speed for vehicles currently in circulation in Europe, to characterize the noise emitted on both traditional and optimized pavements, to build that database and, after completing the test period, to start its dissemination among the interested stakeholders.

In addition, the use of recycled crumb rubber within the asphalt designed in the LIFE E-VIA project and the verification of its actual improved performance, including acoustically, compared to other asphalts evaluated, also allows it to contribute to policies related to the circular economy in terms of EU Green Deal and circular economy action plan.

Finally, the numerous awareness initiatives aimed at citizens (youth and adults) and, in particular the field experiences carried out through soundwalks and soundscape perception surveys have allowed citizens to directly approach the issues of the environment, noise, and e-mobility.

6.3. Analysis of benefits

1. Environmental benefits

Environmental benefits have been generated by the LIFE E-VIA project according to both the developed optimized products: the tyre and the pavement.

From the point of resource efficiency, reduction of greenhouse gases, and public health the classical target conflict for a **tyre** is low noise (realized e.g. via high mass and high damping) vs. low rolling resistance (realized via low mass and low damping). Already for classical ICE vehicles, these performances are critical for the environmental impact of the vehicle as they contribute to the overall vehicle noise and exhaust gas emission. For EVs the relative contribution of the tyre noise to the overall vehicle noise is considerably increased because of the nearly non-existent drivetrain noise. Because of the higher drivetrain efficiency of electrical

engines also the tyre rolling resistance has a relatively higher contribution to the energy consumption of an EV than for an ICE vehicle. Depending on how the electric energy used for charging the EV was created, this still can have a significant contribution to the emission of CO2 and other air pollutants. More importantly, the tyre rolling resistance has a large impact on the achievable mileage of an EV. A large mileage, in turn, is crucial for the public acceptance of EVs as means of transportation. As a consequence, a low noise, low rolling resistance tyre is considerably more beneficial for EVs than for comparable ICE vehicles. Because of the target conflict between noise and rolling resistance, for ICE applications traditionally either tyres with low rolling resistance (UNECE R117 label class A) and slightly higher noise or tyres low noise but slightly higher rolling resistance (label class B) are used. With the development strategies outlined in A3, and the results from the activities in B7, it was possible to develop a tyre which has excellent rolling noise behavior for EVs in urban scenarios while also maintaining rolling resistance label class A. The reduction in fuel consumption going from tyres of rolling resistance label class B to tyres of class A is roughly 0,1l/100km. Proportionally, also energy efficiency increases, and Greenhouse gases and other local pollutants are reduced. Based on roughly 310 million vehicles in the European market with an average yearly mileage of 12000km, a scenario where only 10% of these vehicles are equipped with tyres of rolling resistance class A instead of class B amounts to annual fuel savings of 372 Million liters, or roughly 850 million kilograms of CO_2 emissions.
L_{CPX} measurements were carried out during the last year, from October 2021 to October 2022 to assess the behaviour of the **pavements** right after they were laid and with a significant traffic load. This parameter is measured nearby the contact point between a special reference wheel and the road, essentially evaluating the noise contribution of the road alone, so not including other possible noise sources as the engine or the exhaust pipe. The Green Public Procurement Criteria for Road Design, Construction and Maintenance issued by the European Commission gives some reference value that newly laid pavements have to observe to reflect higher environmental standards that the EU is striving to achieve, firstly to directly benefit its citizens: a **90 dB(A)** reference value is imposed for L_{CPX} road emission at 50 km/h within 12 weeks from laying, while it's expected to stand below **93 dB(A)** within its first 5 years of duty. These are defined as *Core level* conformity of respectively production and durability.
Moreover, *Comprehensive* level values are defined, with a reference value of **87 dB(A)** at production: this was the original project aim concerning the special E-VIA pavement with crumb rubber.
The last measurement session gave the following results for the E-VIA pavements: **89.8 dB(A)** (with 1 dB(A) uncertainty) for the reference pavement and **87.6 dB(A)** (with 1 dB(A) uncertainty) for the special E-VIA pavement that includes crumb rubber. The full comprehensive level was not reached at production, but the project showed that even in urban laying conditions a very good result can be achieved. Given that the developed pavement is still a new product, knowledge and better equipment can lead to laying technique improvement, which can then improve the acoustical results.

The last measurement session gave the following results for the E-VIA pavements: **90.4 dB(A)** (with 1 dB(A) uncertainty) for the reference pavement and **89.3 dB(A)** (with 0.9 dB(A) uncertainty) for the special E-VIA pavement that includes crumb rubber, giving a further environmental advantage in the recycle and reuse of exhausted tyres.
At receivers' facades a reduction of 4.4 dB(A) in terms of Lnight and of 1.4 dB(A) in terms of Lden has been achieved after the intervention realization. A slow deterioration in performance was recorded in the year following asphalt paving, however within the limits of similar literature cases (1.5 dB loss of performance after about 16 months from the laying in terms of Lnight).

2. Economic benefits (e.g. cost savings and/or business opportunities with new technology etc., regional development, cost reductions or revenues in other sectors); state the number of full time equivalent (FTE) jobs created, showing a breakdown in qualified/non-qualified staff.

The used methodology will have an impact. The study carried ou under Actions C1 and C2 was based on ex-ante and ex-post assessments, representing the socioeconomic state (ex-ante) and its evolution (ex-post) by a mix of indicators related to environmental, social and economic aspects.

3. Social benefits (e.g. positive effects on employment, health, ethnic integration, equality and other socio-economic impact etc.).

Regarding social benefits, this is highly linked to the low noise/low rolling resistance target conflict which has been described under environmental benefits. Focusing on the noise part of the target conflict, it can be stated that according to data presented by the European Environment Agency (EEA) more than 100 million EU citizens are negatively affected by high noise levels originating from the road transportation sector which are negatively impacting human health. A significant part of this burden is caused by the road transportation sector in the form of traffic noise. Health risks include an increased likelihood for cardiovascular diseases, cognitive impairment in children, sleep disturbance, tinnitus and annoyance. The WHO assumes that “at least one million healthy life years are lost every year from traffic-related noise in the western part of Europe”. The outcomes from actions A3 and B7 can help reduce this road traffic noise burden by, firstly, providing a tyre with optimized noise performance for EVs operating under urban conditions (average observed reduction from the optimised tyre of 0.8 dB(A) in B7), and secondly, by solving the target conflict low noise/low rolling resistance at a higher level. This second point is insofar of great importance as not having to chose between low noise or good fuel economy is a market enabler for low noise tyres.

Moreover, the widespread adoption of the developed E-VIA pavement developed under Action B1can have important impact on various fronts other than the direct environmental one: it can give a positive effect on the development and employing of new technologies in the field of pavement laying and more importantly a highly specialised workforce, besides directly affecting the noise generation and thus the health of citizens.

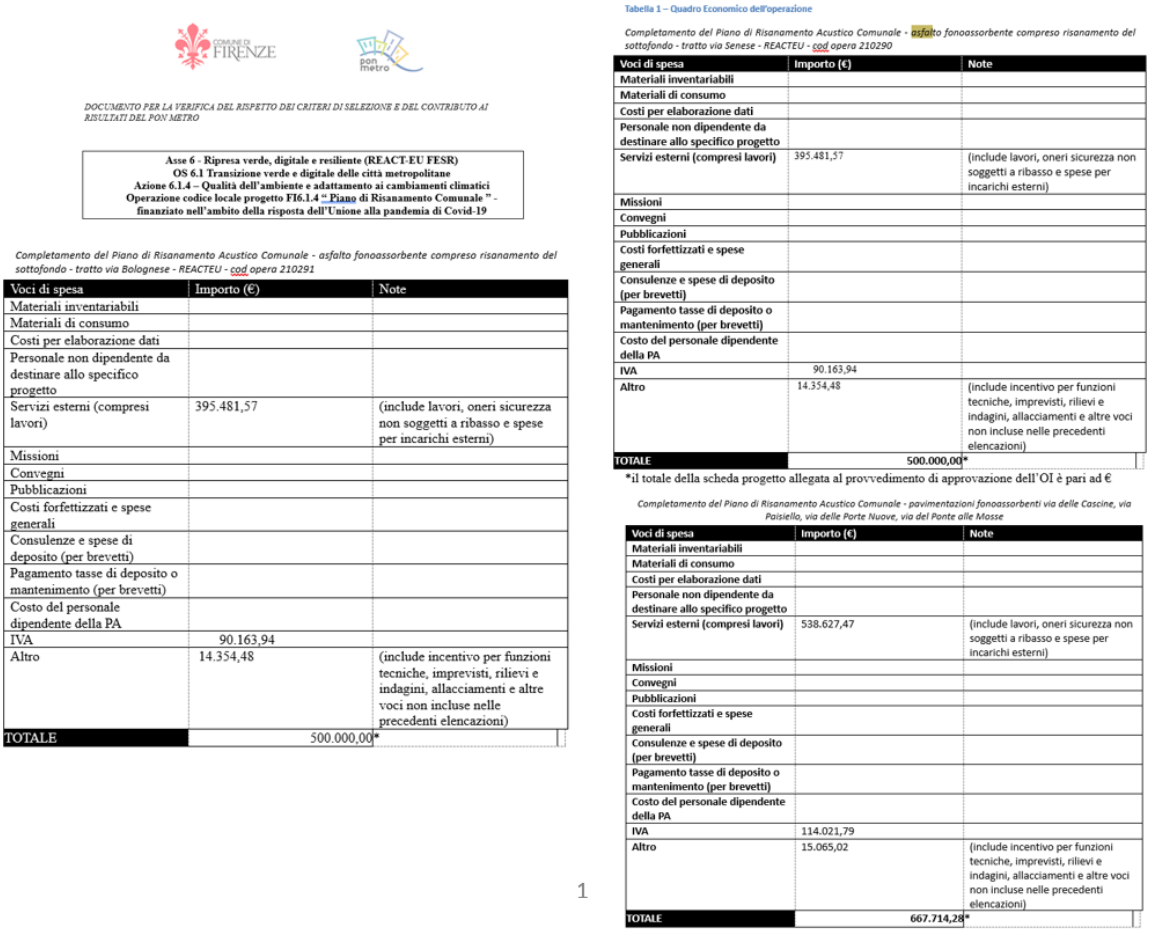
4. Replicability, transferability, cooperation: Potential for technical and commercial application (transferability, economic feasibility - bankability, limiting factors, suitability for additional funding from other streams e.g. structural funds, EIB financial instruments, venture capitals, pension funds, responsible investors) including cost-effectiveness compared to other solutions, benefits for stakeholders, drivers and obstacles for transfer, market conditions, pressure from the public, potential degree of geographical dispersion, specific target group information, high project visibility (eye-catchers), potential for replication in same and other sectors at the local and EU levels, etc. State the project's likelihood of replication (high/low/zero), and if its replication is market-driven or policy-dependant. Specification of potential market/replication vehicles. Possibilities for complementarity with existing market players and/or other solutions/projects (bundling). Those projects who have completed the C2M checklist or engaged in the Close-2-Market (C2M) Initiative should elaborate here on all the relevant

C2M aspects. Those projects should also complete, by the Final Report submission stage, the final C2M checklist provided to them by the C2M experts.

Guidelines issued within Action B6 will help Municipalities to adopt the solutions developed during the project, but more than that they will be an important contribution towards a cultural impact on the Public Administration concerning a new conception of Urban Planning that takes into account acoustic and generally perception, use and environmental impact of the modern infrastructure.

The most direct and effective consequence of the project on the activities of the Municipality is certainly the repeatedly explained one of replicating the use of this new asphalt on other roads. In this regard, the mixture produced by the LIFE E-VIA project has been included as standard reference for the maintenance activities of the urban roads (Global Service).
In particular, about 5.000 m length of resurfacing with E-VIA asphalts has been foreseen during year 2023 (see ISSUE 18 reply) in the Florence Noise Mitigation Plan.

(Projects funded under the Call 2014 onwards must use this format)



COMUNE DI FIRENZE

pon metro

DOCUMENTO PER LA VERIFICA DEL RISPETTO DEI CRITERI DI SELEZIONE E DEL CONTRIBUTO AI RISULTATI DEL PON METRO

Asse 6 - Ripresa verde, digitale e resiliente (REACT-EU FESR)
OS 6.1 Transizione verde e digitale delle città metropolitane
Azione 6.1.4 – Qualità dell'ambiente e adattamento ai cambiamenti climatici
Operazione codice locale progetto FI6.1.4 " Piano di Risanamento Comunale " - finanziato nell'ambito della risposta dell'Unione alla pandemia di Covid-19

Completamento del Piano di Risanamento Acustico Comunale - asfalto fonoassorbente compreso risanamento del sottofondo - tratto via Bolognese - REACTEU - cod opera 210291

Voci di spesa	Importo (€)	Note
Materiali inventariabili		
Materiali di consumo		
Costi per elaborazione dati		
Personale non dipendente da destinare allo specifico progetto		
Servizi esterni (compresi lavori)	395.481,57	(include lavori, oneri sicurezza non soggetti a ribasso e spese per incarichi esterni)
Missioni		
Convegni		
Pubblicazioni		
Costi forfettizzati e spese generali		
Consulenze e spese di deposito (per brevetti)		
Pagamento tasse di deposito o mantenimento (per brevetti)		
Costo del personale dipendente della PA		
IVA	90.163,94	
Altro	14.354,48	(include incentivo per funzioni tecniche, imprevisti, rilievi e indagini, allacciamenti e altre voci non incluse nelle precedenti elencazioni)
TOTALE	500.000,00*	

Tabella 1 – Quadro Economico dell'operazione

Completamento del Piano di Risanamento Acustico Comunale - asfalto fonoassorbente compreso risanamento del sottofondo - tratto via Senese - REACTEU - cod opera 210290

Voci di spesa	Importo (€)	Note
Materiali inventariabili		
Materiali di consumo		
Costi per elaborazione dati		
Personale non dipendente da destinare allo specifico progetto		
Servizi esterni (compresi lavori)	395.481,57	(include lavori, oneri sicurezza non soggetti a ribasso e spese per incarichi esterni)
Missioni		
Convegni		
Pubblicazioni		
Costi forfettizzati e spese generali		
Consulenze e spese di deposito (per brevetti)		
Pagamento tasse di deposito o mantenimento (per brevetti)		
Costo del personale dipendente della PA		
IVA	90.163,94	
Altro	14.354,48	(include incentivo per funzioni tecniche, imprevisti, rilievi e indagini, allacciamenti e altre voci non incluse nelle precedenti elencazioni)
TOTALE	500.000,00*	

*il totale della scheda progetto allegata al provvedimento di approvazione dell'OI è pari ad €

Completamento del Piano di Risanamento Acustico Comunale - pavimentazioni fonoassorbenti via delle Cascine, via Paisiello, via delle Porte Nuove, via del Ponte alle Masse

Voci di spesa	Importo (€)	Note
Materiali inventariabili		
Materiali di consumo		
Costi per elaborazione dati		
Personale non dipendente da destinare allo specifico progetto		
Servizi esterni (compresi lavori)	538.627,47	(include lavori, oneri sicurezza non soggetti a ribasso e spese per incarichi esterni)
Missioni		
Convegni		
Pubblicazioni		
Costi forfettizzati e spese generali		
Consulenze e spese di deposito (per brevetti)		
Pagamento tasse di deposito o mantenimento (per brevetti)		
Costo del personale dipendente della PA		
IVA	114.021,79	
Altro	15.065,02	(include incentivo per funzioni tecniche, imprevisti, rilievi e indagini, allacciamenti e altre voci non incluse nelle precedenti elencazioni)
TOTALE	667.714,28*	

1

But above all the project has important repercussions on the planning and programming activities of the Municipality. In 2024, the agglomeration of the Municipality of Florence will update the Noise Action Plan. The enhancement of electric mobility with the increase in shared vehicles, access limits in some areas of the city for non-electric vehicles, the increase in recharging stations and also the new asphalts tested with the LIFE E-VIA project will constitute an integral part of the new Plan.
During 2024 Florence will introduce the Green Shield Plan. It is a new organization of private mobility with the aim of not allowing the most polluting vehicles to approach the most historic and delicate parts of the city. Along with the growth of public transport, with the new tram lines, there will be new zones with a speed limit of 30km/h and sound-absorbing asphalt. Also in this case, the asphalt tested with the LIFE E-VIA project will be laid in residential areas and in those where a greater use of electric vehicles is assumed.
Another aspect to underline is that the LIFE E-VIA project formed the starting point for the participation of the Municipality of Florence in new projects financed by the European Commission. All of these activities form the basis for experimenting with innovative and sustainable activities to be included in the environmental policies of the Municipality. In fact, the LIFE SNEAK project is producing new results on noise containment with sound-absorbing asphalts in streets where the tramway is present together with private traffic. The HORIZON 2020 NEMO project has developed noise and air pollution monitoring systems that will help strengthen the Green Shield Plan and identify new roads to use the asphalt tested with the LIFE-EVIA project.

As described in the Report of Action B6, a new electric vehicles CNOSSOS coefficients database has been implemented during project lifetime and the coefficients for electric vehicles and asphalt have been found.
In particular, a new procedure to determine correction coefficients for electric vehicles CNOSSOS database has been developed. Sound pressure levels and vehicle pass-by speed have been measured to analyse the traffic noise component due to tyre-pavement interaction.
The outcomes have been preparatory for the determination of correction coefficients for electric vehicle CNOSSOS database, defined by the EU Directive 996/2015 and also in accordance with the recent update introduced by the Delegated Directive 2021/1226/EU, represented in the table below.

CNOSSOS Coefficients	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
$\alpha_{i,m}$	2.3	2.4	1.6	0.3	-0.7	-0.9	0.5	1.7
β_m	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Speed ref (km/h)	70	70	70	70	70	70	70	70

The parameters $A_{R,i}$, $B_{R,i}$, $\alpha_{i,m}$ and $\beta_{i,m}$ have been validated through software modelling using SoundPlan 8.2.
The coefficients were processed and tested on Via Paisiello.
The coefficients will certainly be used in the action plans, as the switch to electric vehicles will certainly be used in the action plans of several managers of public transport, particularly in agglomerations.
If there had been no extension on the deadline of the action plans (originally June 2023, now June 2024), they would have already been used.

In addition to what indicated in Action B8 report, (delivered 31.1.2023), Vienrose is using the new CNOSSOS coefficients for modelling electric vehicles in the simulations for the drafting of the action plans is in charge of, listed below.

Autovia Padana (Major Road Manager) - *contract n. 893/U dated 5/3/2021*
Comune di Modena (Agglomeration) - *contract n. 2266/2021 dated 29/10/2021*
Città Metropolitana di Firenze (Major Road Manager) - *contract n. 2213 dated 22/10/2021*
Comune di Parma (Agglomeration) - *contract n. 2553/2021 dated 3/11/2021*
Comune di Napoli (Agglomeration) - *contract n. 7/2021 dated 16/12/2021*
Provincia di Pistoia (Major Road Manager) - *contract n. 881 dated 8/8/2022*
Comune di Perugia (Agglomeration) - *contract n. 1299 dated 28/5/2022*
Comune di Padova (Agglomeration) - *contract n. 113 dated 7/12/2022*
Provincia di Reggio Emilia (Major Road Manager) - *contract n. 199 dated 14/3/2023*
Comune di Venezia (Agglomeration) - *contract n. 2042 dated 11/10/2022*

5. Best Practice lessons: briefly describe the best practice measures used and if any changes in the strategy employed could lead to possible adjustment of the best practices.

Concerning acoustic and non-acoustic performance of the road, and its impact on the receptors surrounding it, some best practice measurement methods were employed and described in the Report B4 and B6. Specifically, in reference to the EU GPP guidelines the L_{CPX} levels were acquired, pass by measurements were performed, weekly noise evaluation was performed, direct surveys on citizens were completed, 3D texture and mechanical impedance were evaluated and an acoustic modelization of the Pilot Area was obtained.

Several known techniques were adapted to the specifics of the problem, especially in the survey and pass by measurements. For the latter, the technical standards are not currently suited to the correct application in an urban environment and a new approach was described in the Project.

Regarding the process as a whole, an ante/post evaluation should be proposed and employed whenever it's important to have a clear evaluation of the impact of a new infrastructure. Currently, no clear standard is given in this regard for many different techniques as described, but it can be an important adjustment for the future (cfr Fig. 1 for reference).
Besides, the use of validation and certification techniques such as the CPX for the measurement of the noise emission by a road surface can become an important evaluation tool even in urban environments.

Life E-VIA asphalt was proposed **as a standard reference for the Piano Triennale di Bonifica dell'inquinamento acustico of Regione Lombardia.**
The Piano Triennale di Bonifica dell'inquinamento acustico of Regione Lombardia is the instrument provided for by Italian Law 447/95 and Lombardia Regional Law 13/01 for the regional management of noise pollution problems.
This means the optimised asphalt of the LIFE E-VIA project will be proposed as a reference in the Lombardy Region for low-emission pavements.
In the figure below, the cover page of the Piano, delivered and formally approved by Lombardia Region (Certificate of Regular Performance dated 2nd March 2023.


Regione Lombardia

MANDATARIO

Vie en.ro.se. ingegneria

MANDANTI

Università degli Studi di Milano-Bicocca
Dipartimento di Scienze dell'Ambiente e della Terra

ACCON

PIANO REGIONALE TRIENNALE DI BONIFICA DELL'INQUINAMENTO ACUSTICO

In the paragraph 6.5 of the "Three-year regional noise abatement plan", the planning tool produced by a grouping of companies coordinated by Vie en.ro.se. and adopted by the Lombardy Region in December 2022, the analysis of potential environmental impacts of plan Interventions is described; the LIFE E-VIA asphalt was suggested as the optimal standard, with reference to both noise abatement potential and LCC and LCA values.
The plan textually states:
With regard to the potential environmental impacts of "Three-year regional noise abatement plan" interventions, these are briefly described below with reference to the design, construction and operation phases. In general, when choosing the types of intervention (type of barrier for interventions that envisage the construction of noise barriers, type of asphalt for interventions that envisage the laying of low-noise pavements), the types of intervention that define adequate noise abatement levels will be valorised, but, at the same time, those that minimise the overall environmental impact of the work in relation to the different phases of construction, operation and decommissioning of the work. With regard to the assessment of environmental impact, in the process of choosing the intervention typology, the projects that demonstrate that they have selected the best typology based also on LCA and LCC analyses will be rewarded and valorised. For example, LCA/LCC analyses have recently been produced for some low-noise pavement types that have defined the environmental impact of the solution over its entire life cycle: see the results of the LIFE E-VIA project: https://life-evia.eu/ .

3.2 Life E-VIA asphalt will be proposed as a standard for noise mitigation in urban areas in Noise action plans currently under implementation in the following agglomerations, formally in charge of VIENROSE.

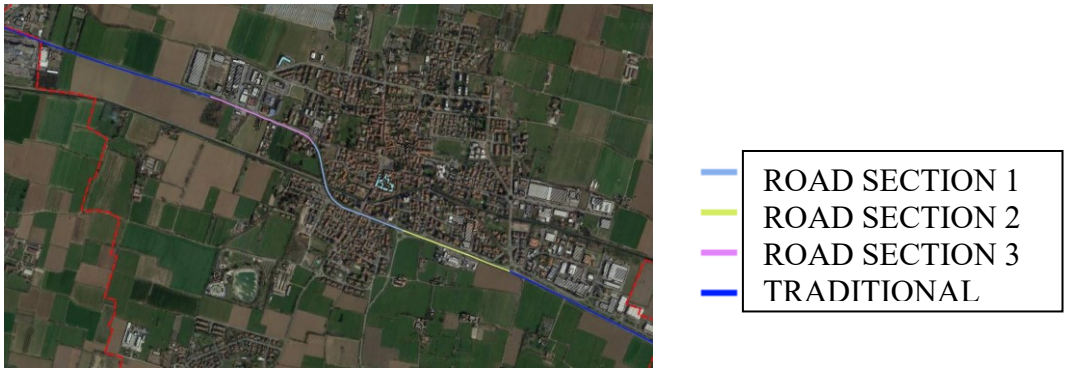
Comune di Modena (Agglomeration) - *contract n. 2266/2021 dated 29/10/2021*
Comune di Parma (Agglomeration) - *contract n. 2553/2021 dated 3/11/2021*
Comune di Napoli (Agglomeration) - *contract n. 7/2021 dated 16/12/2021*
Comune di Perugia (Agglomeration) - *contract n. 1299 dated 28/5/2022*
Comune di Padova (Agglomeration) - *contract n. 113 dated 7/12/2022*
Comune di Venezia (Agglomeration) - *contract n. 2042 dated 11/10/2022*

It will also be proposed in all other Plans for which VIENROSE will be responsible, during the fourth round of END appliction and will be proposed by the Municipality of Florence for the implementation of its Action Plan.

3.3 Life E-VIA asphalt was proposed, laid and tested in three road section of the Comune of Inzago (MI)

Inzago Noise Action Plan

The road on which the asphalt was laid is a local road, Strada Provinciale "Padana Superiore", in the municipality of Inzago, classified as F according to the Italian Highway Code, with a total length of 2.5 km. The resurfacing work was carried out at three different times on three sections of the same infrastructure.



Territorial overview of repaving interventions

Below the tables summarizing the noise reduction measured in correspondence of the receivers building facades (during night period).

Road Section 1 (year 2021)

Codifica Scenario di Misura	Periodo di riferimento	L'$_{Aeq}$ [dB(A)]	Attenuazione [dB(A)]
SC01	TR notturno	39,8	**5,5**
SC02	TR notturno	34,3	
SC03	TR notturno	40,9	**4,5**
SC04	TR notturno	36,4	

Road Section 2 (year 2022)

Codifica Scenario di Misura	Periodo di riferimento	L'$_{Aeq}$ [dB(A)]	Attenuazione [dB(A)]
SC01 (2021)	TR notturno	34.4	**5.3**
SC01 (2020)	TR notturno	39.8	

Road Section 3 (year 2023)

Codifica Scenario di Misura	Periodo di riferimento	L'$_{Aeq}$ [dB(A)]	Attenuazione [dB(A)]
SC03 (2023)	TR notturno	34,7	**6,2**
SC03 (2020)	TR notturno	40,9	

6. Innovation and demonstration value: Describe the level of innovation, demonstration value added by EU funding at the national and international levels (including technology, processes, methods & tools, nature management methods, models for stakeholder involvement, land stewardship models, organisational & co-operational aspects).

Without EU funding it is currently not very common to induce municipalities to employ new pavement technologies - not for lack of interest but also for lack of technological partners that can on one hand give a useful background on the potentialities and on the other assist in providing innovative products. In this regard, the municipality of Firenze is a role model spearheading the implementation of new approaches to the mobility for the sake of the citizen' health.
A wide and deep set of measurements (repeated in several sessions) was possible using the EU funding, in order to experimentally test the site of research: such an in-depth analysis require high technical specialisations and equipment, that in the process can be further refined and adapted to the actual problem posed by the Project and its transition from state-of-the-art to common use.
The action itself of measuring both the "passive" properties of the intervention such as noise emission and the "active" component that is the population impacted by it helped to grow the awareness of the problem, to have a better appreciation of what was achieved and to begin the process of understanding what can be achieved in the future (cfr Fig. 1 for reference).
In this framework the Guidelines issued in Action B6 are an effective model for stakeholder involvement, aiming to be a tool to further diffuse the innovations that the Project brought.
Finally, new cooperations between the project' partners can open new roads for further research and innovation.
Regarding the prototype test sections P and PCR built in Nantes, road surface properties and noise level reduction by comparison with standard impervious road surfaces have demonstrated the efficiency of the solution of low-noise surface in a relevant environment (i.e. the reference test track in Nantes). The technical demonstrators of tyre developed by CRD have also shown a good efficiency in terms of additional noise reduction on the prototype test sections. Thus, it can be considered that the solutions developed and tested within action B2 have raised a Technology Readiness Level (TRL) of 6. The success of the implementation and noise reduction of B1-based test sections in operational environment in Florence (trafficked road surface in urban area) leads to a TRL of 7 to 8 for the developed solutions (low-noise road surface and tyres).

7. Policy implications: Indicate any important achieved targets contributing to the future implementation, design or take-up of regional, national or European legislation. Please highlight any potential unintended impacts, bottlenecks or barriers to the implementation of your project due to regional, national or European legislation including recommended actions further to actions already taken to overcome these barriers.

The LIFE E-VIA project has achieved concrete results on the environmental, circular economy and citizen awareness fronts, leading to a significant EU added value. Specifically, it has contributed to the development of solutions (low-noise asphalt and tyres optimized for electric vehicles) for noise reduction in urban areas, the introduction of specific CNOSSOS coefficients for modeling the contribution of electric vehicles in the context of noise mapping regulated by the European Environmental Noise Directive (END), the use of recycled crumb rubber in the

structure of innovative asphalt in a circular economy perspective, and citizen awareness of noise, health, and electric mobility issues.
Even if the percentage of recycled crumb rubber (w/w) is not so high, it is highlighted that the outcome in terms of circular economy is expected to be appreciable. Indeed, when it comes to the selection of the best performance attention must be paid to the balance between sometimes concurring instances (e.g., expected life and mixture workability). Not only is the selected percentage very important when extending the treatment to many roads, but the success of such a new technology depends on its ability to comply with many requirements (holistic approach). The selected mixture has positive consequences on many performances (e.g., noise, waste reduction) and performs adequately from many points of view, including safety, noise reduction, waste reduction, and workability of the mixture during production. Importantly, this last factor is crucial from a technical and environmental standpoint. It would be easy to add more crumb rubber and increase the production temperature without controlling (and revealing!) this detail. In contrast, all the data and parameters were progressively tuned in order to make it possible to have a mixture that is really easy to produce and implement. The plentiful replications of the solution (in Florence and in other regions) testify that this new technology is easy to implement and meets plant owner expectations. This complies with having market-oriented solutions.
The following paragraphs report the assessments made in relation to the various environmental aspects, based on the scenario occurred during the project, namely:
- the lower percentage of electric vehicles in the total traffic flow compared to what was foreseen when the proposal was drafted
- the lower percentage of crumb rubber that it was possible to include in the mixture, determined by the need to ensure adequate safety performance and durability of the asphalt.

Despite this, the expected result referring to the priority on which the proposal was built, i.e. the reduction of environmental noise in densely populated urban areas, was largely achieved in terms of both the emission levels measured at the receivers' facades (overall reduction of noise emitted) and the asphalt/tyre optimised interaction (reduction of wheel/asphalt noise)

- Waste management. To this end, it is noted that the mass of non-appropriately managed waste (t/y) which turned out to be lower than expected since the addition of high quantities of crumb rubber, CR, to the mixture was not possible to the negative consequences in terms of swelling and increase of the viscosity of the asphalt binder. This explains the reduction in terms of both tons per year and in terms of cubic meters of landfills saved. It is noted that in this case, the reduction of waste is due to the crumb rubber of end-of-life tyres that are recycled in the pavement. Consequently, for waste management, the benefits are not associated with higher percentages of electric vehicles. Note that the relevant figures are explained below.

Reduced resource consumption-aggregates. The saving of mineral aggregate (t/y) was lower than expected. In fact, even if multiple interventions have been scheduled, the reduction in the use of crumb rubber as an additive in the bituminous mixture has caused the consequent reduction in the figure that refers to the “reduced resource consumption”. For reduced resource consumption, this is due to the reduced consumption of mineral aggregates, linked to the use of crumb rubber from end-of-life tyres. Consequently, also in this case, it is noted that this indicator (saving of mineral aggregate) is linked to pavements and not to the percentage of electric vehicles. Note that the relevant figures are explained below (i.e., Assessing the total mass of HMA (about 42t); Assessing the total mass of CR needed (about 0.8t).

- Reduced resource consumption-energy. In this case, the values (amount of energy consumed per year, MWh/year) are due to the use of crumb rubber in the friction course mixture. The derivation of this value depends on the following baseline: HMA tons, CR, aggregate density, dimensions, CR percentage (w/w). Furthermore, they depend on the fact that recycling the CR is a viable strategy and has many advantages with respect to stockpiling/landfilling the tyres and or using them to recover energy. Note that the relevant figures are explained below.

- Air quality and emissions. The PM (g/day) reduction was lower than expected. In fact, the reduction of PM due to the decrease in the use of diesel cars is just at the beginning of a cycle. Over the last years, the decrease in the number of diesel cars has been unsatisfactory and lower than predicted. By referring to the benefits in terms of air quality and emissions, it is noted that the positive outcomes mentioned above for the pertaining KPI derive solely from the increased percentage of electric vehicles. It is noted that for PM, positive consequences are expected also from the use of the pavement technology used in Via Paisiello. Indeed, in this case, further positive outcomes are envisaged because it is expected that CR-added mixture will have higher durability and this could imply the reduction of the amount of PM emissions over time because of the diminished number of maintenance operations per given period of analysis. Note that the relevant figures are explained below.

- CO2 reduction. The reduction of CO2 emissions (Kg/Km per person) was lower than expected. In fact, it is noted that, for example, over the years 2019-2022, the increase in the number of electric vehicles in Italy has followed quite an unsatisfactory trend. By referring to the benefits in terms of reduction of CO2 emissions, it is noted that these positive outcomes assessed in the pertaining KPI derive solely from the increased percentage of electric vehicles. However, for pavement-related consequences, it is possible to observe that further positive outcomes are envisaged due to the higher expected life of CR-added mixtures. Note that the relevant figures are explained below.

(Projects funded under the Call 2014 onwards must use this format)

Deliverables list

Number	Title	Brief description	Related Action	Due date	Actual date of delivering	Public document (P), Confidential document (C)
1	Dissemination Plan	Document explaining the overall dissemination strategy	D1	30/09/2019	30/09/2019	P
2	Monitoring Protocol	Document including all the required knowledge for the effective project's management	E1	30/09/2019	30/09/2019	P
3	Life E-VIA website	Preparation of first contests and website launching	D1	31/12/2019	31/12/2019	P
4a	Technical Report Actions A1, A2, A3	Document including the update state of the art concerning electric vehicles and their noise emissions together with people's perception	A1	31/03/2020	12/06/2020	P
4b	Technical Report Actions A1, A2, A3	Document including the update state of the art concerning recent quiet pavement technologies and their performance over time	A2	31/03/2020	09/06/2020	P
4c	Technical Report Actions A1, A2, A3	Document including the update state of the art concerning the tyre role in the context of EV and ICEV	A3	31/03/2020	31/07/2020	P

5	B3 Tender specification definition	Details about the tender procedure for pilot asphalt paving added as Annex to the B3 Report	B3	28/02/2021	19/04/2022	P
6	B1 Report	Report on asphalt design	B1	31/03/2021	29/04/2021 (first version) then updated until 30/11/2022 with the final version	P
7	B2 Report on prototype implementation and tyre/road noise performances	Report on the selection of the optimal combination of road surface and tyre in order to reduce noise in urban area, prior to the implementation of the pilot test section in Florence (Italy) within Action B3	B2	30/11/2021	31/05/2022	P
8	Video of prototype construction	Video about the realization of the prototype in Nantes	D1	31/12/2021	30/06/2021	P
9	B3 Report about the implementation in the pilot area	Report about the description of the pilot case realization in Florence	B3	31/03/2022	19/04/2022	P
10	B5 Report	Report about soundscape perception in different scenarios	B5	30/04/2022	31/12/2022	P
11	3 press conferences	Press conferences about project's outcomes	D1	31/07/2022	07/10/2022	P
12	B6 Report	Report about the evaluation of EV emissions	B6	30/09/2022	31/01/2023	C
13	Guideline about the use	Document about the use and	B6	30/09/2022	31/01/2023	P

	and application of the methodology output	application of the methodology output				
14	B4 Report	Report about results of the track efficiency test in the pilot area	B4	31/10/2022	31/01/2023	C
15	1 Article published in an open access top ranked journal	Article published in an open access journal NOISE MAPPING: "Road surface influence on electric vehicle noise emission at urban speed"	D2	31/12/2022	30/06/2021	P
16	1 Article for local magazines about EV Festival	Article published on ANSA.it	D2	31/12/2022	31/10/2022	P
17	1 radio campaign	Radio campaign about project's development	D1	31/12/2022	Not achieved	-
18	15 Noticeboards in English language	Noticeboards in English about different project activities and outcomes	D1	31/12/2022	31/01/2023 (13 on 15 realized)	P
19	2 open sources articles on peer-reviewed international journals for dissemination of the obtained results	1 Paper "with editor" on Construction and Building Materials journal "Road pavements' dynamic stiffness measurements by means of impact hammer in a non-resonant configuration" And 1 Paper published in the Romanian Journal of Transport infrastructure, peer-review	D2	31/12/2022	31/01/2023	P

		open-access journal referenced by JCI.				
20	3 Articles for peer-reviewed open access journal (e.g., Materials, MDPI and Applied Acoustics	1 Paper published on Open Access Sustainability 2020 about the sustainable pavement materials for the urban roads. 1 Paper published on the special issue "Understanding the impact of emobility on urban noise pollution" of the Journal "NoiseMapping" 1 Paper published on Sustainability journal "Adjusted Controlled Pass-By (CPB) method for urban road traffic noise assessment" answers to reviewers sent	D2	31/12/2022	31/01/2023	P
21	5 Noticeboards in French language	Graphic documents in French about different project activities and outcomes	D1	31/12/2022	30/06/2022	P
22	5 Noticeboards in German language	Graphic documents in German about different project activities and outcomes	D1	31/12/2022	30/09/2022	P
23	5 Noticeboards in Italian language	Graphic documents in Italian about different project activities and outcomes	D1	31/12/2022	30/09/2022	P

24	Proceedings of workshop in Reggio Calabria and students' contest awarding (USB keys) – 50 copies	Materials about the workshop organized in Reggio Calabria and about students' contest directly published on the project's website	D2	31/12/2022	31/01/2023	P
25	Report on yearly participation in INAD (3 reports 2020, 2021, 2022)	Reports in Italian with a summary in English about the INAD initiative and the communication to schools about the project realized only in 2021 and 2022 due to the cancelling of the initiative in 2020 because of the spread of the Covid-19 pandemic	D1	31/12/2022	31/07/2022	P
26	1 promotional video about EV Festival	Changed in a video about the pilot asphalt laying together with interviews	D2	31/01/2023	30/06/2021	P
27	After LIFE Plan	Document about initiatives foreseen in the After LIFE period	E2	31/01/2023	31/01/2023	P
28	B7 Report	Report about tyres performances	B7	31/01/2023	31/01/2023	C
29	B8 Report containing Replicability and Transferability plan	Report about Replicability and Transferability strategy with annexed Exploitation & business plan for asphalts	B8	31/01/2023	31/01/2023	P
30	B8 Technology exploitation plan for the transfer of EV tyre noise	Document containing the exploitation plan for tyres	B8	31/01/2023	31/01/2023	C

	optimization technology into the market by CRD					
31	C1 Report	Report about values obtained for indicators and KPI and calculation methods	C1	31/01/2023	31/01/2023	P
32	C2 Report	Report about LCC and LCA analysis	C2	31/01/2023	31/01/2023	P
33	Exploitation Plan (Tyres > CRD / Asphalts > UNIRC)	Synthesis of information reported in the other exploitation documents	E2	31/01/2023	31/01/2023	P
34	Final project report	Final project report	E1	31/01/2023	31/03/2023	C
35	Layman's report	Disclosure document about project's results	D1	31/01/2023	31/01/2023	P
36	17 different scientific papers to be presented in national /international congresses	Presentation in national and international congresses about project's outcomes	D2	31/03/2023	31/01/2023	P
37	Proceedings of Final Event in Florence (USB Keys) – 400 copies	Materials about the final event directly published on the project's website	D2	31/03/2023	31/10/2023	P