VILLE DE PARIS

COOL & LOW NOISE ASPHALT PROJET *LIFE*

LAYMAN'S REPORT

A LOOK BACK AT 5 YEARS OF INNOVATION TO IMPROVE THE LIVES OF PARISIANS

BRUITPARIF · EUROVIA · COLAS · LIED PIERI · MAIRIE DU HUITIÈME · MAIRIE DU 15 PARIS

This project is provided by the European fund *Life*

PROJECT IDENTITY CARD

Project location :
Paris - 3 pilot sites
(rue Frémicourt, rue Lecourbe and rue de Courcelles)

Project start date :
2017

Project end date :
2023

Total budget :
2.3 M€ invested including 1.3 M€ of European funding

Financial partners :
LIFE fund LIFE16/ENV/FR/000384 and the City of Paris

Immediate beneficiaries :
1000 Parisians impacted

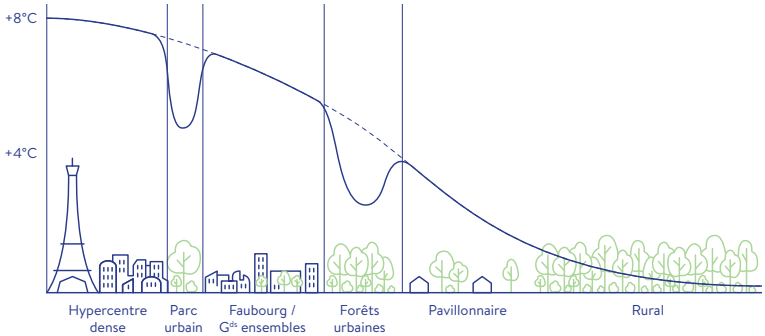
FOREWORD

In major European cities, 37 million people are exposed to noise levels that are dangerous to their health. In Paris, 22% of the population is affected. In parallel with this problem of noise pollution, studies have shown the increasing intensity and duration of heat waves in Europe over the past 30 years. These episodes are amplified by the phenomenon of Urban Heat Islands (ICU) characterized, in urbanized areas, by air and surface temperatures higher than those in rural areas. These two phenomena, especially when combined, are harmful to the health of residents of these urban areas.

Co-financed by the European Union as part of the LIFE fund and the City of Paris, the Cool & Low Noise Asphalt project benefits from a partnership with the technical evaluation center for the sound environment in Ile-de-France (Bruitparif), the Colas and Eurovia companies, the Paris Cité University (LIED PIERI). It is implementing new bituminous road surfaces on 3 Parisian pilot sites. Their innovative phonic and thermal properties will be evaluated until 2028.

Objectives: reduce heat and noise emissions, gradually develop the operation throughout the City of Paris, then on a European scale. This ambition is part of the adoption by the City of Paris of a range of innovative solutions to combat the effects of global warming and urban densification:

- encouragement of eco-friendly and electric motorization,
- revegetation,
- improvement of the sound and thermal properties of materials used on roads.



Temperature curve depending on urbanization
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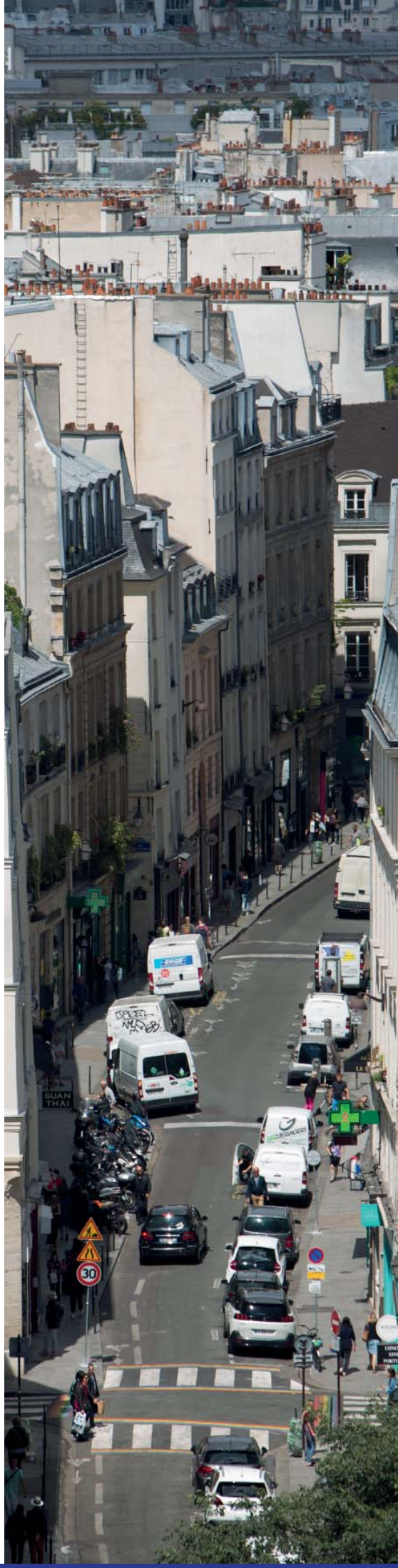
SUMMARY



2,3 M€
invested including €1.3 million of European funding.

3
pilot sites

600 m
of coverings installed

1000
Parisians impacted

3
innovative coatings

2
public works companies

1
noise observatory

1
university

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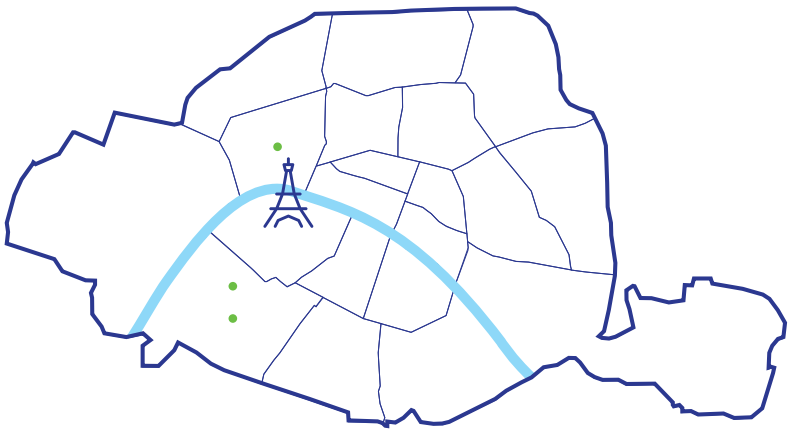
PROJECT INTRODUCTION

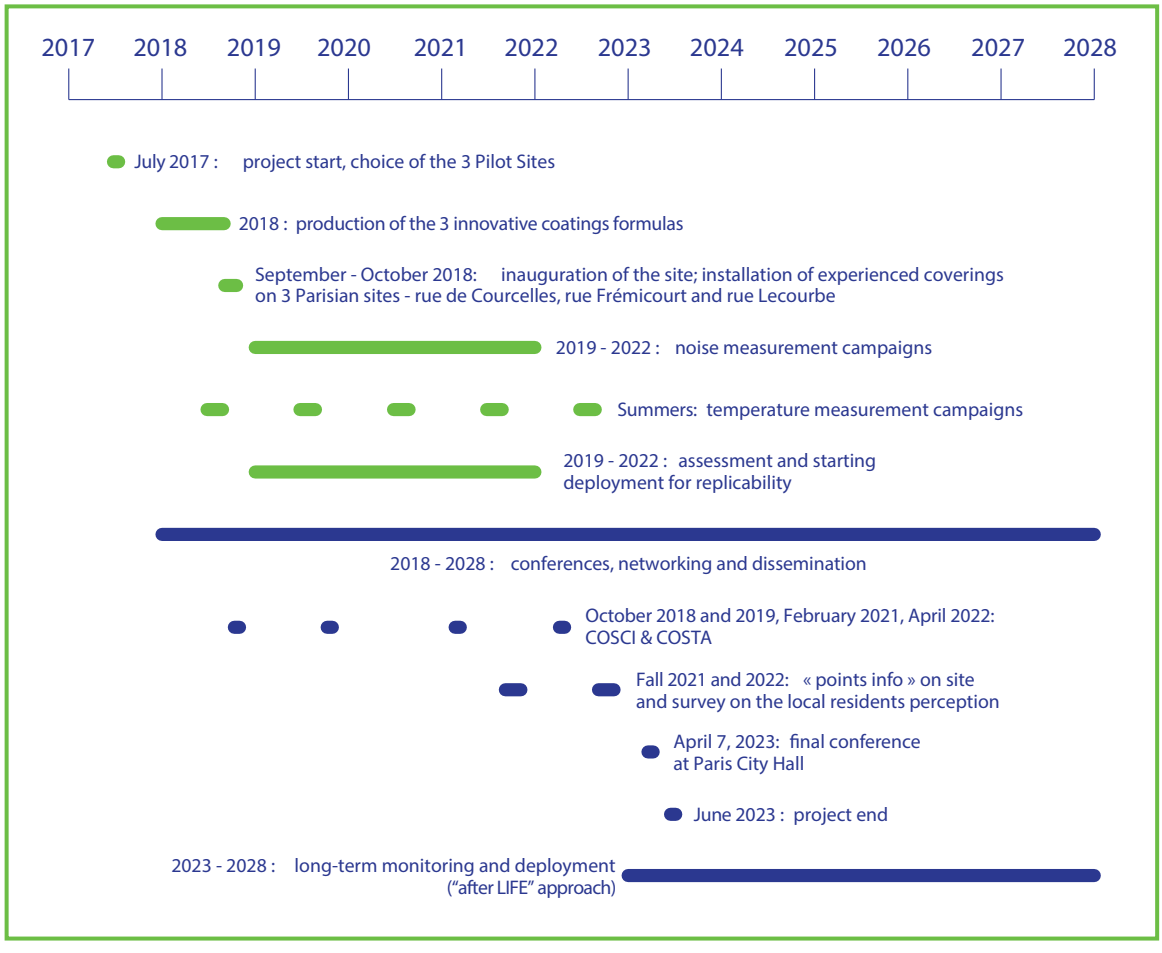
1. WHAT IS THE LIFE COOL & LOW NOISE ASPHALT PROJECT?

The LIFE COOL & LOW NOISE ASPHALT project aimed to reduce noise from road traffic in the city (rolling noise) and to reduce the intensity of UHI by developing innovative formulas for bituminous coatings which have phonic and thermal properties, while maintaining a good mechanical durability.

The results of the evaluations show that the objectives identified at the start of the project were achieved in the majority of cases, and that the LIFE COOL & LOW NOISE ASPHALT solutions can be included among the possible responses for environmental adaptation and noise reduction, in an integrated approach to improve the quality of life for everyone in an urban environment.



2. THE PROJECT AGENDA



EXPERIMENTATION AND EVALUATION

ANIMATION AND COMMUNICATION

Reduce noise pollution generated by road traffic on urban roads at 50 km/h

Mitigating the effect of UHI by spraying non-potable water, retained on the surface by the innovative coatings

Use clear aggregates to limit heat absorption

Facilitate the installation and maintenance of the proposed coverings

Limit additional costs to a maximum of 10% compared to a conventional coating

3. THE OBJECTIVES SET IN 2017

	OBJECTIVES		
	2018 -just after installation	**2021 - last measurement campaign before the project end**	**2027 - 5 years after the project end**
Phonic performance			
Reduction in rolling noise (Lr) compared to the existing one (Lri)	< = - 5 dB (A)	< = - 3 dB (A)	< = - 1 dB (A)
Reduction in rolling noise (Lr) compared to the reference coating (ref)	< = - 3 dB (A)	< = - 2 dB (A)	< = - 1 dB (A)
Reduction in facade noise (Lf) compared to the existing noise (Lfi)	< = - 3 dB(A)	< = - 2 dB (A)	< = - 1 dB (A)
Reduction in facade noise (Lf) compared to the reference covering (ref)	< = - 2 dB (A)	< = - 1 dB (A)	< = - 0,5 dB (A)
Thermal performance (variations depending on climatic conditions)			
Reduction in air temperature at 1.5 m height (pedestrian height) through watering compared to existing dry pavement	- 1,5 to - 2,5 °C	- 0,5 to - 1,5 °C	- 0,5 to - 1,5 °C
Reduction in temperature felt at 1.5 m height (pedestrian height) thanks to watering compared to the existing dry pavement	- 2,5 to - 3,5 °C	- 1,5 to - 2,5 °C	- 1,5 to - 2,5 °C
Reduction in air temperature at 1.5 m height (pedestrian height) in the summer period by albedo effect compared to the existing and the reference covering	- 1 to - 2 °C	- 1 to - 3 °C	- 1 to - 3 °C
Reduction in temperature felt at 1.5 m height (pedestrian height) in summer due to albedo effect compared to the existing one and the reference covering	- 2 to - 3 °C	- 2 to - 4 °C	- 2 to - 4 °C
Durabilité physique et géométrique (microrugosité et macrorugosité)			
SMA and BB phonic coating	VEP > 65 PMT > 1,4	VEP > 50 PMT > 1,0	VEP > 50 PMT > 0,8
Poured asphalt	VEP > 65 PMT > 0,7	VEP > 50 PMT > 0,5	VEP > 50 PMT > 0,5

4. THE PROJECT LEADERS

- Ville de Paris
- Bruitparif
- Mairie du 8e
- Mairie du 15e
- Université Paris Cité Lied Pieri
- Colas
- Eurovia

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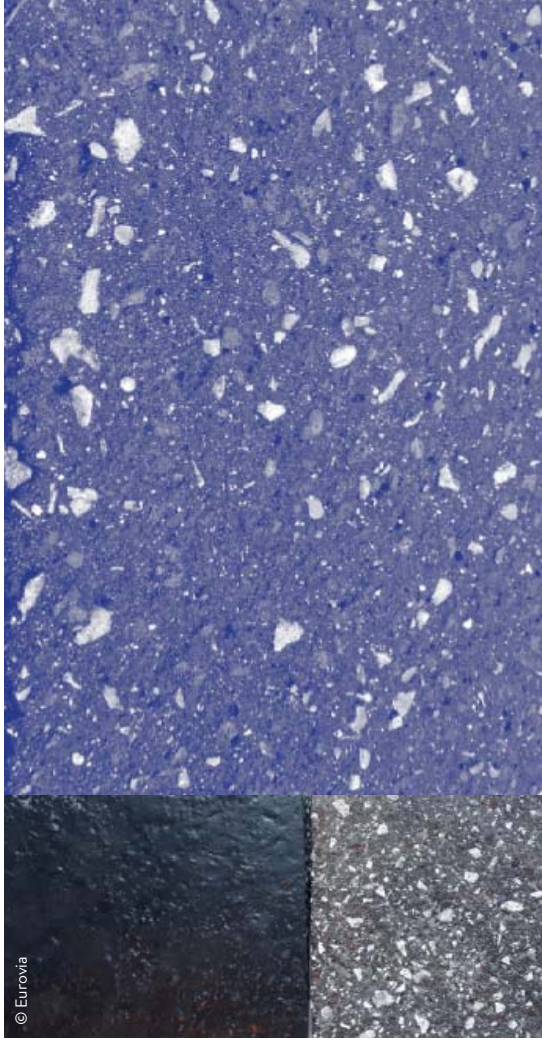
METHODS AND TECHNIQUES

1. 2018 : THE FORMULATION OF INNOVATIVE ASPHALT MIXES



THE FORMULATION DEVELOPED BY EUROVIA: PUMA

As part of this project, EUROVIA has developed an innovative formula for hot-cast asphalt road surfacing.

› **The product formulation was carried out on PUMA asphalt pavement. The mechanical study was carried out on the PUMA bonding coat/asphalt complex in order to solve the constraints of the pilot site (implementation of a thin layer of coated material then the PUMA coating without reworking the foundation).**

From an economic point of view, the maximum additional cost compared to the reference technique must not exceed 10%.

To meet the sound and thermal objectives, the choice was made to combine the albedo properties of a pale aggregate and the porosity of light aggregate. With the principle that pale aggregates limit the absorption of solar energy while porous aggregates will provide water retention and absorption of rolling noise. To guarantee an immediate effect of the product, the choice was made to carry out a surface treatment by shot blasting.

Through this choices analysis, eleven different formulations were produced by varying the nature of the constituents as well as their proportions.

The different formulations were characterized on mechanical, phonic and thermal aspects through a large battery of tests, in order to classify them and select the optimal PUMA formula.

Mechanical behavior
of the product was studied using five laboratory tests. The indentation was measured to verify the good punching behavior of the product. The handling of the PUMA seal was also examined to verify its possible mechanical and manual implementation. Since shot blasting was carried out on the product, it was necessary to check that the specimen undergoing the surface treatment did not show any degradation. We also characterized the product from an adhesion point of view with the determination of the average depth of the surface macrotexture. Finally, given the traffic and the presence of a Bus corridor on the pilot site, we verified its durability and its resistance to rutting through the Hamburg test.

Phonic behavior
was understood through two tests. The Kundt Tube which allows the measurement of the absorption coefficient and the surface impedance of acoustic materials. As well as the surface quantification of porous aggregates using an image processing method to determine their concentrations on the surface of the coating.

Thermal behavior
was evaluated in two quantities, colorimetry and albedo. The colorimetry of a coating corresponds to the eye's sensitivity to light intensity (L*) and the color nuances a* (green <-> red) and b* (blue <-> yellow). The albedo (a) of a surface measures the extent to which a surface receiving light reflects this light: it is in fact the reflective power of a surface.

THE 2 FORMULATIONS DEVELOPED BY COLAS: BBPHON+ AND SMAPHON

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COLAS has used all its know-how to develop two innovative asphalt formulations by optimizing classic formulations, adding new performances on acoustic level, durability, reduction of UHI effects and at controlled costs.

LThe objective being both to respond to the issues of durability of coatings in urban environments as well as to the expectations of local residents in terms of sound and thermal comfort.

These innovative products are :

- **BBphon+ (BB 0/6) with high acoustic quality. This formula was developed in order to reduce significantly the level of traffic noise.**
- **SMAphon (BB 0/10) allows acoustic gain in the most restrictive urban areas.**

The pale aggregates used in the design of these two coverings contribute to reducing the absorption of incident solar radiation. Stripping the black bituminous binder due to traffic reveals the natural color of the aggregates.

These mix formulas have been validated under the most severe conditions used to date at European level.

IMPEDANCE TUBE TESTING TO DETERMINE ACOUSTIC PERFORMANCE

The two-microphone impedance tube test makes it possible to determine the absorption coefficient **α** of a coating.

At one end of the tube, a speaker generates an incident sound wave. At the other end of the tube, the tested cylindrical specimen of a defined thickness (manufactured using the Gyropac) is placed in a sample holder. The incident wave is partially reflected by the test specimen, which forms a standing wave. The signal is decomposed into an incident component and a reflected component. These are determined from the relationship between the sound pressures measured at two locations by the microphones.

The absorption coefficient is calculated from the transfer functions of the signal, its incident part and its reflected part.

THE CANTABRO TEST MODIFIED TO MEASURE IMPACT RESISTANCE

This non-standardized test gives an indication of the overall resistance of the asphalt to the surface stresses that it is likely to undergo.

As part of the protocol developed by the Colas Core Center, 4 test pieces are made using the normal Duriez type molding method (80 mm diameter mold, introduced mass of 1000 g). Once unmolded, the test piece is measured and weighed to the nearest 0.1 g under the same conditions as for the water sensitivity test. We can thus determine the average void percentage of the series of test pieces..

As part of the LIFE COOL & LOW NOISE ASPHALT project, the test pieces are put in an enclosure at - 10 °C for at least six hours. Then, they are placed one by one in a Los Angeles drum without abrasive load and undergo for 500 revolutions wear. After the test, the test piece is weighed again to the nearest 0.1 g. The modified Cantabro wear loss is the mass loss reduced to the initial mass, expressed in%.

The final mass loss is the average of the four values obtained. The results are interpreted in a comparative way between the different formulas tested.

$$P = 100 \times \frac{(M_1 - M_2)}{M_1}$$

THE PLUCKING TEST (DARMSTADT SCUFFING DEVICE) TO MEASURE SHEAR RESISTANCE

The test simulates “plucking”, a term designating the tearing of aggregates from the surface of a bituminous coating plate, caused by the shearing passage of a tire (3 bars). This is lowered onto the plate with a defined static force. The plate performs a combined rotation and back and forth movement in the horizontal direction, which results in forces under the tire simulating the effect of tangential traffic.


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Duriez test tube after Cantabro test (500 turns of Los Angeles drum)

Two different procedures are applied one by one on each plate :

- The CRR (Belgian Road Research Center) SB250 v3.1 procedure is carried out at 25°C, with a support force of 1000 N and 10 cycles (five series of two cycles). A cycle corresponds to half a turn of the plate clockwise then half


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© COLAS - Joachim Bertrand

Machine de plumage du Core Center de Colas

a turn counterclockwise, and five round trips of the plate, simultaneously. After each series of cycles, the torn aggregates are collected using the vacuum cleaner integrated into the machine, in the collection bin. The mass loss is determined by weighing these recovered aggregates.

› The second procedure is “severe”. At 25°C, the machine performs 50 cycles (five series of ten cycles) with a support force of 2000 N.

The result expressed in g/m² (mass loss/damaged surface) is the average on four 26x26x5cm3 plates..

COLORIMETRY TO KNOW THE CLARITY OF THE AGGREGATES

During the formulation study, clarity measurements were made on different aggregates, using a 45/0 geometry colorimeter using a D65 illuminant at an angle of 10° for the observer, according to a protocol developed by the LEM-VP (Public Space Laboratory of the City of Paris).

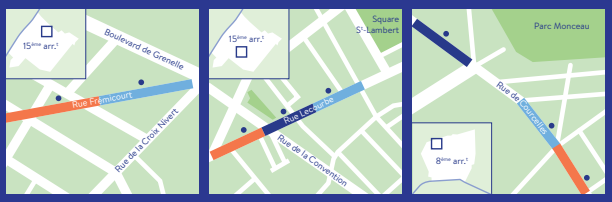
The trichromatic components L*, a* and b* are measured (CIE 1976, standard NF X 08-000). The measurements are carried out on a thick bed of 6/10 aggregates, previously washed and dried, corresponding to a test portion of 4-5 kg. (50 measurements: repetitions of 5 measurements then mixing the aggregates).

2. SEPTEMBER - OCTOBER 2018 : THE CONSTRUCTION SITE AND THE INAUGURATION

LES 3 SITES D’EXPÉRIMENTATION

Diagram of the three pilot sites for testing bituminous coatings

From left to right : rue Frémicourt, rue Lecourbe and rue de Courcelles



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INAUGURAL WALK ON OCTOBER 16, 2018


© COLAS - Joachim Bertrand


Rue de Courcelles
© COLAS - Joachim Bertrand


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IN THE PRESS


Rue de Frémicourt
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3. MEASUREMENT METHODOLOGIES

A. THERMAL MEASUREMENTS

HEAT FLOW MEASUREMENT AND TEMPERATURE, ALBEDO EFFECT OF THE COATING, WATERING

Strengthening the presence of water in the city has immediate benefits for cooling the human body. Relying on the existence of a non-potable water network, the LIFE COOL & LOW NOISE ASPHALT project enabled the implementation of an experimental protocol for watering streets during hot days.

Each portion (albedo or watered) is equipped with a weather station in its center. These stations measure all the parameters necessary to estimate the thermal comfort of pedestrians :

- At 1.5 m: air temperature and relative humidity, black globe temperature.
- At 4 m: air temperature and relative humidity, wind speed and net radiation.

Road thermal sensors

The black globe temperature makes it possible to quantify the radiant atmosphere on comfort (a sort of temperature “in the sun” as opposed to the temperature “in the shade”).

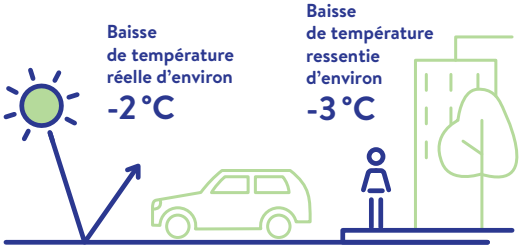
The UTCI indicator is an outdoor thermal comfort indicator which takes into account various factors: air temperature, relative humidity, wind speed and average radiation temperature (which makes it possible to characterize the surrounding radiative environment) . Certain hypotheses are also made about clothing, metabolism, etc. in order to be able to calculate an equivalent air temperature for reference conditions.

Regarding the evaluation of heat flows in the pavement material, each of the portions is equipped with a temperature and heat flow sensor in front of the station, at approximately 5 cm depth.

5 heat flow and temperature measurement sensors were installed under the asphalt covering :

- 2 rue de Courcelles
- 2 rue Lecourbe
- 1 rue Frémicourt

OBJECTIF À 3 ANS



WATERING PERIODS

Cooling streets by sprinkling non-potable water naturally targets periods of heat waves. In Paris, the heatwave criterion corresponds to a minimum temperature above 21°C and a maximum temperature above 31°C, on average over 3 consecutive days. In order to increase the number of tests, watering is triggered as soon as the average summer temperatures (Tmin ≥ 16 °C and Tmax ≥ 25 °C) are exceeded in calm weather and clear skies. The protocol is triggered according to the weather forecast, in the morning from 7 a.m. to 11:30 a.m., with spraying every 1.5 hours, and in the afternoon from 2 p.m. to 6:30 p.m., every 30 minutes.

Heatwave alert level
$T_{air}^{max} > 31$ °C
$T_{air}^{min} > 21$ °C

Pavement watering criteria
$T_{air}^{max} > 25$ °C
$T_{air}^{min} > 16$ °C
Wind speed < 10 km/h
Cloud cover: sunny

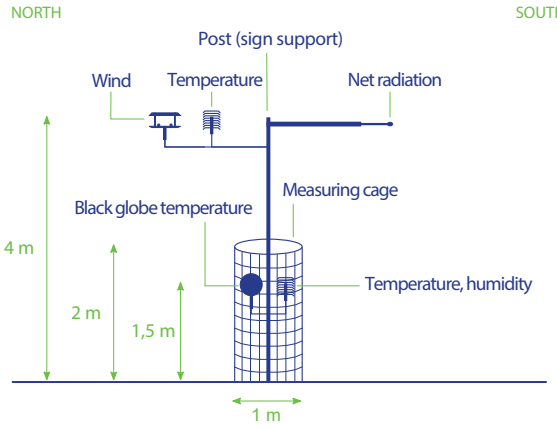
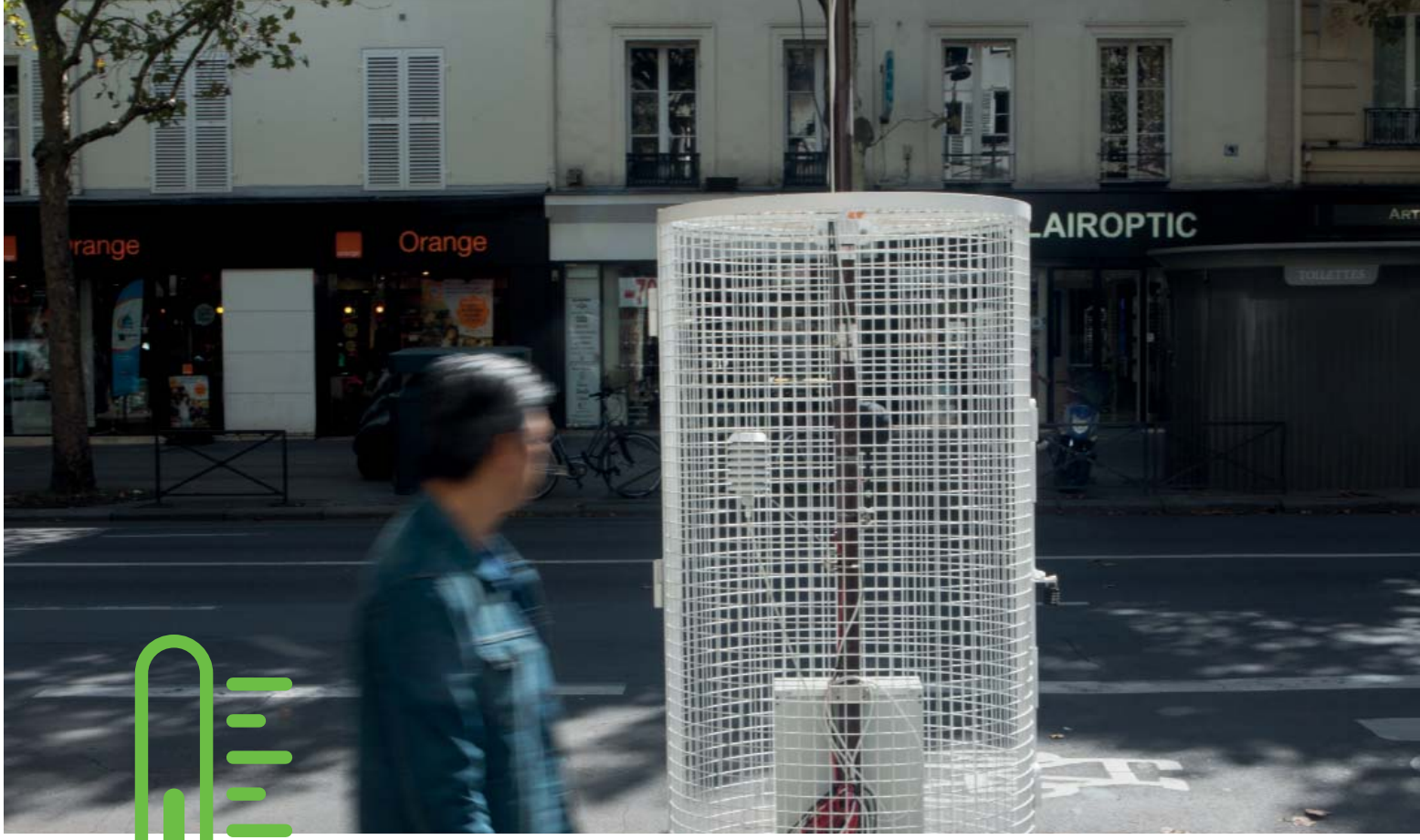


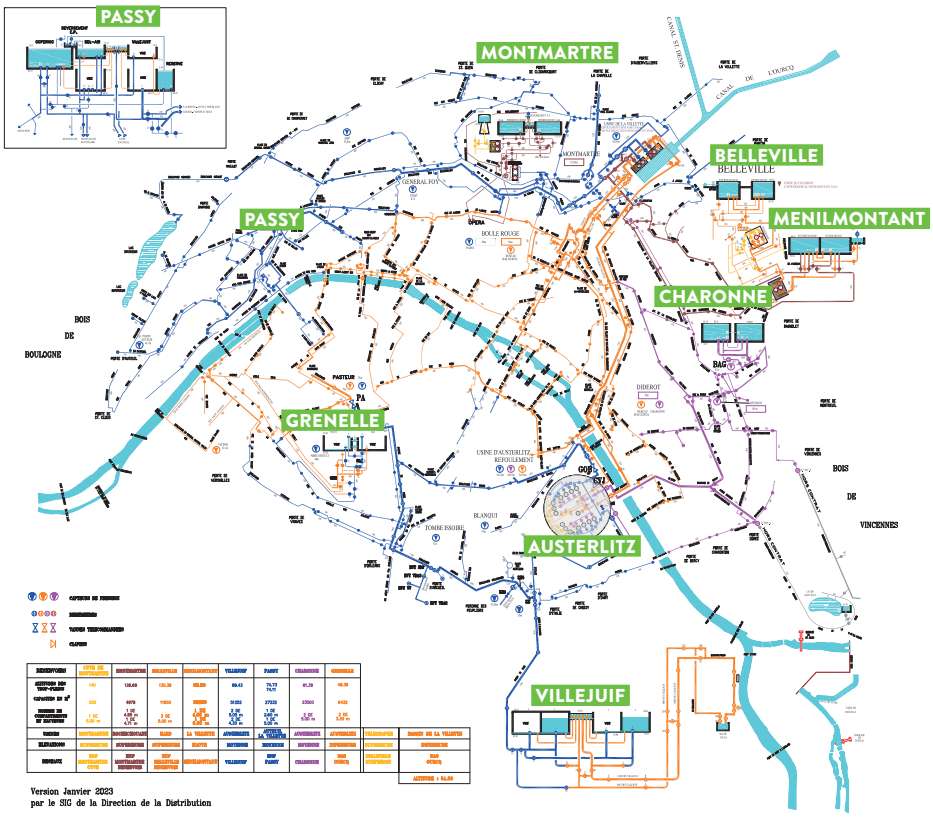
Diagram of a weather station



THE PARISIAN NON-POTABLE WATER NETWORK

Urban watering can be implemented in Paris thanks to the use of its non-potable water network.

The non-potable water network, with an approximate production capacity of 500,000 m3 of water per day but operated at only 30% of its total production capacity, is today mainly used to clean roads, watering the city's parks and gardens, feeding the lakes and rivers of the Bois de Boulogne or even cleaning the sewers. The water in this network comes mainly from the Ourcq canal and the Seine. It is coarsely filtered but is not subject to any chemical treatment.



B. ACOUSTIC MEASUREMENTS

Two types of acoustic measurements are carried out. The first aim to compare sound levels on building facades, between innovative and reference coverings. These are continuous measurements, which are the subject of annual reports. The seconds directly relate to the noise of the tire on the road (also called “CPX measurements”). This is an acoustic acquisition system installed on an electric car.

These are one-off measurements carried out once a year, during the night. Their objective is to know the intrinsic performances of the coatings and to follow their evolution over several years, in order to study the durability of their performance.

THE CPX METHOD

The principle of the CPX near field method is to measure continuously and at constant speed the sound level LVRef and the acoustic homogeneity τVRef of a road surface by measuring the contact noise between the tire and the road and thus evaluate its acoustic performance.

It is based on three simultaneous acquisitions: the Leq indicator of tire-road contact noise, the speed of the test vehicle and the distance traveled in the test zone. The Leq measurement is carried out using three microphones placed near the tire. The instantaneous speed of the vehicle is measured by an optical sensor which also makes it possible to evaluate the distance traveled.

The measurement system is an assembly composed of a test vehicle equipped with a specific assembly for the acoustic acquisition chain coupled to an optical sensor and a meteorological station.

The vehicle is a Renault ZOÉ life. This electric car allows us to cope with the noise of a combustion engine. Before each test we must equip it with the set of measuring tires because this tire must be stored to limit the evolution of its characteristics. The bar allows microphones to be fixed to measurement positions while limiting aerodynamic noise. The microphones are connected to the acquisition card located inside the vehicle. The optical sensor is also connected to the acquisition card and is placed at the rear of the vehicle. It allows the measurement of the instantaneous speed and the distance traveled during the test.

The measurements were carried out every year during the summer period.

NOISE MEASUREMENTS ON THE FACADE

Continuous measurements are carried out using permanent stations equipped with class 1 sound level meters from RION, model NL52. These stations are placed on supports such as lighting poles, specific or temporary poles or on any facade element likely to accommodate a measurement system for a long period.

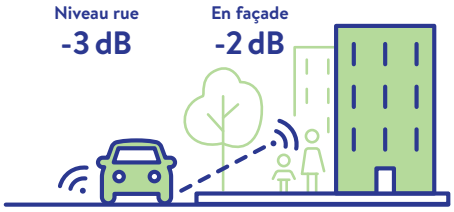
The measurement locations are chosen to avoid being moved over time as much as possible. The microphones are positioned 4 meters high from the ground. We ensure that these locations are representative of rather continuous traffic by moving away from areas of potential vehicle acceleration, so the measuring stations are as far away as possible from traffic lights or bus stops. We also ensure that the stations are minimally impacted by noise other than that generated by road traffic. We thus avoid positioning ourselves in direct proximity to noisy activities (car garage, discotheque, etc.).

Particular attention is paid to the positioning of the microphones in relation to the traffic lanes. For a given site, the microphones are positioned at the same distance from the traffic lane and on the same side of the lane. Depending on the distance between the microphone and the facade of the nearest building, additional short-term measurements are carried out in order to be able to adjust the sound levels to an equivalent of “2 meters in front of the facade”, corresponding to the measurement conditions recommended in the standard NF S 31 185 relating to the measurement of road noise, and allowing the results of road noise indicators to be compared during the day (6 a.m. - 10 p.m.) and at night (10 p.m. - 6 a.m.) in relation to the regulatory limit values set by France, which are respectively 70 dB (A) and 65 dB (A).

In order to document the three planned experimental sites, 6 sound level meters are mobilized:

- 2 for the rue Frémicourt site (reference board, board with acoustic coating)
- 2 for the rue Lecourbe site (reference board, board with acoustic coating)
- 2 for the rue de Courcelles site (reference board, board with acoustic coating)

3 YEAR OBJECTIVE

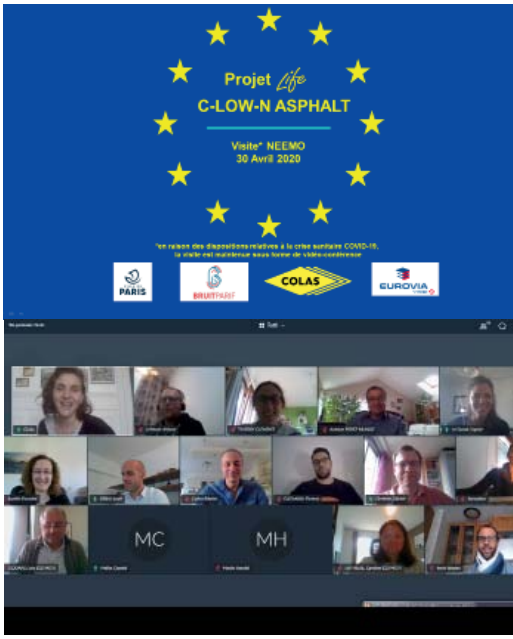


The sound level meters are placed in the middle of each plank, so that the noise measured comes almost exclusively from the noise generated by the passage of vehicles on the plank concerned. The sound level meters are calibrated every 24 months by a laboratory accredited by Cofrac. In addition, intermediate self-checks are carried out on site by the Bruitparif laboratory every 8 months.

03

LEADING AND COMMUNICATION

1. 2018 - 2022 : PROJECT LEADING



COSCI & COSTA (OCTOBER 2018 AND 2019, FEBRUARY 2021, APRIL 2022)

Since 2018, the annual COSCI & COSTA event has been an opportunity to discuss the results of the project with the partners of the scientific committee (COSCI) and the committee of stakeholders or Stakeholders (COSTA).

It was a valuable opportunity to share experience with numerous European and international projects (Italy, Spain and the United States).

In 2019 the event provided an opportunity to discuss methods and first measurement results.

Canceled in 2020 due to Covid, the committee met in 2021 in videoconference format. In 2022, the consolidated results of the project were presented, and it made it possible to raise awareness and inform a wide audience of professionals: numerous European and international administrations were present, as well as civil engineering companies; and research laboratories.

NEEMO VISITS

The NEEMO organization acts as an external auditor to verify the progress of the project's actions, and provides a communication link between the main beneficiary of the funding (the City of Paris) and CINEA, the European Commission agency for climate, infrastructure and the environment. Its annual visits are an opportunity to take stock of what has been done and what remains to be done, and to clarify both the technical and financial aspects of the project.

2. AUTUMN 2021 AND 2022: LOCAL “INFO POINTS”: LISTENING TO PARISIANS

The LIFE ASPHALT team met on site with residents of the streets affected by the experiment, with information points organized twice on each site in 2021 and 2022. A survey form was also distributed in 2021 to gather more widely the feelings of people in the sector (residents, but also traders and users of public spaces).

The feedback is strongly positive, with several testimonies of a perception of improvement in the quality of the environment..

THREE STANDS TO COMMUNICATE THE RESULTS AND COLLECT THE FEELINGS

SEPTEMBER 18, 2021: RUE FRÉMICOURT

SEPTEMBER 25, 2021: RUE LECOURBE

OCTOBER 2, 2021: RUE DE COURCELLES

SATISFACTION SURVEY*

Since changing the coating
of pavement in the last quarter of 2018

63% of respondents noted a reduction in road noise.

AMONG THEM

32 %
consider this reduction to be low

44 %
consider it average

23 %
consider it important

82 %
attribute this reduction to the component **"Rolling noise"**

6 %
attribute it to the component **« Engine sound «**

**A satisfaction survey on the perception of road noise was implemented in situ in October 2019 among users and residents of rue Frémicourt. The questionnaire is available on the website.*

BENEFITS AND PERCEPTION

- 3 décibels

is equivalent to
dividing the road traffic **by 2**

04

RESULTS OF THE 2019-2023 SURVEY CAMPAIGNS

1. THERMAL SURVEYS

We see that increasing the presence of water in the city has immediate benefits for cooling the human body. Intermediate results showed interesting trends in reducing the temperature felt at sidewalk level. However, **the consolidated conclusions of the study in June 2023 show that the coatings have not achieved the hoped-for results.** It will remain to be evaluated in 5 years, at the end of the so-called After life evaluation period, whether the thermal properties of the materials will have undergone improvements..

THERMAL MEASUREMENTS

Impact of watering in the three pilot sites in 2019, 2020 and 2021 combined
LIFE objectives: -1.5 to 2.5 Maximum effect in 2021

RUE FRÉMICOURT [1]		
	Impact of watering on the innovative zone	
	Air temperature at 1.5m	UTCI [2] at 1,5 m
Maximal reduction	- 0,8 °C	- 2,4 °C
Mean effect	- 0,3 °C	- 0,7 °C

RUE LE COURBE				
	Impact of watering on the innovative zone		Impact of watering on the reference zone	
	Air temperature at 1.5m	UTCI [2] at 1,5 m	Air temperature at 1.5m	UTCI [2] at 1,5 m
Maximal reduction	- 0,8 °C	- 2,1 °C	- 0,5 °C	- 1,4 °C
Mean effect	- 0,5 °C	- 0,9 °C	- 0,3 °C	- 0,6 °C

RUE DE COURCELLES				
	Impact of watering on the innovative zone		Impact of watering on the reference zone	
	Air temperature at 1.5m	UTCI [2] at 1,5 m	Air temperature at 1.5m	UTCI [2] at 1,5 m
Maximal reduction	- 0,8 °C	- 1,9 °C	- 0,6 °C	- 2,1 °C
Mean effect	- 0,4 °C	- 0,7 °C	- 0,3 °C	- 0,7 °C

[1] For rue Frémicourt, the reference zone could not be achieved due to construction site constraints
[2] **UTCI :** The Universal Thermal Climate Index is a measurement indicator created by the International Society of Biometeorology. It makes it possible to calculate the thermal stress felt by humans by combining several parameters (metabolic activity, clothing, air temperature, wind speed, humidity, etc.)

Overall, the results are achieved in terms of reduction in air temperature and approximately on thermal stress with respective reductions of around 1°C and 2-3°C UTCI.

The effect of the new coating alone installed on rue de Courcelles (BBphon+) indicates a deterioration of microclimatic conditions. A priori, this degradation is attributed to the albedo of this material, potentially lower than the pre-existing coating.

Overall, innovative coatings exhibit low albedo, whether measured in the field or in the laboratory, including sandblasted samples. Sandblasting aims to strip the surface layer of bitumen, this indicates that the aggregates used are not reflective.

Laboratory tests make it possible to project the microclimatic performance of SMAphon and PUMA. According to these tests, the SMAphon would degrade thermal stress without helping to combat the urban heat island. For its part, PUMA would have a positive impact on air temperature without a negative counterpart on radiosity.

Overall, there is no visible aging phenomenon for the microclimatic results of watering or the new material installed on rue de Courcelles. The drying time of innovative coatings tends to increase over the years. It is slightly higher for PUMA than the asphalt on rue Lecourbe, while it is comparable on rue de Courcelles.

The results were interpreted in a socio-economic assessment to compare costs and benefits, which was finalized in June 2023. In a context of scarcity of water resources, the conclusions of the study should point towards a very limited watering practices.

SOCIO-ECONOMIC IMPACTS OF THERMAL RESULTS

Based on these results and the existing literature, we can affirm that the socio-economic impacts of street watering are extremely low. The scientific literature that we have examined and the testimonies that we have been able to collect agree on the fact that the benefits of this technique are extremely limited. They do not compensate for the initial investment (irrigation network, coating, etc.) and do not justify the importance of the resources mobilized (water).

Revegetation remains the priority action for refreshing urban spaces but other palliative measures are being studied where the provisions of the subsoil do not allow for revegetation. Shade shelters, for example, will be tested on several sites in the 12th arrondissement to reduce the feeling of heat during the summer of 2023.

WATERING TECHNIQUE IN PERSPECTIVE

It is important to conclude on the fact that the use of drinking or fresh water has become a subject of major concern after the serious episodes of drought in 2022 and 2023 in France. Concerns about drought and water are now shared by a majority of French people and are at the heart of important political decisions[3].

Watering siding, however, is not a refreshing strategy that should be abandoned. There are many ways to improve this technique. Traditionally, street watering has been used by residents in many cities to improve thermal comfort during heat waves. In **Japan, uchimizu** (ritual watering of streets with a bucket and ladle) was practiced to wash away street dust and refresh. **In the Old Nice district, watering the streets in the early evening was still used at the beginning of the 20th century to improve ventilation and cool residents during the night (Figure below)**. Watering helped reduce the air temperature on the ground floor. The heated air was evacuated thanks to the glass roofs of the interior courtyard, the roofs and the shutters which were overheated during the day: the cooled air from the street was then sucked in, passed through the transoms and rose towards the different floors thanks to the thermal draft. Residents could then benefit from cooled air and natural ventilation for nighttime comfort. In Old Nice, the streets were watered by the city services while the courtyards were watered by the residents.

We can hypothesize that watering narrow streets and interior courtyards at the end of the evening could contribute to improving the nighttime indoor thermal comfort of adjacent naturally ventilated buildings in Paris. The idea would be to draw inspiration from the cooling strategies of Old Nice to apply them in the districts where the streets are the narrowest and where there are still naturally ventilated buildings (the HBMs of Paris are still largely naturally ventilated , but the use of mechanical ventilation is systematized by the city of Paris). In this case, a more general reflection on the design and renovation of the Parisian built environment should be implemented, in order to favor passive and bioclimatic cooling strategies.

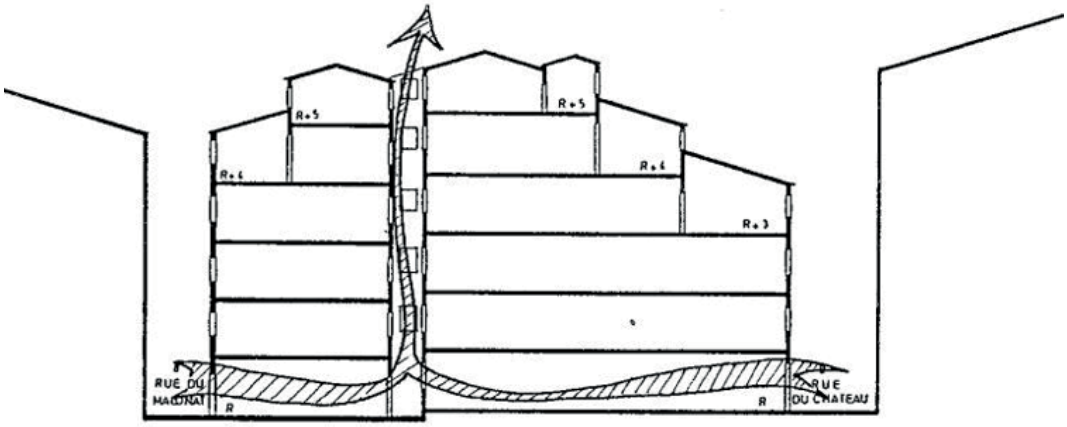


Figure : Section of the natural ventilation system powered by watering the streets and the interior courtyard of a building in Old Nice.
Source : PETITCOLLOT Christophe, « Nice : la cité sous le vent », Science et avenir, n°475, 1986, p. 76-79.

[3] BERTHELIER Anthony, « Sécheresse : la grande inquiétude des français », Huffington Post, March 4, 2023
https://www.huffingtonpost.fr/politique/article/secheresse-la-grande-inquietude-des-francais-exclusif_214758.html

2. ACOUSTIC SURVEYS

Concerning the phonic aspects, innovative materials are very effective.

The three innovative road surfaces are tested against the standard coating usually deployed by the City of Paris on Parisian roads (ACR 0/10 AC2 and BBMA 0/10).

Also, sections of approximately 200 m of these standard coverings were also laid on the three experimental sites. For the thermal and microclimatic evaluation, a third section retaining the original coating is used as a "control" section.

Rolling noise Δ LA10 22h-6h	COMPARED TO THE EXISTING					COMPARED TO THE REFERENCE				
	2018	2019	2020	2021	2022	2018	2019	2020	2021	2022
LIFE objectives	**-3**	**≤ -2**				**-2**	**≤ -1**			
Rue Frémicourt (SMAphon)	-4,0	-3,7	-2,0	-2,8	-2,8	-2,3	-1,8	-1,2	-0,9	-0,4
	-4,3*	-3,9*	-2,9*	-3,3*	-3,0*					
Rue de Courcelles (BBphon+)	-2,0	-1,9	-0,7	-0,9	-1,0	-2,8	-2,6	-2,4	-1,4	-1,3
	-3,5*	-2,7*	-2,1*	-2,0*	-1,8*					
Rue Lecourbe (PUMA)	0,7	-0,1	0,6	-0,1	-0,4	--	--	--	2,7**	2,8**
	-1,2*	-1,1*	-1,1*	-1,4*	-1,5*					

Table: Differences observed ΔLA10 10 p.m.-6 a.m. (all days combined); *temperature correction; ** roadway distance correction

CPX	COMPARED TO THE EXISTING				COMPARED TO THE REFERENCE			
Δ LAeq at 50 km/h	2019	2020	2021	2022	2019	2020	2021	2022
LIFE objectives after installation in dB(A)	-5	≤ -3			-3	≤ -2		
Rue Frémicourt (SMAphon)	-4,4	-2,3	-2,0	-1,6	-3,5	-2,2	-2,1	-2,0
Rue de Courcelles (BBphon+)	-4,7	-2,4	-1,8	-1,4	-3,3	-1,5	-1,3	-1,1
Rue Lecourbe (PUMA)	-2,1	-1,9	-1,5	-1,4	--	--	+1,6	+1,8

Table: Results of CPX measurements at 50 km/h; years 2019 to 2022.

REMINDER

Rolling noise: this is the noise created by the contact of the tires with the road, measured at the level of the tire-surface contact and at the level of the building facade.

Compared to the reference: this is the measurement compared to a "classic" coating installed at the same time as the innovative one, to maintain a consistent comparison in terms of surface wear characteristics.

Compared to the existing state: this is the measurement in relation to the existing coating before the experimental site works.

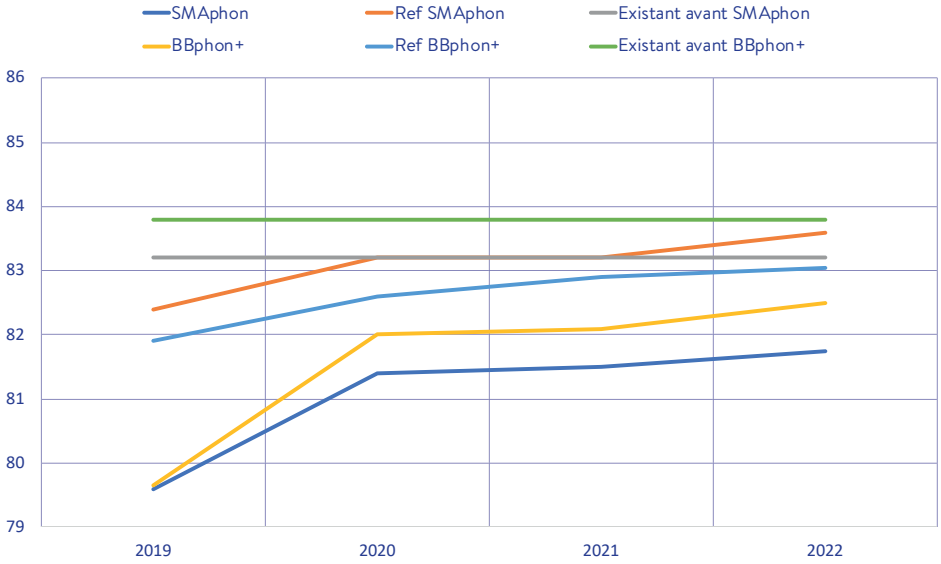
TO NOTE

The reduction in sound levels is greatest at night when single vehicles pass, higher speeds and other sources of noise are reduced (works, human activity, etc.).

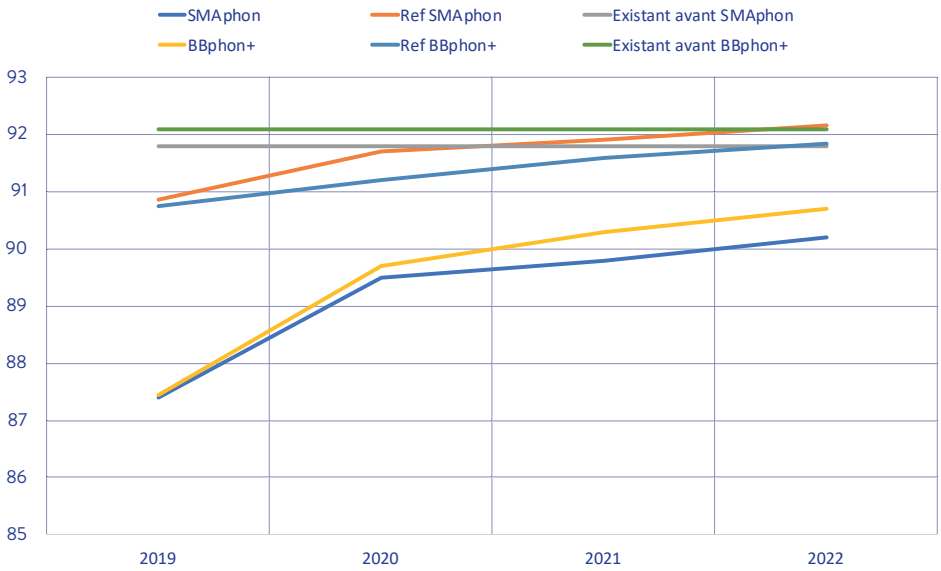
The results show the maintenance of a reduction in sound levels associated with tire/road contact noise over the night period four years after the installation of the experimental coverings.

However, a significantly faster deterioration in the acoustic performance of innovative coatings than that of standard solutions is observed in 2022, except for PUMA whose performance appears stable over time. As part of After LIFE, continued monitoring of acoustic and mechanical performances after the end of the project will provide an assessment until 2028, i.e. a period of 10 years.

Evolution of the CPX measurement at 30km/h for a selection of coatings



Evolution of the CPX measurement at 50km/h for a selection of coatings



SOCIO-ECONOMIC IMPACTS OF ACOUSTIC RESULTS

Based on the results observed on the reduction in nighttime noise levels linked to the testing of new coatings, the benefit generated for the Parisian population in terms of health and economic impact can be quantified, in the case of an application to a part or all of Parisian roads with experienced coatings. On the basis of these noise reductions taken into consideration over the period 10 p.m. - 6 a.m., the evaluation of the annual savings in millions of euros (€M) generated by the use of innovative road surfaces could be initiated. The evaluation takes into account the main economic factors: health (discomfort and disruption of sleep), economic (loss of productivity) is now available. These costs are compared to the average costs of use and maintenance of innovative solutions compared to conventional road surfaces.

Different deployment scenarios for innovative solutions on the Paris road network are studied as part of the LIFE Cool & Low Noise Asphalt project: partial or full deployment. After 5 years, the estimated savings are considerable: around €34 million for partial deployment (10% of the road surface) and €404 million for full deployment (1,600 km of road) of the innovative solution rather than the standard solution. The investment is amortized before the second year for all the scenarios studied.

Continuing to monitor acoustic performance after the end of the project will provide a socio-economic assessment over a period of ten years. If this pilot project is successful, the entire Parisian road network could ultimately benefit from a coating with sound and thermal properties, becoming an example for European communities and professionals..

05

2023 - 2028 : AFTER-LIFE ACTIONS

For After-LIFE, the City of Paris is committed to continuing monitoring actions for installed coatings, as well as communicating and disseminating the necessary information for replicability. The companies Colas and Eurovia, as well as Bruitparif, are also committed to continuing this monitoring.

Regarding the thermal aspects, the coatings did not achieve the expected results. The radiative property of the albedo effect was assumed in advance for the use of clear aggregates in the formulations of road coverings, but the surveys showed it to be not high enough. It will remain to be evaluated in 5 years, at the end of the After Life evaluation period, whether the thermal properties of the materials will have undergone improvements due to mechanical stripping due to use. In addition, the socio-economic analysis showed that the benefit of watering wide roadways during the day is zero. This is why there will be no intermediate actions to pursue for the thermal and microclimatic aspect.

1. THE ACTIONS PLANNING

1.1 ACOUSTIC PERFORMANCE MONITORING

› One near-field noise measurement campaign (CPX) per year.

- This will allow us to know the durability of sound-proof coatings in terms of acoustic performance.
- These data will complement those already measured on the Paris ring road.

› Maintaining sound measurement devices on the facade.

- Their use will make it possible to assess the impact of road development on overall noise reduction over time.
- These data will complement those already measured on the Paris ring road.
- Operational maintenance of permanent noise measurement stations.

› Missions carried out each year :

- Use of facade noise measurement data (LAeq1s).
- Use of meteorological data Météo France (Paris Montsouris).
- Calculation of acoustic indicators LA10 and LAeq on the facade (day/evening/night) per calendar year.
- Updating results on the LIFE project website.

› **Missions carried out every 2.5 years :**

- Use of LAeq results on the facade (day/evening/night) per year.
- Assessment of the health impact associated with the noise component (DALY discomfort and sleep disturbances) per year.
- Updating results on the LIFE project website.
- Publication and presentation of results in conferences with a European and/or international dimension.

1.2 MECHANICAL PERFORMANCE MONITORING

› **A Monitoring Committee (COSUI) per site and per year.**

› **An average texture depth (PMT) measurement campaign per site and per year.**

2. THE COMMUNICATION PLANNING

› **COLAS and EUROVIA have written a note including all the information necessary for the production of the products (SMAphon, BBphon+ and PUMA) as a contribution to the replicability of the techniques on a European scale.**

- The dissemination and publication of specifications related to the project will be done via internal channels and the website life-asphalt.ue

› **The partners commit to participate in conferences, congresses and technical days around the themes of the project, and to publish scientific articles on the experimentation of the project.**

COOL & LOW NOISE ASPHALT PROJET LIFE

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