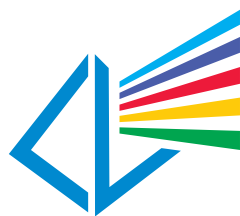




The project has received funding from the LIFE Programme of the European Union under GA number LIFE19 ENV/GR/000100



# LIFEVISIONS

InnoVative photocatalytic paintS for healthy enviroNment and eNergy Saving



Improve indoor Air Quality

Save energy

using innovative photocatalytic paints



The project has received funding from the LIFE program of the European Union under GA number LIFE19 ENV/GR/000100



## LAYMAN'S REPORT

JANUARY 2024





# LAYMAN'S REPORT

JANUARY 2024



### Description:

The main scope of the project is the production of an innovative photocatalytic paint, which aims at improving the quality of the indoor environment while it will enable significant energy savings in buildings.

### Budget Info:

**Total amount:** 1,403,752 Euro (EC Co-funding: 54%)

**Duration:** Start: 07/09/20 – End: 06/02/24

### Partners:

National Center for Scientific Research DEMOKRITOS (Coordinator)

Foundation of Research and Technology – Hellas

Aristotle University of Thessaloniki

VITEX S.A.

EVOLUTION PROJECTS PLUS



The project has received funding from the LIFE Programme of the European Union under GA number LIFE19 ENV/GR/000100

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LIFE-VISIONS

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# 1.

## FRAMEWORK OF THE PROJECT

European Union (EU) considering milestones and stage targeted goals for building sector sets a long-term strategy for 2030 and 2050 mainly aiming to energy and climate upgrade. In this line of approach and based on LIFEVISIONS Project efforts, specific outcomes and results have been derived, valuable for Air Quality (AQ) Improvement, Energy consumption control as well as carbon indicator.

Among the existing various techniques (purging with outdoor air, using ultraviolet germicidal irradiation etc.) to mitigate the problem of contamination in the indoor environment, photocatalysis, as an alternative technology, is considered to be the safest, innovative, effective, economic and promising solution (Fig.1).

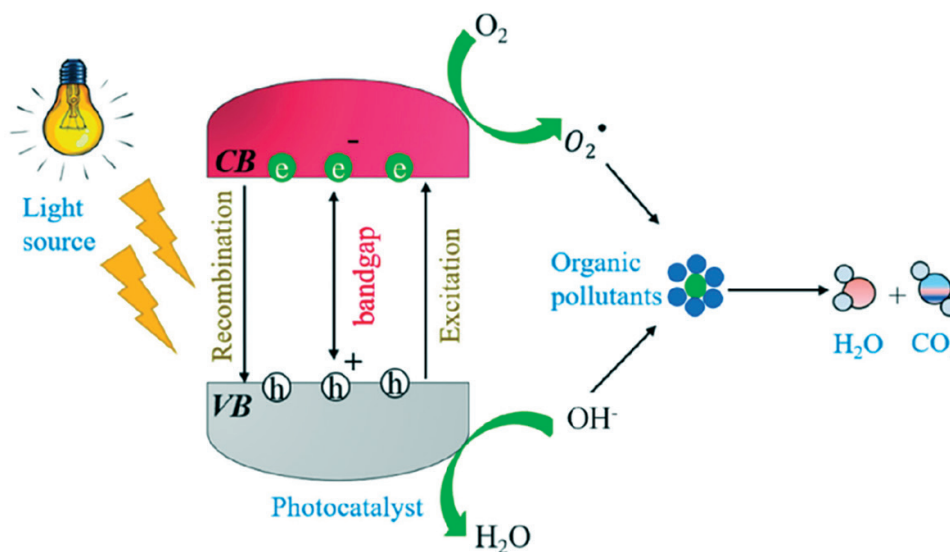


Figure 1 The photocatalytic process

VISIONS had initially set realistic targets for the resolution of the IAQ and energy consumption issues, using an already proven innovative photocatalytic nano-material which is able to degrade air pollutants using Visible Light, as opposed to the existing products on the market, which operate using UV radiation (Fig2). The proposed technological solution is able to reduce more than 40% of specific air pollutants (e.g. NO<sub>x</sub>, VOCs), translated to reduction on the demand for air-cleaning systems, air conditioning and other mechanical ventilation, leading to up to 20%

less energy usage with a significant impact on the long- term energy demand and elimination of the overall socioeconomic costs due to the adverse health impact, caused by indoor air pollution. Therefore, VISIONS sharing the same perspective with the signatories of the Covenant of the Mayors for Climate and Energy, constitutes of a potentially new tool for the effective reduction of indoor air polluting agents, improving citizens day-to-day life, while contributing to the National and EU coordinated efforts for the promotion of GREEN DEVELOPMENT technologies for less energy consumption.

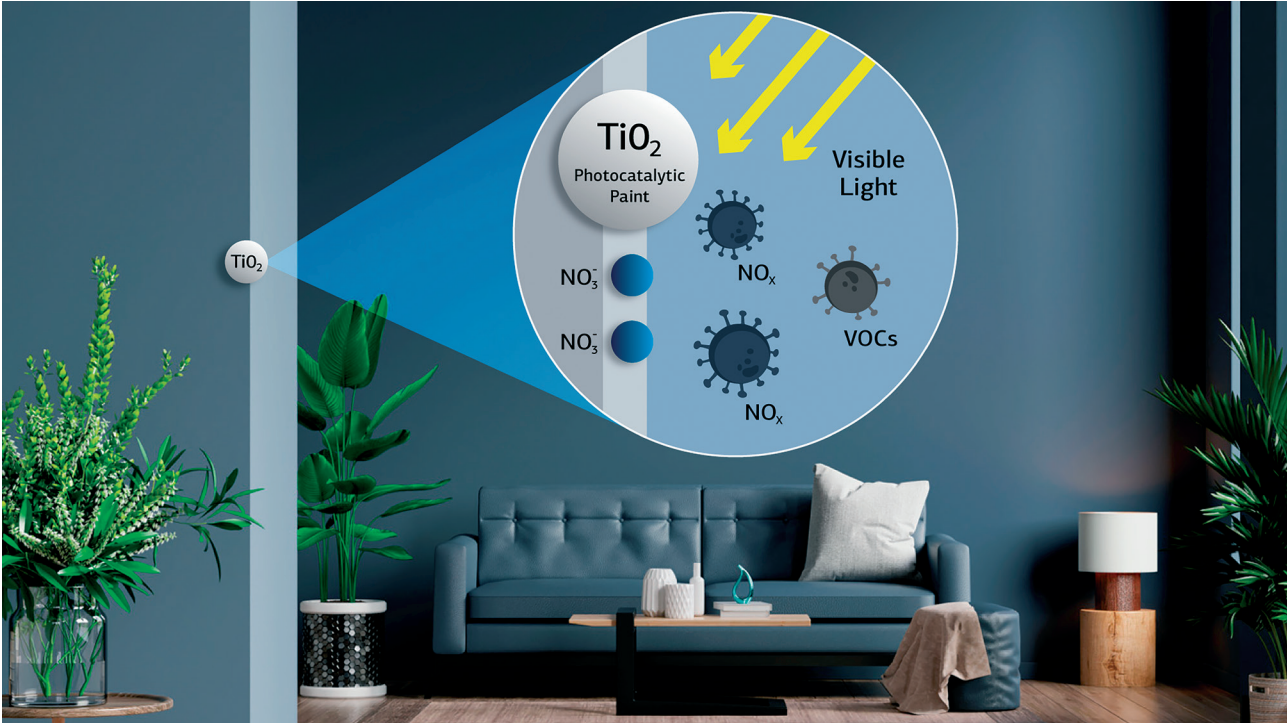


Figure 2 The LIFE VISIONS photocatalytic approach





# 2.

## OBJECTIVES

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The conceptual approach (Fig. 3) and main objectives of the project are:

### **1. Optimization and Upscaling of a novel photocatalytic material (VISIONS Photo-Powder)**

Optimization of the novel photocatalytic powders synthesis route which are activated in the presence of visible radiation and effectively degrade air pollutants

### **2. Semi-industrial production of innovative photocatalytic paints (Photo-Paints) by incorporating the VISIONS Photo-Powder in various types of paints for real scale applications.**

### **3. Real scale applications of the innovative Photo-Paints in a set of existing Demo-Houses prototype demonstrator and at the Hellenic Naval Academy Buildings.**

Study of the efficiency of Photo-Paints in order to improve the air quality and energy efficiency of buildings.

### **4. Assessment of the effectiveness of the VISIONS Photo Paint for large scale applications through the application of a state-of-the-art numerical modelling (CFD) for different scenarios for the application of the proposed covering technology.**

### **5. Development of performance indicators for evaluation of the photocatalytic efficiency in terms of:**

- the expected reductions in the concentration of specific pollutants in indoor environments
- the resulting reduction of the exposure of the inhabitants
- the expected improvement of the energy efficiency

### **6. Development of a sophisticated Decision Support System (DSS)**

The System serves as a multicriteria support tool towards studying the efficiency of the proposed solutions, processes and methods in future applications. It is based on the outcomes of the photocatalytic activity, the Cost Efficiency Analysis (CEA), the Cost Benefit Analysis (CBA) and the Life Cycle Assessment (LCA)

### **7. Establishment of a commercial company that undertakes the exploitation and promotion of VISIONS technologies and products (Photo-Paints & DSS).**



The nanotechnology and products refined and applied in VISIONS have considerable commercial potential and the company will take over the promotion of the innovative materials and technologies (computational tools) developed as part of the project.

**8. Development of Management, Communication and Dissemination strategy of the project.**

During the implementation of communication actions of the project, innovative methods of dissemination and management of results are applied.



Figure 3 The VISIONS conceptual approach



# 3.

## OVERVIEW OF THE PROJECT ACTIONS

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LIFE VISIONS actions are grouped into 4 main categories:

- Implementation actions
- Monitoring of the impact of the project actions
- Public awareness and dissemination of results
- Project management

The implementation of the action is described as follows:

### **Optimization and Upscaling of synthesis route of the novel photocatalytic powder**

The main objective of this sub-action is to optimize the synthesis route of the novel photocatalytic powders, which are activated in the presence of visible radiation, for enhanced performance while mixing in paints and reduce production cost.

### **Photocatalytic efficiency of optimized material**

The main objective of this sub-action is to quantify the capacity of the optimized powder (Visions-Powder) to degrade photocatalytically inorganic (nitrogen oxides NO<sub>x</sub>) and volatile organic (VOCs e.g toluene) air pollutants.

### **Semi-Industrial production of Photo-Paints**

The main objective of this sub-action is to produce in semi industrial scale organic and inorganic photo-paints by using the Visions - powder (Fig.4).



Figure 4 The VISIONS photo paint production

## Photocatalytic efficiency of photo-paints

The main objective of the sub-action is to quantify the capacity of the Visions photo-paints which were produced, to degrade photocatalytically inorganic (nitric oxides NO<sub>x</sub>) and volatile organic (VOCs e.g toluene) air pollutants.

## Real Scale Applications

### Application of Photo-Paints in Demo-Houses prototype demonstrator

The ultimate scope of the current sub-action is to estimate the effectiveness of the Photo-Paints to degrade air pollutants as well as to eliminate energy consumption in the demo- houses and promote the most promising one to be used in the Hellenic Naval Academy.

### Application of the most promising Photo-Paint in real life conditions. The case of Hellenic Naval Academy

The dissemination of the versatile and clear technology of photocatalysis was manifested by applying the Photo-Paint that gave the best performance when applied and monitored in the Demo-House, with regards to de-polluting efficiency for the abatement of air pollution and reduction of energy consumption, to the Hellenic Naval Academy Buildings which are located in the municipality of Piraeus (Fig.5).

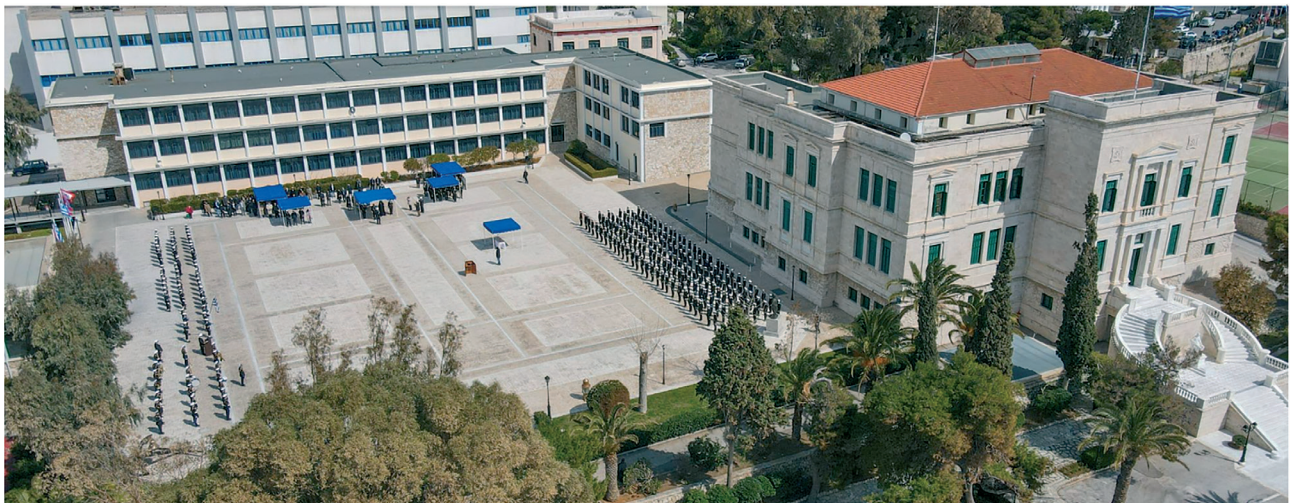


Figure 5 The premises of the Hellenic Naval Academy

## Numerical Modelling and Data Analysis

An advanced Computational Fluid Dynamics (CFD) obstacle resolving model was used to assess the effectiveness of the Photo-Paint in an integrated manner capable to account for multiscale interactions.

## Life Cycle Analysis (LCA), Cost Efficiency Analysis (CEA) & Cost Benefit Analysis (CBA)

A Life Cycle Assessment (LCA) analysis was conducted by assessing all environmental impacts of the proposed Photo Paint technology at all the various stages in their life cycle (extraction of raw materials, manufacturing, use, maintenance, end of life either reuse, recycling or final disposal). Within the frame of VISIONS, both a Cost Efficiency Analysis (CEA) and a Cost Benefit Analysis (CBA) were performed to account for the external costs of the proposed Photo-Paint technology to estimate its expected performance and usefulness and identify its weaknesses and strengths.

### Development of a Decision Support System (DSS)

Development of VISIONS Decision Support System (DSS) (Fig.6) which includes the outcomes of CFD, LCA and CBA described above. DSS intends to be a tool in the hands of stakeholders and end users (Building Construction, Paint Companies, Local authorities) to estimate the effects of each particular photocatalytic application in the abatement of air pollutants as well as in the energy saving sector.

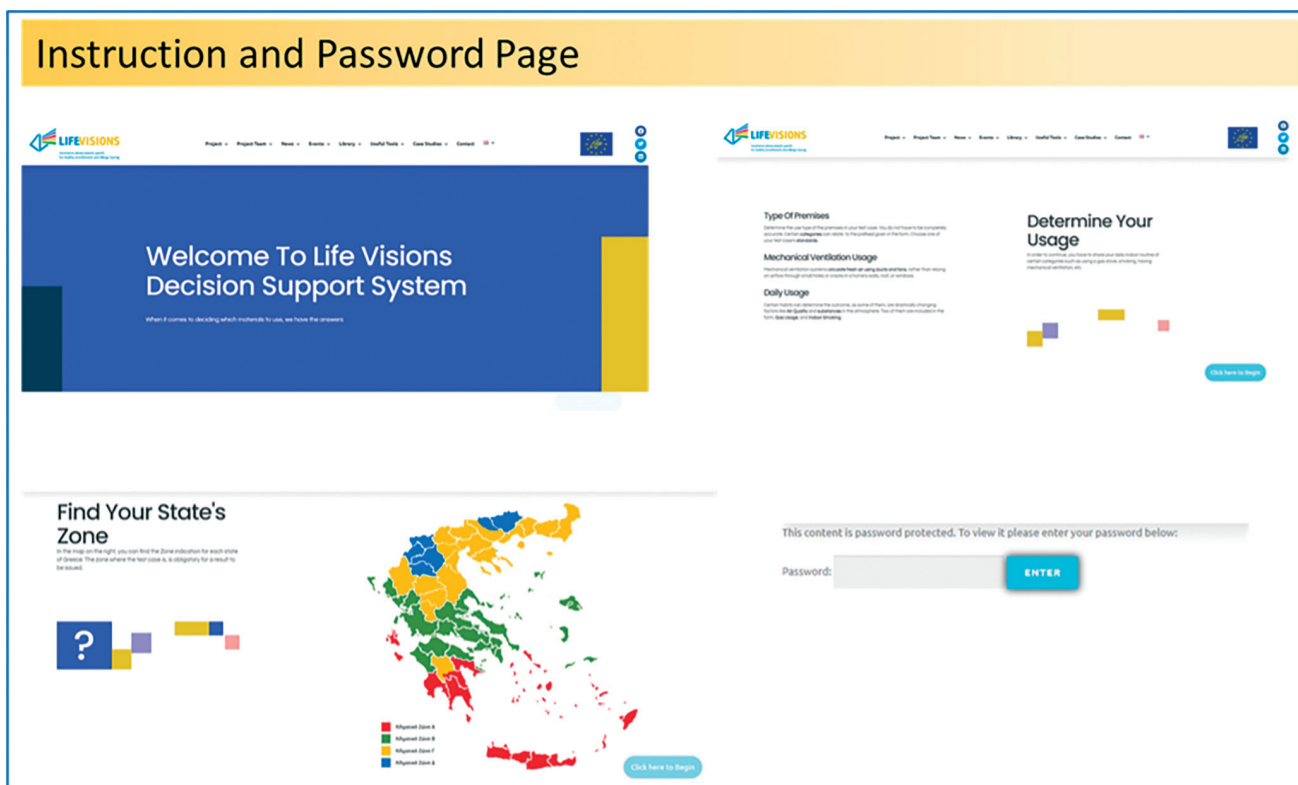


Figure 6 The LIFEVISIONS DSS

### Establishment of a commercial company

The two commercial companies of the LIFEVISIONS project, Evolution Projects+ and VITEX S.A were joined under the umbrella of the established ProVisionAir+ company to exploit the knowledge of the VISIONS outcome. The company is in close cooperation with the LIFEVISIONS Research Centers (NCSRDI, FORTH) and University (AUTH) through license agreements.

## Monitoring of the impact of the project actions

On the basis of the Project's objectives a monitoring system that provides a mechanism by which specific information is provided to the interested parties was developed considering performance indicators. A Socio-Economic Effects' Monitoring Plan was also developed. Using the results, a number of various factors and indicators, such as economic development, employment, the impact of the project on the local community has been identified.

## Public awareness and dissemination of results

The actions include Networking with other Projects and Dissemination Planning & Execution. The objective of Networking with other projects is to share best practices, exchange experiences and assess potential synergies. The following dissemination tools have been developed: Project Logo, Leaflets, Posters, Notice Boards, Project Website, Internet Banners, Social Media, Layman's report, "SmartBuilding" Business Game, Commercials and radio spot, Press Releases, Articles, Newsletters and Scientific publications, Conferences and public events, Open "VISIONS" LIFE Days, Live-streaming conferences, Online Course, Training of energy inspectors. The tools were used separately and/or combined, in order to enable the Project team inform all stakeholders through Tailor Made Dissemination of Project Results and Findings. Actions taken in the framework of Public Awareness include the distribution of materials (Leaflets, Posters, Reports, Newsletters), the purchase of view time for the commercials, the purchase of airtime for the radio spot, the publication of press releases and articles in portals and newspapers, the publications in journals and the dissemination of the online course. Fig.7 provides an overview of the public awareness and dissemination actions while Fig. 8 identifies the stakeholders groups.





Figure 7 Public awareness and dissemination of results

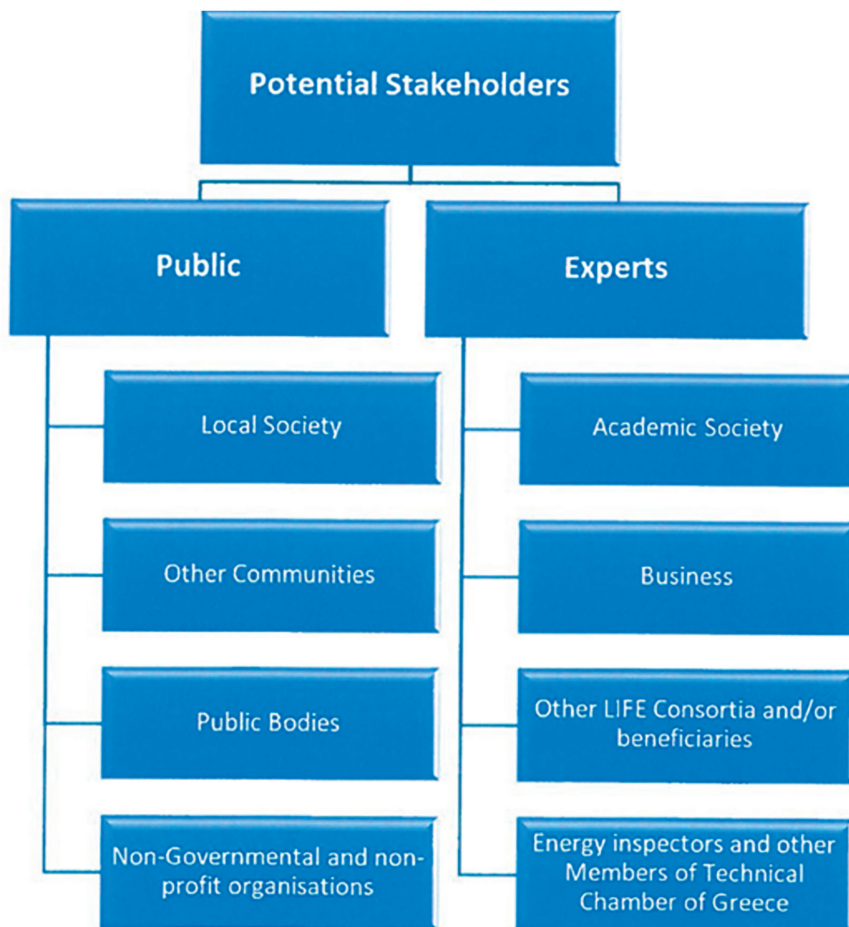


Figure 8 Potential stakeholders





# 4.

## LIFE VISIONS OUTCOMES

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The project outcomes are divided in 6 main sectors (Fig.9):

1. Environment: A degradation of up to 46% for NO<sub>x</sub> and 16% of VOCs from the application of the VISIONS Photo-Paint under real world conditions was measured.
2. Energy: It was determined 10 – 22% energy reduction compared to the conventional scenario (without photocatalysis) because of the ventilation rate reduction. The ventilation rate was determined by the occupancy in the photocatalytic scenarios.
3. Innovation: Optimization & application of photocatalysts for industrial building coatings capable for air de-pollution by visible light. Optimized Visions photo-powder was patented.
4. Economy: Demonstration of the effectiveness of the application sets the platform for a wider application to a number of indoor environments (homes, schools, hospitals)
5. Dissemination: Stakeholders and end users (Building Construction Companies, Chemical and Paints companies, Local and Regional authorities and the public at large) have taken advantage of the outcome of the project as it has been translated into a Decision Support System (DSS). To that end characterization of the sustainability of each particular photocatalytic application could be achieved.
6. Entrepreneurship: Establishment of a commercial company, ProVisionAir+, which will transfer the project findings and tools to the market rapidly.

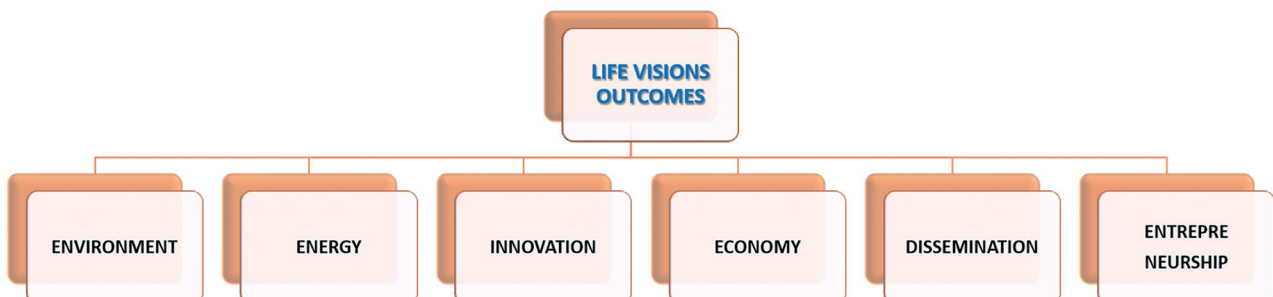


Figure 9 LIFE VISIONS outcomes



# 5.

## BENEFITS

The specific demonstration project helps the assessment whether or not photocatalytically active construction material may be a technology for achieving better indoor air quality and energy savings throughout Europe.

VISIONS prove that it could provide the basis for a European Directive on the usage of photocatalytically active construction materials in Europe. Consequently, it represents an opportunity for the development and implementation of a new de-polluting European strategy. Furthermore, an update of the EU legislation could be achieved based on specific actions of the project which create policy recommendations.

As far as the energy sector is concerned VISIONS contributes to the implementations for energy efficient buildings through the rational use of ventilation systems as a result of photocatalytic activity of indoor building materials. The benefits of LIFE VISIONS are depicted in Fig.10

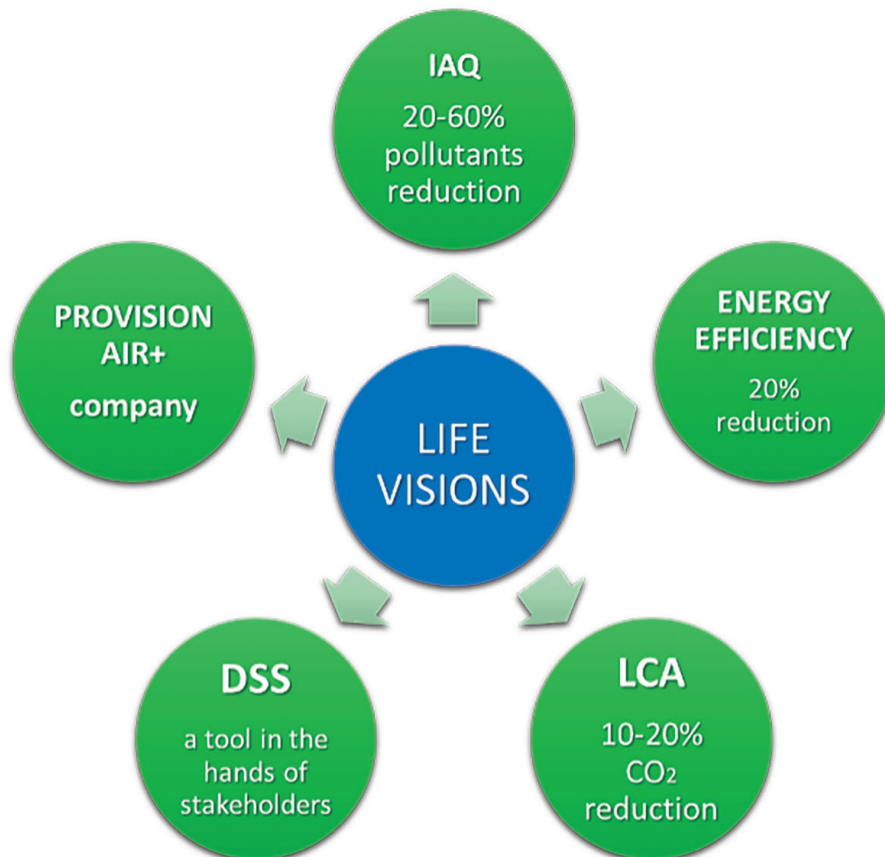


Figure 10 Benefits of LIFE VISIONS

## Indoor Air Quality Improvement (IAQ)

A photocatalytic paint (VISIONS photo-paint) with the ability to degrade air pollutants was produced in the frame LIFEVISIONS Project and applied in two building constructions. The 1<sup>st</sup> application took place in 2 Demo- Houses which are located on the premises of FORTH in Crete and comprise a unique European facility (Fig.11).



Figure 11 The Demo House in Crete

The VISIONS photo paints were applied on the interior walls of the Demo-House (approx. 40m<sup>2</sup>) the so called “Green House”. The other one was considered as reference: the “Conventional House”. The feasibility of the photocatalytic building materials to reduce the air pollutants introduced in the Demo-House indoor environment were estimated through the comparison of the air quality levels and energy consumption in the two “houses” (Fig 12). By activating the photocatalytic building material (turn on the light) the pollution level in the ‘Green House’ was reduced up to 61.7% while in the conventional one up to 24.6%. All side effects (adsorption on walls, photolysis, photocatalysis etc) was also estimated.



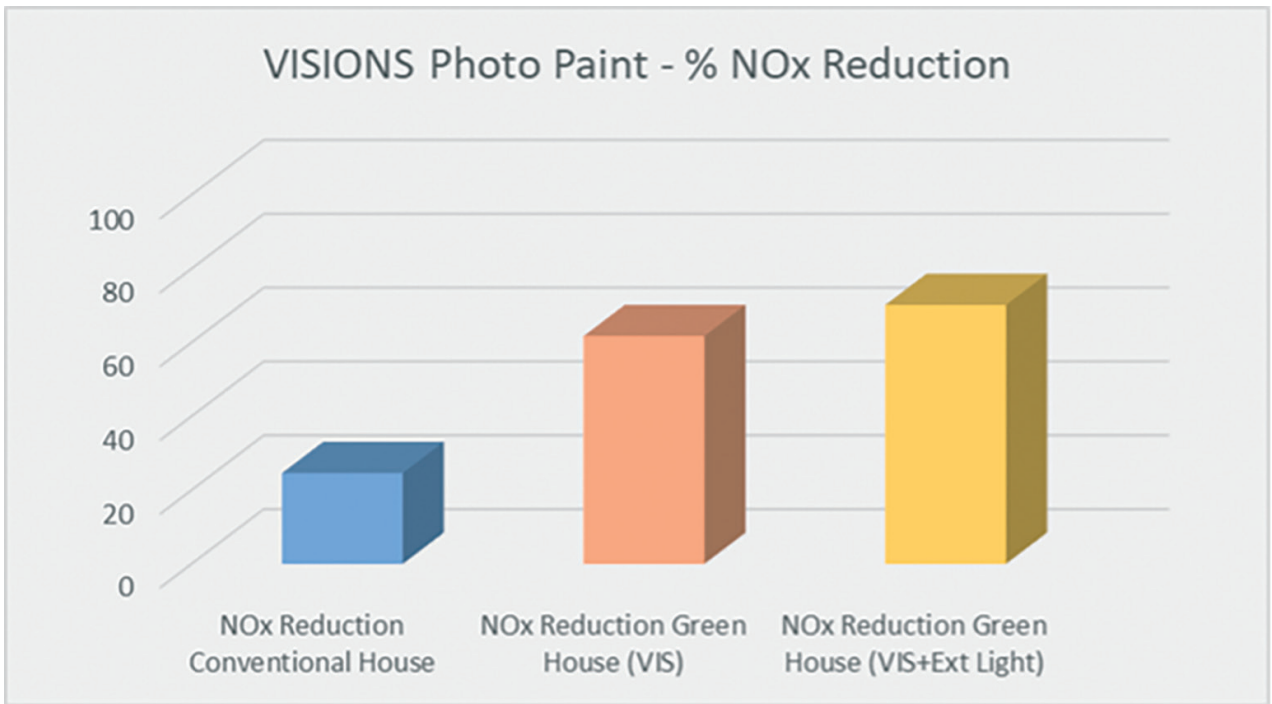


Figure 12 LIFE VISIONS photo paints comparative NOx reduction

The efficiency of the best performing photo-paint in terms of de-pollution and reduction of the energy consumption was further investigated in real scale application to the Hellenic Naval Academy teaching building (Fig.13).



Figure 13 HNA teaching building

Five pairs of classrooms (one in ground floor, two in the 1 st floor and two in the 2 nd floor) were selected for the evaluation of the VISIONS photo-paint. Each pair consisted of a “Green” classroom, where the photo-paint was applied and a “Conventional” one which was paint with a conventional commercial paint. The feasibility of the photocatalytic paints to reduce the air pollutants in the Green classrooms of the Naval Academy was estimated through the comparison of the air quality levels in the pair of classrooms. Results showed an average 46% and 16% lower concentration of NO and Toluene respectively in the green classroom compared to the conventional (Fig 14).

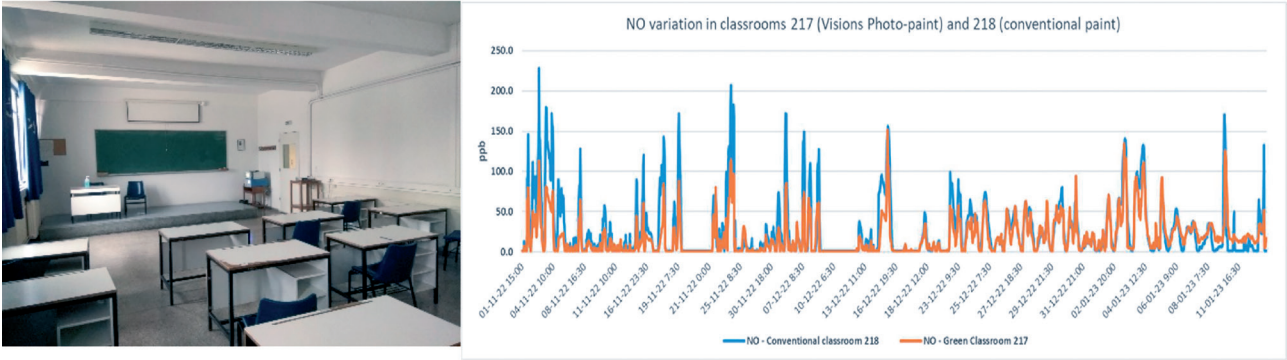


Figure 14 HNA classrooms and NO variation in Green and Conventional class

Taking into consideration the fact that air quality in indoor microenvironments can be controlled easier than outdoors and the expected results of an applied methodology can be easily quantified in indoor environments, VISIONS is the ‘model’ for the implementation of an innovative and cost-effective methodology for the reduction of indoor air pollutants concentrations. Fig. 15 shows the project team at the Hellenic Naval Academy premises.





Figure 15 The Hellenic Naval Academy case study

### Building energy reduction and simulations

- The models yielded results indicating a potential energy reduction of up to 22% when compared to the baseline scenario, primarily due to the reduction in ventilation rates.
- Focusing on the real scale application at scenario 1 (without photocatalysis) the energy consumption reaches 544103.64 kWh/ yr and 236.76 kWh/m<sup>2</sup> of conditioned building area. In scenarios 2 and 3 where photocatalysis was implemented the need for mechanical ventilation decreased (the people density was reduced by 20% and 35%). The energy consumption in the case 2 reached 488796.48 kWh/ yr and 212.69 kWh/m<sup>2</sup> of conditioned building area and in case 3 the energy consumption decreased to 447965.8 kWh/ yr and 194.93 kWh/m<sup>2</sup> of conditioned building area (Fig.16).

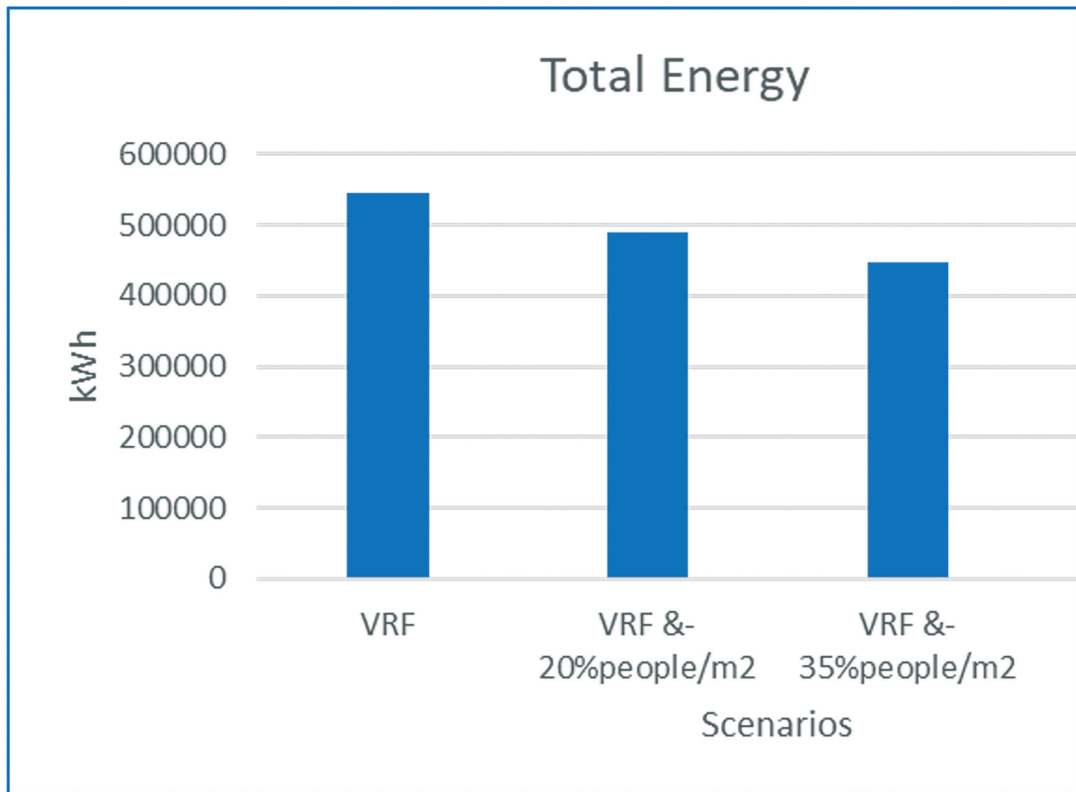


Figure 16 Energy consumption reduction using VISIONS photo paint

### Life Cycle Assessment (LCA)

LCA methodology was applied in the frame of the LIFE VISIONS project, aiming to assess the environmental profile of the photocatalytic paint, following a cradle-to-gate and a cradle-to-gate approach (Fig.17). The total environmental performance of the photocatalytic paint is higher compared to the conventional paint when the whole life cycle is considered and if at least 0.22% energy saving is achieved by the photocatalytic paint application.



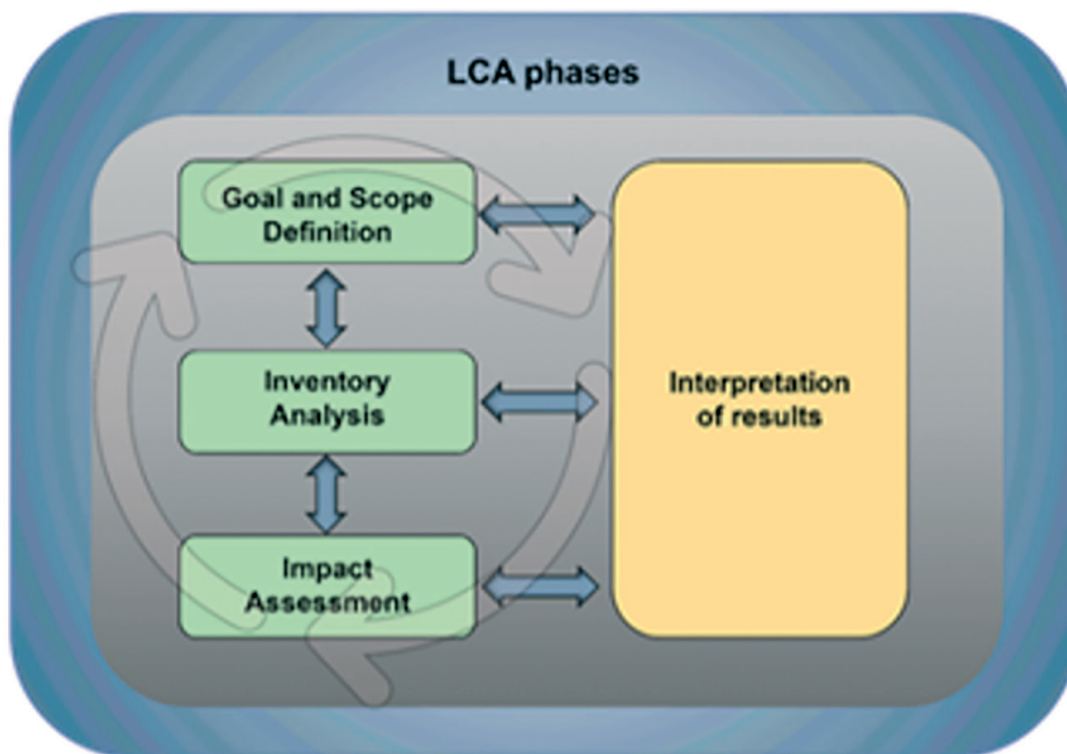


Figure 17 LCA phases

### Decision Support System (DSS)

VISIONS DSS Platform intends to serve as a web-based Guidebook for the characterization of the sustainability of photocatalytic applications and the enhancement of air quality & energy efficiency.

The Decision Supporting System helps the customers to calculate the benefits of using photocatalytic materials and decide the most suitable solution for their building (Fig.18).

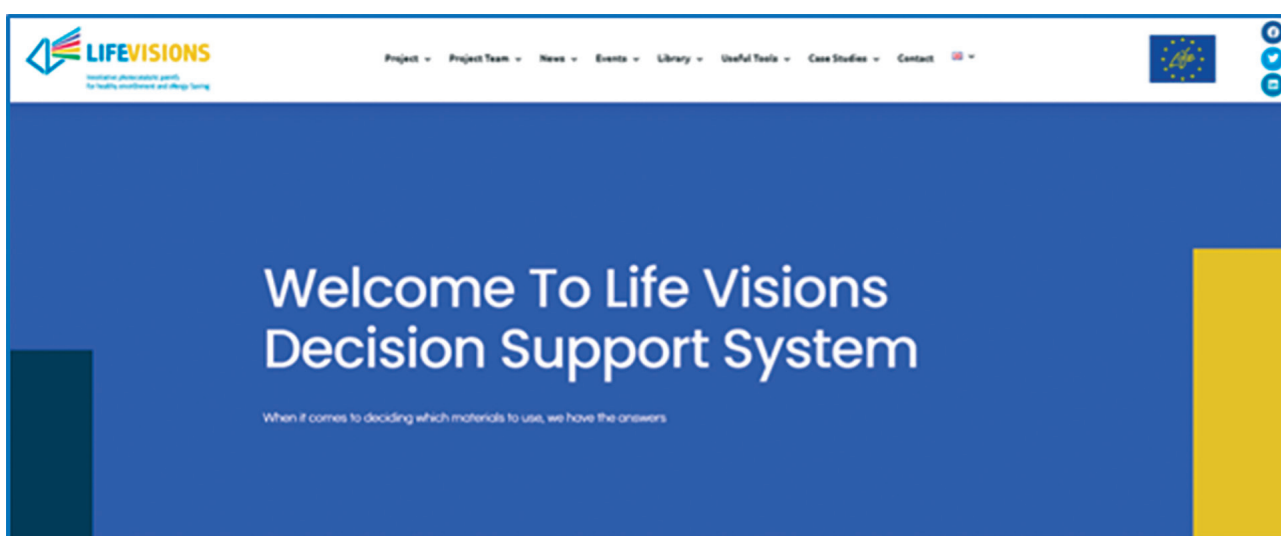


Figure 18 DSS front page

Target groups are manufacturing industries of construction materials, the construction sector, engineers, private/ public buildings directly (Hospitals, Hotels, Industries etc.)

The development of VISIONS Decision Support System (DSS) includes the outcome of CFD, LCA and CBA described above and consists a tool in the hands of stakeholders and end users (Building Construction, Paint Companies, Local authorities) in order to estimate the effects of each particular photocatalytic application in the abatement of air pollutants as well as in the energy saving sector.

VISIONS DSS Platform is a multi-criterion IT modular tool which aims to support the decision of stakeholders and end users on the suitability of photocatalytic applications based on energy efficiency, sustainability and financial feasibility.

It addresses to stakeholders and end users (Building Construction, Paint Companies, Local Authorities) and supports the following decisions

- Effectiveness of photocatalytic application
- Provides multi-criteria predefined solutions
- Support for decision makers on the suitability of the solution based on energy efficiency, sustainability, financial feasibility
- Best practice examples

### **ProVisionAir+ commercial company**

ProVisionAir+ company aims to provide:

- Services for the design of high-quality photocatalytic materials which improve the air quality of indoor environment and the energy efficiency.
- Design, management and exploitation of photocatalytic technology through a DSS software/ platform.

ProVisionAir+ is a commercial company that has been established in the frame of LIFE VISIONS project and aims to provide detailed information and solutions to customers, about improving

The logo for ProVisionAir+ features the text "ProVisionAir+" in a bold, italicized, black sans-serif font. The text is centered within a bright yellow rectangular background that has a subtle drop shadow effect.

the interior air quality and energy savings, by utilizing optimized photocatalytic paints, plasters and other building construction materials formulations.

Specifically:



- Services for the design of high-quality photocatalytic materials which improve the air quality of indoor environment and the energy efficiency.
- Design, management and exploitation of photocatalytic technology through a DSS software/ platform. The Decision Supporting System helps the customers to calculate the benefits of using photocatalytic materials and decide the most suitable solution for their building.

The promotion of the company's services will be mostly based on the existing channels of its commercial partners and it addresses to the following clients (Fig.19):

- Industrial – Constructive companies
- Manufacturing industries of construction materials
- Construction companies
- Engineers, Architects, building experts
- Private/ Public Buildings directly (Hospitals, Hotels, Industries etc.)
- Residential owners or tenants
- Administrator and operators responsible for the interior air quality of the rest sectors described in the previous slide (factories, offices, hotels, gyms, etc.)

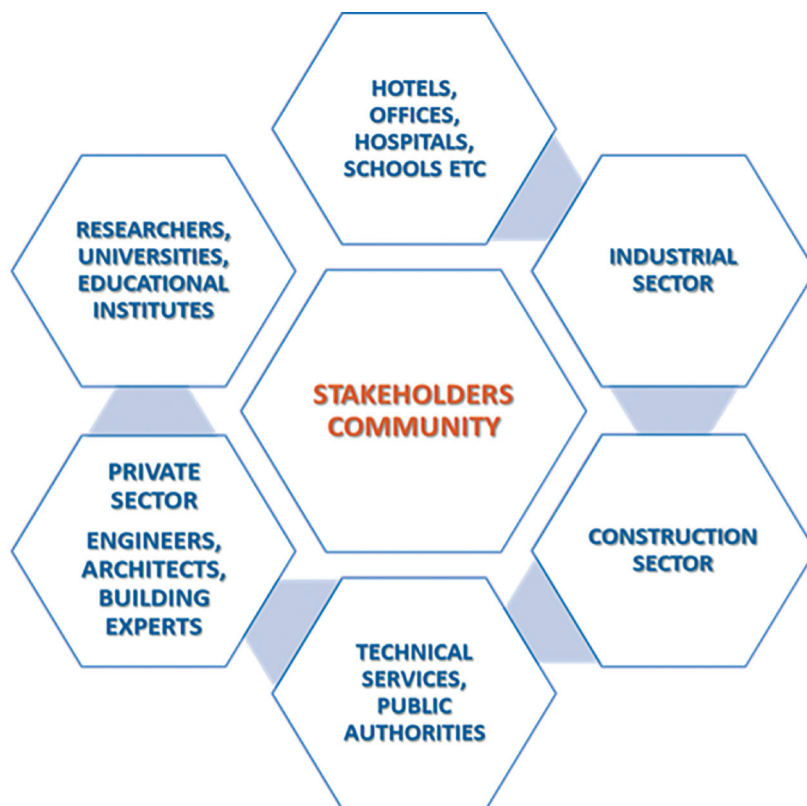


Figure 19 Stakeholders community

## Public awareness and dissemination of results in numbers



### LIFE VISIONS: Best European project for the Environment at the GREEK GREEN AWARDS

LIFE VISIONS participated as an exhibitor at the 5th VEDRE TEC exhibition for environmental technologies, circular economy, and smart cities. Participants had the opportunity to highlight every aspect of cutting-edge environmental issues from photovoltaics, waste management and small hydro to recycling, biogas, and green public procurement. Companies, institutes from the private and public sector, scientists, universities and State and local government provided answers and solutions through workshops and seminars during the three-day Verde.tec Forum held on March 17 - 19, 2023 in Athens. More than 13,000 visitors had the opportunity to interact with experts in the field and gain valuable insights into the latest trends, advancements, and best practices.

LIFE VISIONS was honored with the best EU project award for the environment at the Greek Green Awards. The event highlighted organizations, local government agencies and businesses that put scientific knowledge and technological innovation at the service of the environment, with their selection being made by a specialized scientific committee. The event took place on Friday, March 17 at 16:30 in the MEC conference hall (Fig.20).

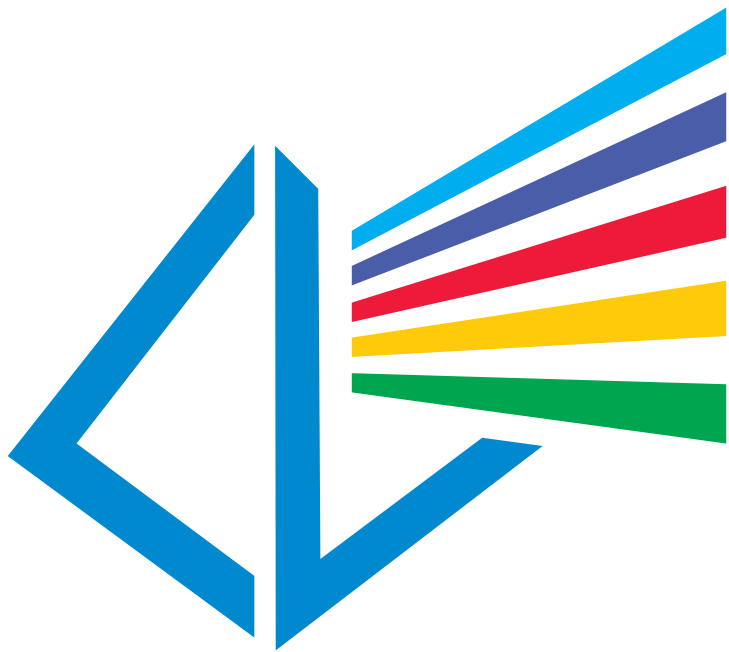
LIFE VISIONS also had the opportunity of networking and interacting with other LIFE projects in the framework of LIFE Program's participation in both the Verde.tec fair and Verde.tec forum. LIFE program organized a two-hour LIFE session which promoted LIFE's four sub-program and the LIFE 2023 Calls for proposals. Also, various LIFE project technologies and best practice examples in the clean energy transition, climate change mitigation and circular economy fields

were presented. The session included a 'speed pitch' where several ongoing LIFE projects, including LIFE VISIONS presented their technologies and methodologies.





Figure 20 LIFE VISIONS at the Greek Green Awards



Improve  
indoor Air Quality

Save energy  
using innovative photocatalytic paints



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