ECO² -SCHOOLS as learning-action living labs

Deliverable 2.1: Use Cases Definition

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Abstract	Deliverable 2.1 presents the project's Use Cases, focusing on the renovation plans of the 5 Educational Buildings. The document also discusses the procedure in shaping the Use Cases and provides a detailed definition for the renovation works of each Pilot Site. A key part of the process is the forming of the Use Cases Template which is crucial for the Pilot Sites to describe their renovation plans. The insights and implications of these Use Cases for energy efficiency in Educational Buildings are thoroughly described and analyzed, offering valuable input for the whole project.
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Executive summary

Deliverable 2.1 (Use Cases Definition) aims to provide an in-depth exploration of the methodology, development, and application of the Use Case Template. This was developed to become a critical tool designed to foster energy-efficient renovations in educational buildings across the various Pilot Sites in Europe which are vital parts of the project. It underscores the crucial role of stakeholder involvement and data analysis in driving innovation and environmental sustainability. The document presents the specific renovation plans, motivations, and adaptations of these pilot sites, demonstrating the broad applicability and potential of the methodology for driving energy efficiency and sustainability in diverse settings. Moreover, it highlights the substantial environmental impact of retrofitting educational buildings and the pivotal role of the Use Cases within the project, showing how they contribute to energy reduction, decarbonization of the energy sector, and the promotion of open schooling. The deliverable ultimately provides valuable insights into the feasibility of achieving substantial energy savings with minimal costs and maps out a clear, replicable pathway towards sustainable, high-performing educational buildings.

Chapter One includes an introduction to the document scope and structure with a description with its objectives. Moreover, it highlights the key parameters of the Deliverable and particularly the Use Case Template Creation, which is essential for designing the Use Cases, the process that was followed along with the Use Cases Definition for each Pilot Site.

Chapter Two outlines the systematic approach employed to develop and shape the Use Case Template, a critical tool designed to enable energy-efficient renovations in educational buildings. The chapter provides insight into the template's meticulous design process and emphasizes its key features, detailing how it caters to a diverse range of factors. Furthermore, it highlights the extensive data collection process integral to the Use Case development. This procedure was carried out by the Pilot Sites Representatives who were appointed form each Pilot Site to interact with the stakeholders and the building executives to acquire a deep view into the needs of each Pilot Site along with the plans for sustainability and alignment with the NEB principles.

Chapter Three focuses on the core part of the Deliverable since it provides a detailed description of the methodology described in Chapter 2 across various the 5 Pilot Sites of the project. The chapter provides a description the five Pilot Sites, demonstrating not only the implementation of the Use Case Template but also depicts in detail the renovation plans, motivations and adaptation of the 5 Pilot Sites to the NEB LAB principles It begins with the green school campus of Ellinogermaniki Agogi in Greece, then transitions to the green neighborhood campus and renovation living-lab in Microville 112, Coursy, France. The narrative continues with the Ciência Viva Science Center in Portugal, the University College Cork in Ireland, and the Sigtunaskolan Humanistiska Läroverket (SSHL) in Sweden. Each section details the unique context, challenges, and renovation plans for the respective educational buildings, illustrating the broad applicability of the project's methodology and underscoring its potential for driving energy efficiency and sustainability in diverse settings. Overall this Chapter aims to show the renovation plan of the Educational Buildings

Chapter Four initially discusses briefly the significant environmental impact of retrofitting Educational Buildings across Europe and the crucial role of the Use Cases in the project. Retrofitting these buildings can drastically reduce energy consumption and contribute to the decarbonization of the energy sector, aligning with the objectives of the European Green Deal. The Use Cases foster open schooling and innovative, energy-efficient solutions tailored to the needs of educational communities. They demonstrate the feasibility of achieving substantial energy savings with minimal costs and outline a clear, replicable pathway towards sustainable, high-performing educational buildings. This is achieved by creating strategic energy master plan for each demonstration site.

Chapter 5 includes the final conclusions of the Deliverable summarizing the main topics that were developed in the document.

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1 Introduction

1.1 Purpose of the document

Deliverable 2.1 Use Cases Definition is a key document for the whole project presenting the framework and strategies associated with the renovation plans for five selected Educational Buildings across Europe. This Deliverable aims to promote the energy efficiency actions in these buildings, which aligns with the European Green Deal's objectives. Some coral issues that are discussed in the Deliverable are the following:

- **Use Case Template Creation:** It is the most important part of the Deliverable since it describes the development of the Use Case Template, an essential tool that allows the Pilot Site Representatives to systematically describe their renovation plans. This segment presents the rationale, design process, and key attributes of the template, emphasizing its crucial role in structuring and guiding the renovation planning.
- **Data Collection Process**: In that part are described the actions of the Pilot Site Representatives who were responsible for gathering the data**.** The Pilot Site Representatives play a critical role in developing the Use Cases for energy-efficient renovations in Educational Buildings. Their activities include conducting desk research, site visits, interviews, using monitoring tools, and surveys to collect diverse data. They then analyze this data, assembling, organizing, and reviewing the information in depth to provide a comprehensive understanding of the needs and challenges of each institution. This robust process ensures the Use Cases are both accurate and tailored to the specific needs of each Pilot Site.
- **Use Case Definition for Each Pilot Site:** The core part of the Deliverable that provides comprehensive, site-specific details about the renovation plans for the five Pilot Sites across Europe. It acts as a tangible demonstration of how each site intends to implement their strategies and what their specific renovation works involve.

In summary, Deliverable 2.1 provides as a detailed and strategic roadmap for the energy-efficient retrofitting of educational buildings. It lays the groundwork for tangible action and paves the way for a significant reduction in the environmental footprint of these buildings.

1.2 Scope and audience of the document

The Deliverable aims to provide all the appropriate information to the consortium partners with all the appropriate information about the Use Cases of the project. It could also serve as a reference document for related projects in the field or future actions.

2 Methodology for developing the Use Cases

In this chapter is explained in depth the comprehensive approach that was adopted for shaping the Use Case Template which is a crucial tool that was used to describe the sustainable and energy-efficient renovations of Educational Buildings. This chapter delves into the objectives and contributions of the Use Case Template creation, outlining its detailed along with its structure and its requirements from the Pilot Site Representatives for its completion. It further explores the data collection process elucidating the various techniques and tools used, the critical role of stakeholder involvement in data collection and assisted by the Pilot Site Representatives who are the key persons in carrying out this procedure. This chapter aims to provide a holistic understanding of the methodology implemented Use Case development, ultimately reinforcing the goal of creating optimal and environmentally friendly educational spaces.

2.1 Use Case Template: Objectives & Contribution

The creation of the Use Case Template is a critical component of the larger project mission to foster energy-efficient renovations in Educational Buildings across different geographical zones. The Template is more than just a document; it's an essential tool designed to guide, streamline, and standardize the process of documenting various renovation projects.

The objectives of this Template serve to address the core needs of such a multifaceted project and anticipate the diverse challenges that might arise. These objectives have been outlined with an understanding that each renovation project will occur in its unique context, and will, therefore, have different needs, challenges, and opportunities. The Use Case Template has several key objectives:

- **Capture Diverse Scenarios:** The Template aims to provide to the Pilot Sites an adaptable and comprehensive guide, it allows users to capture diverse scenarios from different regions with varying climatic conditions and building types.
- **Facilitate Best Practices:** The Template seeks to instill best practices in energy-efficient renovations. It provides guidelines on including different stakeholders, integrating new technologies, and considering local climate and societal factors in renovation plans.
- **Encourage Replicability:** The objective of the Template is also to provide lessons learned and best practices discovered in one project easily transferable to others. By standardizing the way information about Use Cases is collected and presented, it becomes easier for future projects to understand and replicate successes.
- **Foster Data-Driven Decisions:** Through sections on existing infrastructure, planned technologies, and expected outcomes, the Template promotes data-driven decision-making. It encourages users to assess their current situation, evaluate various options, and predict results, which can lead to more efficient and effective renovation plans.

The value of a Use Case Template in such a project should be highlighted. It is an integral part of the project infrastructure that, in many ways, shapes the course of the initiative. By providing a uniform structure for collecting and reporting data, it plays a vital role in ensuring that all involved parties share a common understanding and can easily exchange learnings. The Use Case Template serves as a backbone, connecting the different aspects of the project and ensuring their smooth interaction. This influence extends beyond just the data collection phase; it permeates all stages of the project, impacting everything from the planning and execution of the renovations to the final analysis and evaluation of the project's success. The Use Case Template contributes significantly to the overarching project in several ways:

- **Provides a standardized method for collecting and presenting information** about the different pilot projects. This not only helps to maintain consistency across the project, but also aids in comparing the outcomes of different Use Cases.

- **The Template is an invaluable tool for knowledge sharing**. It enables the lessons learned from one renovation project to be understood and applied in other contexts. This can lead to a more rapid and widespread adoption of effective energy-efficient renovation strategies.
- **By outlining what information needs to be gathered and considered,** the template aids in the planning and execution of each renovation. This can increase the efficiency of the project and reduce the risk of missing critical factors.
- **Contributes in demonstrating** the feasibility and benefits of energy-efficient renovations in Educational Buildings. This can contribute to the broader goal of promoting energy efficiency and sustainability in the education sector.

By outlining what information needs to be gathered and considered, the Template aids in the planning and execution of each renovation. This can increase the efficiency of the project and reduce the risk of missing critical factors.

Lastly, the Template can help to demonstrate the feasibility and benefits of energy-efficient renovations in Educational Buildings. This can contribute to the broader goal of promoting energy efficiency and sustainability in the education sector.

2.1.1 Design Process of the Template

Shaping the Use Case Template was a complex process since was required a deep understanding of the factors involved in transforming each Educational Buildings from different backgrounds into energy-efficient facilities. What must be considered is that the 5 Pilot Sites not only represent different cultures, but also belong to different climatic zones, they have different needs, and their target group varies from students to visitors. For this purpose, the Pilot Site Representatives needed to conduct a though study of the current operational patterns of the Educational Buildings. A concerted effort was made to understand the energy consumption habits, the building infrastructure, and the behavior of the users within these buildings.

The objective of creating such a Template was to facilitate a cultural shift that would allow Educational Buildings to adapt to new sustainable models, and behavioral changes through their renovation procedures. Thus, the design process was not limited to the renovation of the technical infrastructure but they extended in order to achieve a transformation of the behavior of the users of the buildings in a more sustainable manner.

Living labs, real-world test environments to co-create, explore, and test new technologies, concepts, and services, were identified as a central mechanism for catalyzing change. They provided an opportunity for direct interaction with new technologies and offered a real-world setting where new ideas could be tested, refined, and validated before being implemented on a broader scale.

Three distinct regions were chosen for setting up these living labs - the Mediterranean, the Atlantic, and the Nordic. This regional selection ensured a broad representation of different climatic conditions and socio-cultural contexts, hence enabling the development of region-specific energy-efficient solutions.

The local, regional, and national value chains in these regions were identified and studied to understand their unique operational models. This knowledge served as a foundation for creating a Template that could demonstrate, evaluate, and replicate innovative solutions specific to different environmental and market conditions.

Finally, the design process involved a rigorous validation stage to ensure the compatibility and adaptability of these solutions for different building types in Mediterranean and Nordic climate zones.

2.1.2 Key Features and Structure of the Template

The Use Case Template was designed to be comprehensive and adaptable, accounting for a broad range of factors. The key features and structure of the Template are discussed in detail below and a short description of them is provided on Table 1.

The Template begins with detailed information about the Pilot Site, including the name and region of the campus, sector, district buildings portfolio, and target groups. This section aims to provide a clear overview of the context in which the Template will be implemented.

Next, the Template delves into the 'Main Characteristics' of the educational complex. It gathers extensive information on the area, the number of buildings, type of planned renovation, and yearly energy consumption, offering a comprehensive understanding of the existing infrastructure.

The 'Type of Planned Renovation' section outlines the specific renovation objectives, the areas or buildings to be renovated, the techniques and materials to be used, and the project timeline. It also includes a cost estimate and a plan for monitoring the renovation's impact.

The 'Motivation' section seeks to understand the driving factors behind the project. It emphasizes the environmental awareness of the site, potential benefits, the project's replicability, any current active networks where the NEB LAB values can be promoted, and strategies for enhancing existing synergies between the Pilot Site and other bodies.

The 'Pilot Concept Description' lays out the specifics of the renovation project and the use of environmentally friendly materials. It also probes the integration of these actions in the existing Building Management System (BMS).

'Adopting the NEB LAB Concept' section reflects on the contribution of the renovation project to the Green School Living Lab, benefits of involving the school community with stakeholders, and the proposed interventions as mechanisms for resource mobilization and strengthening social capital.

The 'Existing technologies / systems / infrastructure' section provides an overview of the existing energy efficiency infrastructure and identifies gaps that could be addressed in the renovation.

The 'Technologies to be integrated in the building’s renovation' and 'Technologies to be used in the design and construction workflow' sections elaborate on the new technologies to be incorporated into the project and their expected benefits.

The 'Value added for the target groups and market potential' section discusses the potential benefits for users, the adaptability of solutions, strategies for raising awareness, potential benefits from digital technology, and the role of district energy management.

'Addressing horizontal enablers' outlines the social innovation benefits, integration of circular economy principles, interoperability aspects of the solutions, potential energy savings, and dissemination strategies.

'Expected Results / Outcomes' provides data on expected energy performance, carbon footprint reduction, and the expected outcomes of innovative digital solutions.

Lastly, the 'Organizations involved' section names the partners involved in the retrofitting process.

Table 1. A short description of the different sections of the Template

Template Section	Short description
Pilot Site Information	Covers details about the Pilot Site, including name, region, campus, sector, district buildings portfolio, and target groups.

Main Characteristics	Captures comprehensive information on the area, the number of buildings, type of planned renovation, and yearly energy consumption.
Type of Planned Renovation	Details the renovation objectives, areas or buildings to be renovated, techniques and materials to be used, project timeline, cost estimate and the monitoring plan.
Motivation	Identifies the driving factors of the project, including environmental awareness, potential benefits, replicability, and strategies for enhancing existing synergies.
Pilot Concept Description	Describes the renovation project specifics, the use of environmentally friendly materials, and their integration with the existing Building Management System (BMS).
Adopting the NEB LAB Concept	Highlights the contribution of the renovation project to the Green School Living Lab, the benefits of stakeholder engagement, and the proposed interventions for resource mobilization and social capital strengthening.
Existing technologies/systems/infrastructure	Gives an overview of the existing energy efficiency infrastructure and identifies gaps that could be addressed in the renovation.
Technologies to be integrated and used	Elaborates on the new technologies to be incorporated into the project and their expected benefits.
Value added for the target groups and market potential	Discusses potential benefits for users, strategies for raising awareness, benefits from digital technology, and the role of district energy management.
Addressing horizontal enablers	Outlines social innovation benefits, integration of circular economy principles, potential energy savings, and dissemination strategies.
Expected Results / Outcomes	Provides data on expected energy performance, carbon footprint reduction, and expected outcomes of innovative digital solutions.
Organisations involved	Names the partners involved in the retrofitting process.

The Template is designed to be comprehensive and thorough, providing a detailed framework to guide the renovation of educational facilities towards more sustainable and energy-efficient practices.

2.2 Data Collection Process for Use Case Development

The data collection process for Use Case development is a comprehensive task that requires a structured and systematic approach. This process involves the extraction of valuable information from various resources, considering multiple perspectives and sources, to generate a rich dataset for the development of the Use Case template. A key factor for the data collection process is is the appointment of the Pilot Sites Representative who is responsible for contacting the Pilot Site stakeholders to collect the appropriate data for the renovation of the Educational Buildings.

2.2.1 Data Collection Process for the development of the Use Cases

A variety of techniques and tools were employed to collect data for the Use Case development. The various steps of this procedure are shown on Table 2:

Table 2. The process of collecting the Pilot Sites data from the Pilot Site Representatives

Step	Method	Description
1	Desk Research	In this phase the Pilot Site Representatives conducted a thorough review of existing literature, reports, and case studies on energy-efficient renovations in Educational Buildings, particularly those located in the Mediterranean, Atlantic, and Nordic regions. This process offered a wealth of background information and a comprehensive understanding of the current landscape in these regions.
2	Site Visits and Interviews	The Pilot Site Representatives conducted site visits and interviews with the staff and stakeholders from various sector to understand the type of the renovation which is needed for each Pilot Site. Such a process allowed an in-depth exploration of the specific contexts and unique challenges faced by these institutions.
3	Monitoring Tools	The Pilot Site Representatives needed to have access to quantitative data from the various monitoring tools were used from the buildings. These included energy metering systems and sensors, which enabled accurate tracking of energy consumption and other relevant parameters.
4	Surveys	Surveys were employed to gather information from a broader range of stakeholders, including pupils, administrative staff, public authorities, and others. These were designed to gather feedback on various aspects of the proposed renovations and their potential impact on the user experience.

In order this data collection process to be conducted successfully, a multi-pronged approach was adopted to ensure quality and diversity of information gathered for developing the Use Case for each Pilot Site. development. Desk research was essential to understand the overall concept of renovating buildings activities and gathering vital insights into energy-efficient renovations in Educational Buildings. In this way the Pilot Site Representatives were provided with a broad spectrum of ideas for potential renovation strategies and with knowledge about good practices. Moreover many site visits, observations and interviews with key persons who were involved to the renovation process was pivotal for gaining first-hand, practical insights into the specific contexts and unique challenges faced by the Educational Buildings considered in this project. This step was crucial in tailoring the approaches to the specific needs of each institution.

Monitoring tools were used to gather hard data, particularly in terms of energy consumption and relevant parameters. This quantitative data offered a precise understanding of the baseline and potential energy savings that the renovation could achieve.

Surveys allowed the team to gather a wider range of opinions and feedback from various stakeholders. The information collected through surveys helped to gauge the potential impact of the proposed renovations on the user experience, thus facilitating the refinement of the project's plans based on this feedback.

2.2.2 Analysis of Collected Data

The analysis of collected data was key procedure in the data collection process, ensuring the effectiveness of the Use Case development. The process of analyzing data was largely guided by the Pilot Site Representatives, who had a crucial role in gathering and deciphering data from their respective educational institutions.

The first step in this process was the assembly of data. The Pilot Site Representatives were responsible for gathering all relevant data from their educational institutions. They accomplished this by tapping into the extensive networks within their organizations and relevant stakeholders. The data covered a range of aspects, including the physical characteristics of the schools (area, type of buildings, existing energy consumption, etc.), planned renovations, and the motivation behind energy-efficient initiatives.

The Representatives collected this information through various methods. For instance, they had direct conversations with various stakeholders like the school's administrative staff, technical personnel, teachers, and students. In some instances, Representatives would utilize their school's internal databases or documentation to gain access to necessary information.

Once the data was collected, the Pilot Site Representatives had to organize the information. This process required cataloging the data in a way that was consistent and meaningful, focusing on separating the collected data into key categories like 'physical characteristics,' 'planned renovations,' and 'motivations.' This categorization that was requested from the Template enabled a more systematic approach when the time came to register the data into the Use Case template.

Following the organization of data, the Pilot Site Representatives carried out a thorough review of the collected information. They examined the data in its various categories to understand the the current state of their institutions, the specific objectives and goals of their renovation plans, and the underlying motivations driving these energy efficiency initiatives.

The Pilot Site Representatives were uniquely suited for this task. Given their in-depth knowledge of their institutions and the wider context, they could interpret the data in a way that was both detailed and holistic. This rigorous analysis process ensured that the data feeding into the Use Case template was not only accurate but also comprehensive, offering a multifaceted understanding of each educational institution's unique situation.

The outcome of this data analysis was a rich, detailed, and well-organized set of information that could be used effectively in the development of the Use Case template. By meticulously collecting, organizing, and analyzing data, the Pilot Site Representatives were able to provide an invaluable contribution to the Use Case development process.

2.2.2 Involvement of Stakeholders in Data Collection

Stakeholder engagement in the data collection process for Use Case development was vital to the project's success. The project involved stakeholders, each offering unique perspectives and expert insights. Architects, teachers, students, and other key stakeholders contributed their valuable knowledge and experience to this process, enabling the Pilot Site Representatives to acquire comprehensive, context-rich data that informed the creation of effective Use Cases.

Pilot Site Representatives played the role of a crucial link, facilitating the flow of information between the project and the larger stakeholder network. They leveraged their position within their respective organizations to engage in direct communication with these stakeholders. This process was conducted with the explicit intent of understanding each stakeholder's perspective, thus ensuring the collected data reflected the full spectrum of views and requirements pertinent to the project.

In their dialogues with architects, Pilot Site Representatives gained understanding about the concepts behind energy-efficient and educationally optimized building designs. Through this, they were able to comprehend the architects' motivations for innovative, sustainable, and functional educational spaces.

Similarly, the interactions with technology providers offered the Representatives insight into the potential technological solutions that could be applied to address energy inefficiencies. They were also able to understand how these providers saw their technologies contributing to the project, thereby identifying the benefits and potential challenges of their integration.

Discussions with financial bodies provided the Representatives with a broader understanding of the financial landscape surrounding retrofitting projects. This helped them comprehend the importance of identifying and facilitating access to funding opportunities, as well as the need for ensuring financial viability.

The Representatives' conversations with local stakeholders and non-formal actors such as NGOs, SMEs, and science centers gave them a clear idea of the local community's needs and aspirations. These interactions were critical for aligning the project's direction with the community interests, ensuring that the renovations were not just environmentally sustainable but also economically beneficial and socially acceptable.

Educational institutions, including teachers and students, played a pivotal role in the data collection process. Their inputs about the pedagogical requirements of the learning spaces and user experiences offered rich, firsthand information. This helped the Representatives in shaping Use Cases that catered not only to the sustainability goals of the buildings but also to the effectiveness of these spaces in promoting quality education.

Interactions with the building owners and the Chamber of Quality allowed the Representatives to understand the motivations behind investing in renovations and the standards for ensuring quality in construction and retrofitting practices.

In all these interactions, the Pilot Site Representatives meticulously collected data, ensuring the stakeholders' perspectives were accurately represented. These interactions were not just about data collection but also about understanding the stakeholders' vision and the context surrounding the renovation project. This understanding was crucial in creating Use Cases that consider the multiple facets of renovation – from financial viability and technological integration to user experience and local community impact.

Through continuous dialogue and close collaboration with stakeholders, the Pilot Site Representatives gathered comprehensive and contextually rich data. This detailed stakeholder engagement process added significant depth to the data collection process, ultimately leading to the development of effective and impactful Use Cases for Educational Buildings renovation.

3 Use Case Definition for Each Pilot Site

In this section the 5 Pilot Sites have provided all the renovation plans, goals and ambitions following the instructions provided in the proposed Template.

3.1 Ellinogermaniki Agogi: Green School Campus

	**EA School Campus**	**Pallini, Attica, Greece**
	Sector: Primary/Secondary Education	
	District buildings portfolio: School buildings	
	Target groups: Building owner and users (students, administrative & teaching staff), municipality	
	Link: https://www.ea.gr/	

Main characteristics (area (squared meters), type of planned renovation, number of buildings, yearly energy consumption, etc.) – Motivation

MAIN CHARACTERISTICS

Ellinogermaniki Agogi (EA) (Figure 1) is a private school complex located in the periphery of Attica. Established in 1961, it schools today approximately 2500 students. Additionally, the school offers employment to 250 teaching staff and 330 administration staff. The complex of the buildings of the school is in Pallini, a municipality in the Attica region, being thus an excellent case study for typical Mediterranean climate conditions with regards to energy efficiency in buildings.

Figure 1. EA School – Main campus after the completion of certain renovation works. Solar panels that will contribute to the energy efficiency of the school are visible on the roof of the building.

The school has already in place a strategy towards energy efficiency of the school campus, that includes the construction of a new energy efficient building of 1500 m^2 (in operation in September 2021), the renovation of the primary school building (construction in 1995), the construction of a bioclimatic school canteen (2023) and a large scale solar park (2022) along with the purchase of electric school buses fleet (150 vehicles) in 2025 (through the Just Transition Mechanism (JTM) of the Green Deal Investment Plan for Greece). The total foreseen investments go up to 5,5MEuros. The current total area of the school buildings adds up to 15,807m^2 (to reach 17.307.00m^2 in September 2021). and the energy consumption yearly is estimated at 1,8 GWh for the main complex of school buildings (Kindergarten, Elementary school, High School and Lyceum) resulting to 1,1MtCO_2e.

TYPE OF PLANNED RENOVATION

In the context of this project, a large scale pilot with several separate demos is being proposed, focused on achieving high energy performance and energy savings, use of innovative and sustainable energy solutions, improved indoor environmental quality for the users, optimal dynamic matching of on-site renewable energy generation and building/neighbourhood consumption, creation of "living-labs" and innovation clusters, replicability and propagation of methodologies to be used in other projects. To achieve the above, a series of point interventions are proposed including the construction of a new unit to act as a model for positive energy performance, the creation of a solar car park, the partial renovation of an existing building and the testing of the DR smart grid flexibility scheme. The focus of the pilot, which will permeate all the individual demos, will be the development of solutions for energy efficiency in school buildings (Green School Living Labs) through increased consumer engagement in energy saving practices and gamification. There are over 3000 daily users with a substantial energy consumption.

MOTIVATION

EA is very much interested in forging a strong ethos to its students with regards to the environment, healthy living and the use of modern technology and has participated in many research projects both E.U. and privately funded Having established close links with schools from other countries, it has also created synergies with the Municipality of Pallini. These synergies can be further enhanced with regards to the energy grid and circular economy plans. Given that the community of EA consists in its majority of the future citizens of tomorrow, this pilot will have a major indirect impact to the society but also a direct impact to the district, by alleviating the energy grid of the area and offering clean energy to municipal users. Also, the replicability of the pilot is major as there are 13.000 school units in Greece, where energy performance/consumption monitoring is limited. EA is coordinating a large network (more than 1.000) of Open Schools (www.openschools.eu) that are acting as innovation hubs and agents of change in their communities. Through this network the NEB-LAB approach and solutions will be also promoted to numerous schools in Europe.

Pilot concept description

For the realisation of the pilot a series of interventions is foreseen which will be articulated around the following demos:

CONSTRUCTION OF SOLAR PARKING LOTS – DEMONSTRATING INTERCOMMUNAL GRID ENERGY BALANCING AND PROVISION OF FLEXIBILITY SERVICES TO THE POWER GRID

A modern hi-tech photovoltaic park (adopting a nature-inspired architectural design) in the parking lot with canopies will be constructed offering the chance to charge EV fleets in an optimised way. In a vehicle-to-grid approach, the vehicles may also feed the internal grid and support it with ancillary services, allowing bidirectional energy fluxes, and acting as a new player eventually providing services to the power grid. One EV will be bought in the context of this demo, to show the scalability of reducing energy consumption of the school, from their buses' fleet. A smart digital solution will be developed, to test the distribution of energy between the school and the community by matchmaking energy surplus and demand for internal and external users with EV vehicles. An additional digital solution will be developed, to collect production and consumption metering data, provide forecasts, estimate the available flexibility and allow the exchange of information between the school and the grid operator (HEDNO) to simulate a DR scheme.

CONSTRUCTION OF A ZERO-ENERGY BIOCLIMATIC SCHOOL CANTEEN, TO ACT AS A BENCHMARK FOR NET ZERO/POSITIVE ENERGY PERFORMANCE AND FUTURE INTERVENTION

A new school canteen building of 40m^2 will be designed with materials with low embedded CO_2, and it will include innovative solutions to produce the energy required for its operation, including natural ventilation systems, hybrid BIPV solutions for facades, use of BIM a digital from federated sources, to reduce energy consumption during the building operations to be integrated in a BMS actuator model. Energy needs will be optimised using tailored architectural features and materials (very effective building insulation, green roof, low-energy lighting, and equipment). It will also make use of local and renewable energy (schools swimming pool to act as heat storage tank, MCHP running on vegetable oil and new generation solar panels) and water is managed (recovery of rainwater, specific vegetation in the schools' organic garden).

The canteen is located to the central campus plaza which is bridged over to interconnect the primary and secondary school buildings. The bioclimatic canteen building is part of the school strategy towards the transformation of food systems that require low-carbon, circular and planted based approaches. The school operates an organic school garden that apart of acting as an open educational environment for all students is producing significant amount of vegetation being consumed in the school canteen.

Figure 2. Bioclimatic Canteen Transformation

USING THE SCHOOL'S SWIMMING POOLS AS THERMAL STORAGE

EA campus hosts two indoor swimming pools with a total volume of 700m^3. Swimming pools with Dehumidification systems for indoor air use to be a good spot for water sources heat pumps (HP) thanks to combined cooling and heating process, coupling necessary in multiple operational scenarios. Heat pumps using natural refrigerants like CO_2 (ODP=0, GWP=1) in compliance with F-Gas ordinance, suitable for large temperature swing, maximizing the use of cooling– heating coupling, provide the right temperature for every process. Also fulfil the framework conditions for efficient heating networks and process heat from renewable energies (Figure 3).

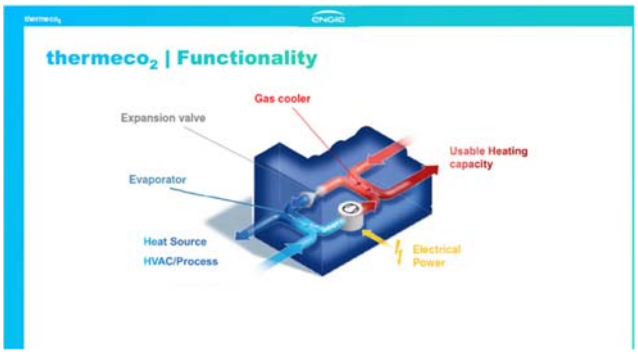
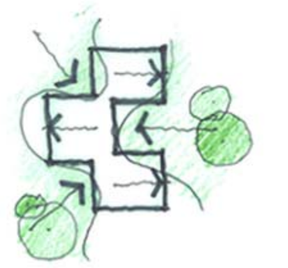


Figure 3. A diagram of an ecofriendly pool

Dehumidifying and cooling large indoor pools can be quite a substantial challenge because of the heavy sensible/latent heat load placed on refrigeration equipment. In the framework of the NEB-LAB project a heat pump mechanism will be used for the exchange of heat between the main building and the swimming pools. A control strategy will be designed to utilize existing components to remove heat without the need of an external condenser. Simply explained, the existing air conditioning facility will use the thermal storage capacity of the swimming pool to hold excess heat created during air conditioning of the facility (e.g., the Sports Hall, the School Building, the Main Amphitheatre or the Indoor space of the pool itself). However, if cooling demand not coupled with heating demand, then thermal storage hot water buffering will be necessary to implement the HP solution.

RENOVATION OF AN EXISTING BUILDING

A part of the main building will be renovated aiming at reducing the existing life cycle carbon footprint and reduce energy consumption by 30%. The renovation will include the use of innovative insulation materials, smart facades, use of indoor and outdoor smart meters, sensors, actuators in specific areas of the main building. The above data is anticipated to be further used in the future and integrated in the existing BMS of

the building, which is also anticipated to be enhanced in the future, to smartly manage areas of the building (e.g., heating, lighting within each classroom) with the aim of reducing energy consumption.  **ADOPTING THE NEB-LAB CONCEPT:** All the above demos will be part of the Green School Living Lab concept to raise awareness on buildings energy efficiency to school students but also to the local community. EA aims to demonstrate that when schools partnering with their local communities and stakeholders, they could become agents of community well-being through their involvement in co-creative research and innovation on energy and resource efficiency in the school settings, inspired by the green school demonstrators. Exploring the interdependent relationship between the school, families and their community through an ecological systems perspective, the proposed interventions employ an interpretivist construct to demonstrate the importance of interconnected relationships as a mechanism for mobilising resources, strengthening social capital and building collective capacity. Develop citizen awareness raising activities spreading the concept of energy and resource efficient building and renovating and promote education and training for sustainability.
Existing technologies / systems / infrastructure (incl. Energy Metering Systems, sensors, monitored data, etc.)
The main buildings of the school complex use electric power, provided by the Greek public Electricity provider. For the lighting fluorescent lamps are being used. The main energy source used for heating is petrol. The school has installed sensors for lighting, temperature etc. in some limited areas of the school (7 classrooms).
Technologies to be integrated in the building's renovation
Indoor and outdoor atmosphere control with energy use reduction/optimisation: **a/**Development and use of innovative digital solutions solutions for energy monitoring, analytics and recommendations platform. **b/** Smart, Covid-compliant air purification systems for a safer environment, and upscaled BMS for energy management Smart facades: **a/**Automatic shading devices for solar control, **b/**Eco Insulation, **c/**innovative photovoltaic panels. Non-Energy – Resource Efficiency: Use of smart devices, integrated with a dedicated platform
Technologies to be used in the design and construction workflow
Construction flow optimisation**:** BIM and Digital Twins for integrated design and enhanced construction programmes**;** Indoor and outdoor atmosphere control with energy use reduction/optimisation & Smart Facades**;** BIPVS' & Energy Storage Systems**,** HAVC.
Value added for the target groups and market potential
a/The notion of school as a living lab promotes partnering of school with the local communities and stakeholders. **b/** The implemented solutions will be scalable to other school buildings. **c/**The implemented solutions will be scalable to other school buildings. **d/** Develop citizen awareness raising activities spreading the concept of energy and resource efficient building and renovating. **e/** Promote education and training for sustainability, helping all actors (school staff, students, families, citizens) development competences and positive behaviors for green practices. **f/**All the innovative digital technology that will be developed and used in this project has a strong market potential **g/** Promotion of district energy management through DR flexibility scheme.
How you intend to address horizontal enablers (social innovation, circular economy, interoperability
a/ *Social innovation* will be addressed through community engagement in 'Green' practices (in the school environment, community involves students, teachers, and other visitors). **b/** ICT and *interoperability* can be seen as an enabler for data gathering for data-driven optimisation services for the buildings energy

management through the solutions mentioned above. **c/** Through the construction of the solar car park and the use of ICT energy management solutions it is anticipated to create a link to the *energy value chain for integrating with smart energy grids* by including electricity distribution network operator (HEDNO). **d/** Energy savings for the building owner (school) results in capital savings which could be invested in further green initiatives within the municipality (e.g., planting trees, creating communal gardens), and in-turn get tax discounts from the municipality, creating thus a simulation model for an *energy/green circular economy model*. This will be further simulated by the promotion of the *energy flexibility*. **e/** All the above promote *social cohesion* via the establishment.
Expected Results / Outcomes
-High energy performance and energy savings (energy production of 1,5 GWh per year from the solar park), Reduction of carbon footprint - Improved indoor environmental quality for the users – Development of innovative digital solutions for energy management (Anticipated 20% reduction in electricity consumption due to this) – Zero-energy School Canteen - Creation of "living-labs" and innovation clusters/social innovation/social cohesion- Smart energy grid synergies.
Organisations involved
PARTNERS: EA: Building and infrastructure, Green School Living Lab, BURO HAPPOLD: Building Simulation and Participatory Design, Social Value; TEKEM: Consulting engineers, INTRASOFT: Technology and platform provider, ENGIE: Solar Park Construction, Heat Pumps and Energy management Solutions, HEDNO: DSO triggering the Demand Response – Demonstration of flexibility scheme, FRAUNHOFER-FIT: Internal and External Spaces (buildings and landscape) Augmentations, DELOITTE and NTUA: City Synergy Strategy and Green Neighborhood Development Planning, UBT: Sustainability Citizenship and Behavioral Change.

3.2 Microville 112, Coursy, France: Green Neighborhood Campus

Eco² Campus Microville112	**Courcy, Grand Reims, France**
Sector: Primary/Secondary/Tertiary/Lifelong Education	
District buildings portfolio: Green Neighborhood Third Place, a ~40 buildings/55000 m2/65 ha former Military Airbase being renovated in 5 years as a Sustainable Microcity (Microville Durable®), learning-action living lab for neighborhoods and villages in transition, at 3 generations.	
Target groups: Building owner and users, municipality, schools/universities/educational third places communities, R&D teams, public/private institutions, best innovative efficiency solutions providers with zero marginal cost and common shared added value.	
Link: www.microville112.org	

Main characteristics (area (squared meters), type of planned renovation, number of buildings, yearly energy consumption, etc.) – Motivation

MAIN CHARACTERISTICS

Eco² Campus Microville 112 (initiated by AS&E) (Figure 4) is an open cooperative educational third place, totem place in the core of the renovation process of former Military Airbase BA112 in Courcy, Grand Reims (FR). This site was the first Military Airbase in France, where the aviation has started in 1909 with testing disruptive light aircraft innovations. This is also a place where surrounding villages of Courcy-Brimont have, by 2 world wars with high concern, build a strong value for cultural openness, cooperative support, Peace for the Living, shared by 3 generations. Hundred years later, in 2008 the Military Airbase has definitively closed, with as consequence a decrease by half of the population. Ten years long the site was closed to human living, but the buildings still maintained in good state. The Nature has taken the place with patient high value adapted biodiversity. The village of Courcy's as a Community did not want to let a low value project take the place on the Airbase, being seen by public institutions as a negative value brownfield. Nevertheless, the Village Council and population have made the commitment to develop a new forward-looking vision of this heritage, as a high potential revival project with positive value for the site and surrounding territory. A high voluntary partnership was initiated with Alliance Sens & Economie, for a systemic renovation of the existing buildings/infrastructures/natural site with support of a dedicated cooperative society of collective interest "SCIC foncière Microville112". This common open cooperative society for non-profit (as all benefits are reinvested for just-safe shared added value, in continue progress) was created by 09/12/2021, the full property was transmitted from the French State Military Domain to the village of Courcy and brought to the starting capital for the creation of SCIC Microville112. A dual dimension process is started for facilitating the installation of new occupants (in transitional use of existing buildings and cooperative development by contracting with investors/project leaders, without selling the ground but attractive leasing with a compensation as cooperative investment in the commons).

The Eco² Campus project was initiated in 2022, as a central "Totem place" and first demonstrative facility using a pair of existing buildings for building common learning-action with a multi-stakeholders cooperative "worksite-school", systemic change scalable methods and high efficient/low resources innovative solutions for Climate Neutral & Smart renovation of Microville112, that will become a systemic learning-action living-lab for the 30 minutes territory of Grand Reims urban area, as other neighborhoods/villages in France and in the EU. enlightening the process and highly efficient solutions, that will be upscaled to the whole Microville112 as Green Neighborhood Campus and systemic renovation living-lab.

The ~40 existing buildings (5 main periods 1900, 1920, 1950, 1970, 1990 and different typologies) are commonly jointly supplied with thermal energy, electricity, water, sanitation (5 district heating oil-fired collective boilers, 1 wastewater treatment plant, 2 high voltage transformers). Half of the buildings have been retrofitted with double glazed PVC windows and insulated internally. Roofs are in good state (sloping roofs, non-habitable attics, wood and metal structures). Walls are of bricks, natural stone, cement plaster, composite wood, metal insulated sandwich panels. The buildings are mainly oriented north-south with 2 main façades exposed to the natural daylight and sun.

Figure 4. ECO²-Campus Microville112: starting a worksite-school and systemic renovation living lab, combined with creativity by interaction with a New European Bauhaus Cultural Center

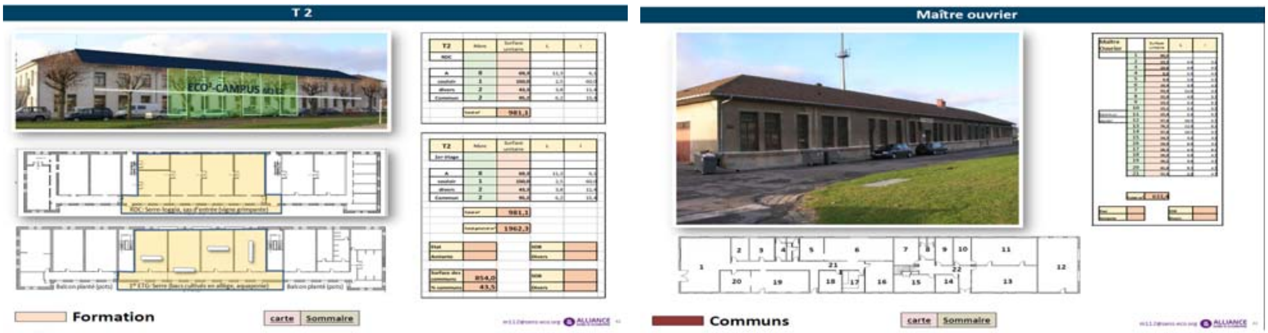


Figure 5. Floor plans and designs of the Microville 112 buildings under renovation

A for start central “Totem place” and first demonstrative facility

As a 10 years long closed military airbase, Microville 112 pilot has as specificity that there is by the beginning of the project no existing school in activity. Therefore Alliance Sens & Economie has organised preliminary contacts and 3 co-design workshops that progressively involve a local as national community of schools (public, private, universities, research teams, permanent education stakeholders) that are involved, with the challenge to reuse a former military educative building that will be renovated as a for start central “Totem place” and first demonstrative facility (1962 m² on two level, 16 classes, each 69,3 m² / 11,3 m x6,1 m). This educative third place will interact with former workshop building “Maître Ouvrier” that will host in residency artists (633,4 m², ~16 rooms/artists cells), by a green courtyard in between the buildings, that will host creative exhibitions as outdoor class workshop activities. On the south facade, the neighboring historical “Command building” on the Place d'Armes is intended to become a “New European Bauhaus cultural centre” and central meeting place in the heart of Microville 112 (Figure 5).

TYPE OF PLANNED RENOVATION

Reims Grand Est region has a temperate climate with a micro-climate conditions due to the limestone soil combined with good sun exposition (very characteristic of wineyards domains), winters can be a bit harder than in other French regions. A central scope is to consider the seasons and need to adapt the habits.

The scope includes (Figure 6):

- **Renovation of the existing educational spaces:** (classrooms, workshops, exhibition and meeting spaces, sanitary) with a smart cooperative approach to sobriety by retrofitting a for new educational uses improved space. As much as possible the renovation action plan will be co-designed and realized as a "worksite-school" combining complementary skills/experience of a community of schools, continue education institutes, apprenticeship companies, citizens associations, research by design interdisciplinary advisors, in co-learning-action. This will offer the opportunity in just 3 years to start being trained as a student, make an apprenticeship on site with a limited proof of concept, realize the renovation as a young skilled professional.

Figure 6. Illustration: scalable "worksite-school" test activities on Microville112 Pilot Site, a coproduced Bamboo extension that will deliver a multifunctional Green Hall connecting and extending the capacity of the educational third place ECO^2-Campus M112 (80-90m x26m x11m 2 levels multifunctional greenhouse, local bio sourced net zero bamboo structure, green roof and central rainwater collection, covered by a thin film solar canopy bioinspired textured color to the façades, circular water cistern and basins in the basement, hydroponic indoor plantations and fish farming, glazed facade composed of recycled deconstruction wood frames opening outwards and painted in different colors, new spaces co-learning-action.

- **Using best efficient and easy to deploy climate-neutral technologies**: contactless battery-free smart switches, upcycled paintings, by colours and luminous piercings in walls natural light improvement, white biosourced reflexive roof coating, biosourced outdoor/indoor insulation, upcycled furniture and interior learning landscape design, decentralized internet sensors (low energy secured local cooperative network), lifi integrated into led lighting, natural ventilation combined with parietodynamic windows/air inlets, seasons reflexive microshading, rainwater harvesting and grey water recycling, direct solar thermal and natural light photovoltaic in self-consumption, combined with a microgrid (thermal hot/cold, middle/low voltage, optical fiber internet/intranet, heat/cold energy linear storage, charging stations for electric vehicles and trailers).

- **Co-design, test on a real scale proof of concept and build at a large scale a Bamboo Extension 4 seasons Greenhouse:** (bamboo negative carbon biosourced material, cultivated locally, green roof with rainwater harvesting, in the basement integrated rainwater storage, grey water treatment with a bamboo filtering installation combined with aquaponic basin, natural roof ventilation and parietodynamic recycled windows glass façade, low energy daylight optimized facility.

MOTIVATION

Microville 112's motivation is to develop, in no more than 5 years, an open wide living lab of a change making cooperative renovation process; this by learning-action (learn-test-consolidate-upscale) starting the coproduction of a "Sustainable Microcity" (Microville Durable®, territoire de la demi-heure Climatiquement neutre et intelligent). The full-scale project will work as a lighthouse demonstrator for neighborhoods/villages in transition at 3 generations in Grand Est region, France and wider in the European Union. Winthin NEB|LAB Eco² Schools, Alliance Sens & Economie is bringing a condensed systemic demonstrator with as use case the Climate neutral and smart renovation of a former military Educational Buildings (2 buildings with surrounding environment), that will become in 3 years a open cooperative educational third place in the heart of the multi stakeholders process for starting the renovation of Microville112. This living lab will be Climate neutral (low consumption positive energy buildings with renewables in self-consumption, circular renovation with biosourced materials, newbuild carbon neutral extension using bamboos and thin solar film, a cooperative energy strategy for shared storage and mobility, decentralized internet for sustainable shared information and monitoring). As all these techniques are quite new (in Reims, France-Belgium cross border area) and mobilize still not conventional skills/experiences, the ECO²-Campus will play a key role in supporting and empowering learning-action with a multistakeholders community. The pilot will facilitate this by the mean of shared learning spaces and infrastructures, and a full-scale worksite-school. In no more than 3 years, this will enable a student to document and learn on this real use case, develop new skills driven by multi-stakeholders cooperation on a common step by step Climate neutral and smart renovation project, then be involved in the worksite-school as apprentice/work-study on a real scale proof of concept, and finally be active part of the full renovation as young professional

Pilot concept description

The planned intervention on ECO²-Campus Microville112 is a systemic Climate neutral renovation project that will be implemented in learning-action quick steps, challenged by a clear forward-looking concept with 2 phases implementation (forward looking cooperative experimentation);

Phase 1) transitional occupation: build a multistakeholders commitment as a community (start to do things together with 4 test-activities), codesign and learn by doing a climate neutral renovation action plan.

Phase 2) lighthouse demonstrative renovation project: a real scale worksite-school, scalable proof of concept for renovation of ~40 buildings, cooperative living lab at 3 generations for the Reims region, schools, neighborhoods/villages in France and in the EU.

For the realization of the pilot, a series of interventions is foreseen which will be validated/refined by co-design. As the Community will become co-owner (co-user, co-investor, co-producer) of the ECO²-Campus Microville112. The ambitious step by step coproduction of this central "Totem place" and first demonstrative facility will start by installing a local permanent "documentation space" with an interactive Climate neutral renovation fresk (based on "Fresque Renaissance Ecologique" with Post Its, plans, photographs, documents, a screen for computer projections) and a next door "workroom" that will be used for common meetings of the "Chamber of quality" and "pilot-site project team" building interaction with the multiple stakeholders/challenging issues. A pedagogic exhibition space will be arranged in 2 sequences, 1st for presentation of students exploratory work and the 2nd for discovering the needed change to Climate neutrality connected with the 5 themes for Climate neutral renovation (1- retrofitting buildings in series, 2- open for the neighborhood, 3- new space design for learning, 4- a community in transition by learning-action, 5- reconnecting with Nature food-biodiversity).

This for co-design space is essential to build a full step by step engagement of the users, trainees and educators in “worksite-school” conditions, public-private institutional supports and co-investors.

The partnership for using-investing the ECO²-Campus will be first formalized in the form of an association for prefiguration, then most probably the constitution of a cooperative society of collective interest to co-carry sustainable investment and associated services. This will support the needed detailed technical/financial study, sponsors and users-payers engagement, as secure the worksite-school and systemic renovation living lab.

For the realization of the pilot a series of interventions is foreseen articulated with proof-of-concept demos:

RENOVATION OF THE HEAT/COLD, ELECTRIC INFRASTRUCTURE WITH THE EXISTING FORMER MILITARY EDUCATIONAL BUILDINGS

Figure 7. A sample of solar panels

A dual Energy Thermal and Electric daylight best performance solar installation will be implemented to replace the central heat network that was using fuel oil (and is now out of function). This installation will be directly connected to the existing radiators for using direct sun at low temperature, with a possible reversibility from mild hot (in the winter) to mild cold (in the summer) (Figure 7). This will be possible by developing a horizontal heat/cold conversion and storage infrastructure, that will be able to extend to the next buildings with considering a progressive microgrid cooperative investment. Natural bioclimatic ventilation will achieve a low-tech retrofitting strategy using the capacity of the natural air, soil temperature, shaded and sunny facade with smart protection, plants and rainwater collection to climatize the building in a for humans activities optimized comfort space.

The micro-grid will, as validated by the ECO²-Campus community (co-design of the use case implementation), provide following combined services:

- Rainwater collection and storage, grey water recycling by using smart filtering and plants as bamboo for natural cleaning.
- Use of heat directly produced by the sun daylight (solar tubular captors with nanotechnology coating) and by bioclimatic architecture principles,
- Natural ventilation combined with innovative low tech airflow management (e.g., parietodynamic windows), canadian well (using stable temperature of the ground and basements of the buildings),
- Horizontal storage of heat/cold,
- Fatal heat recovery (e.g., micro-data center immersed in an oil bath for heat exchange free cooling),
- Heat/cold storage (48h, possible interseasonal hot water silo)
- Decentralized heat pumps, peletier effect converters, heat-cold batteries that can be implemented for securing energy when needed (eg. by night, extreme bad weather conditions, grid support to Microville112).
- Photovoltaïc electricity with dual service (low voltage for direct use as lighting, 220 volt converted electric current for other uses as computers, electric vehicles/trailers charging stations).
- High efficient/low environmental impact storage of electricity (ex. flywheel, compressed air battery...).
- High speed optic fibre, lifi and/or smart wifi decentralized cooperative network.
- Smart energy management with users centred interactive sobriety services (wireless self-energy harvesting captors, holochain hub securing a local community of objects/users/services).

The central criterion for making a choice between technologies is achieving the best performance balance combining climate neutral sobriety, a business model tending to zero marginal cost, renewables energies in self-consumption, sustainability with very low environmental impact, a user centred design, a long-life quality, real measurements lifecycle evaluation, openness for continue improvement.

A second criterion will be the opportunities to ease the installation/maintenance, build a systemic change demonstrator with a community of schools and in train professionals being involved in a worksite school.

RENOVATION OF A SECOND MORE DEGRADED EXISTING BUILDING "MAÎTRE OUVRIER" THAT WIL HOST ARTISTS STUDIOS (New European Bauhaus Cultural Center).

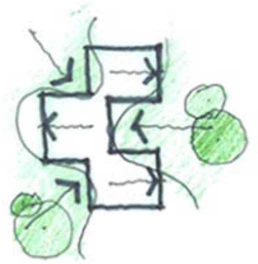
This former military troops materials maintenance workshop is being transformed in a residency hosting artists studio, with a common external exhibition and training court. This will open opportunities for synergies with the ECO²-Campus learning-action activities, as with the cultural dimension of the heart of Microville112 (living exhibitions-events welcome building on the "place d'Armes"), a cultural café-library and local cooking experimental canteen, a sculptures exhibition courtyard protected by a solar canopy and a guest house for visiting researchers, experts and artists.

The former workshop building will be eco-renovated with biosourced and circular materials, with associating as less as possible new technologies when really needed with useful user centred added value (as natural daylight + led lightening, contactless dynamic management of heating, individual account metering of the energy consumptions by the artists and collective events activities). The target is 100% of the energy produced by renewables in self-consumption connecting with the neighboring buildings, with a collective smart use of the energy needs (at least -30% of energy need, and natural lifestyle active change of habits as for ex. close and open the shutters, manage natural ventilation...).

This building will offer a complementary view of the possibilities for a Climate neutral renovation action plan applied to workshops and common activities spaces in Educational Buildings. Active human processes are a key element of the active renovation strategy, that will be codesigned within the "worksite school" process.

NEWBUILD CARBON NEUTRAL BAMBOO EXTENSION THAT WILL CONSOLIDATE THE ECO²-CAMPUS SERVICES AND AUTONOMY

The 2 existing buildings will be interconnected with a large scale a Bamboo Extension 4 seasons Greenhouse. This newbuild carbon neutral construction will be full part of the "worksite school" process. This will offer possibilities to codesign this next generation building with combining best efficiency biosourced and smart circular technologies (bamboo negative carbon biosourced material, cultivated locally, green roof with rainwater harvesting, in the basement integrated rainwater storage, grey water treatment with a bamboo filtering installation combined with aquaponic basin, natural roof ventilation and parietodynamic recycled windows glass façade, low energy daylight optimized facility). This codesing will at the same time open opportunities for collaboration with skilled-experienced craftsmen and creative artists.



ADOPTING THE NEB-LAB CONCEPT: All the above process and demos will be part of the NEB LAB Eco² Schools learning-action living lab concept. This will raise awareness on how we have solutions in hands to address the needed sidestep for Climate neutral renovation of Educational Buildings, neighborhoods/villages (renovation of the spaces for learning build infrastructure and education for Climate changemakers process. As bringing the local community in action is the main first steps issue, the ECO²-Campus will have 3 lives : the first in temporary use of the existing buildings and surrounding spaces, the second during the Climate neutral renovation worksite-school, the third by extending to the ~40 surrounding buildings on Microville112 (55000 m²/65 ha) with a capitalization-dissemination in Grand Reims/Région Grand Est area (+ national-cross border, European network of pilots and follower schools, cities/villages networks). The ECO²-Campus will reach its full scale within no more than 5 years. Moreover this next generation "educational third place" will become a cross border shared expertise, documentation and learning centre, starting the "Eco² Schools as New European Bauhaus Labs" network in 6 Climate-cultural cross border regions (for Microville112 : France-Belgium-Netherlands-Luxemburg-Germany-Switzerland). This positioning will ensure a forward looking input and development of common added value services, in connection with the 5 pilot-sites, for empowering +150 schools to start a local Climate neutral renovation action plan.

Existing technologies / systems / infrastructure (incl. Energy Metering Systems, sensors, monitored data, etc.)
The main Educational Buildings (former military training classes, meeting rooms and offices) was using a heat water network installation with radiators and thermostatic valves. Upper lighting is provided by fluorescent tubes with reflectors. The ventilation system is using natural convection and modular lower and upper windows openings. The main energy used for the heat network was à double external high temperature oil boiler room. This building has à central common electric network with a single meter and circuit breaker panel (no possibility to have exploitation with individualized metering of the consumptions. The reims stone façades are insulated from inside with glass wool panels and plasterboard. The building has aluminum doors and double glazed qualitative pvc windows.
Technologies to be integrated in the building's renovation
Various technologies combined common infrastructure and services: Such technologies will be integrated within the ECO²-Campus renovation process, that will concern 3 different buildings with complementary approach. *Note: At this initial state of the project, is not needed to list and name the key technologies, as they are fully part of the community codesign process. They will be revealed, matured, tested and implemented step by step with help of "common codesign workshops", "advisory sessions", "thematic conversations" and "users cases challenges". This description will be completed progressively in the next steps.*
Technologies to be used in the design and construction workflow
The project will implement a user-centered BIM documentation of the project (all documents will be collected, shared, maintained and approved by cooperation on a common platform, that wil start very simply and be improved by human learning-action catching the opportunity of the e-documents and tokens dematerialization). This will be developed with considering the need of locally secured cooperative decentralized infrastructure, supported by a sustainable community in continue improvement. Shared documentation from the exploratory phase, to the codesign and proof of concept (worksite-school combined projects), until the full renovation and exploitation phase for continue improvement (technical and change of behaviors aspects). A decentralized innovative architecture (Holochain) with wireless/without battery network of sensors and control interfaces centered on smart users' experience design by as simple as possible interaction. Technology will be used only when/where there are no low tech alternatives.
Value added for the target groups and market potential
a/ Partnering of Microville 112 with the local communities and stakeholders since the whole Educational Buildings promotes the notion of living labs. **b/** Scalability of solutions to other Educational Buildings. The implemented solutions will be (~40 buildings, 55000 m2 on Microville112). Note that NEB LAB Eco² Schools approach with hubs in 6 climate-cultural cross border regions). **d/** Raising awareness for a Climate neutrality committed community by promoting the concept of energy and resource efficient building. **e/** Promote α learning-action "worksite-school" process helping all actors (school staff, students, families, citizens) develop their competences and apply positive behaviors for green practices by implementing education and training for sustainability. **f/**All the innovative digital technology that will be developed and used in this project has a strong market potential (following schools, neighborhoods/villages) **g/** Promotion of positive energy with renewable in self-consumption microgrid with shared production, storage, smart consumption and best sustainable quality services by cooperation (cooperative society of collective interest, for non-profit long term added value common infrastructures-services).
How you intend to address horizontal enablers (social innovation, circular economy, interoperability
a/ *Engagement of the wide community in Green Practices.* Several new stakeholders can be engaged in the project. **b/** *Improving data gathering* since it is required for an effective building energy management system using solution mentioned above. **c/** *Innovative Integration*. Fostering social innovation through multistakeholder collaboration and hands-on learning experiences and embracing the circular economy by

applying bio sourced materials and energy-efficient technologies in the renovation and extension projects of the ECO^{2}-Campus Microville112. The use of 100% solar renewable energy infrastructure and the use of smart energy management solutions it is anticipated to create a link to the *energy value chain for integrating with smart energy grids* by including electricity distribution cooperative network design of Microville112. **d/** *Return of investment* for the building owner. In such a case there are capital savings which could be invested in further green initiatives within the ECO^{2}-Campus, Microville112 and neighboring villages. This will be further simulated by the promotion of the *energy cooperative flexibility at the scale of the former military airbase as a whole*.
Expected Results / Outcomes
-The building is expected to achieve 100% of the energy in self-consumption - Passed standard energy need in schools (old existing Educational Buildings as the military airbase): 400 kwh/student (35% for lighting and ventilation = 140 kwh/student), 2519 kwh heat/student (year 2001 reference, 70% for heating = 1763 kwh heat/student). Electricity = 27 kWh/m2 Heating = 127 kWh/m2 Future situation - After Climate neutral renovation: -60% of lighting consumption = 35% x27kWh/m2 x40/100 = 3,78 kWh/m^2 -25% of electric consumption = 65% x27kWh/m^2 x75/100 = 13,16 kWh/m^2 -30% of heating consumption = 127 kWh x70/100 = 88,9 kWh/m^2 Total electricity after renovation = 16,94 kWh/m^2 Total heating after renovation = 88,9 kWh/m2 1kWc = 900 à 1400 kWh/year. This is still to be defined in the document-explore phase of the NEB LAB Eco^{2} Schools codesign process.
Organisations involved
PARTNERS: AS&E, SCIC Microville112, multistakeholders partnership will be defined in October 2023 by a first public communication and official engagement of first contributors and sponsors.

3.3 Pavillion of Knowledge- Ciência Viva Science Center, Portugal

Pavilhão do Conhecimento	**Lisbon, Portugal**
Sector: non-formal education	
District buildings portfolio: Science Center building	
Target groups: Science center visitors, administrative staff and stakeholders (school Representatives, external collaborators from academic institutions (Pedro Reis and Nuno Canha), Portuguese association for green roofs, DECO (Consumers Defence Safeguard Portuguese Association), Stravillia (sustainability consulting company) and the Network of Ciência Viva Centers).	
Link: https://www.pavconhecimento.pt/	

Main characteristics (area (squared meters), type of planned renovation, number of buildings, yearly energy consumption, etc.) – Motivation

MAIN CHARACTERISTICS

Ciência Viva, the Portuguese National Agency for Scientific and Technological Culture (Figure 8), was created in 1996 to promote public awareness of science and technology and science education at a national level, with a particular emphasis on young people. Starting up as a unit of the Ministry of Science and Technology, it is nowadays an association, which includes as its members, public bodies and research institutes. The Agency promotes and supports science education projects at schools, placements for secondary school students in research laboratories during the holidays, and summer science activities for the public. Since its creation, Ciência Viva has been developing activities along three different and complementary streams: science education (schools), public awareness of science (citizens) and a national network of science centers.

The Pavilion of Knowledge in Lisbon is the largest science center in Portugal. Since 1999 receives around 250,000 visitors per year. It is also the headquarters of Ciência Viva, coordinating a network of science centers across the country. Ciência Viva's network of 22 science centers, in collaboration with universities and local authorities, acts as a platform that drives regional development in scientific, cultural and economic dimensions.

The Pavilion of Knowledge consists of three floors that comprise a total floor area of 11300 m^2:

- basement located below ground (floor -1): parking lot.
- ground floor (floor 0): reception, exhibitions rooms, technical rooms, cafeteria and warehouses.
- first floor (floor 1): library, laboratory, auditorium and exhibitions rooms.
- Mezzanine (floor 1): open-space, offices.

The energy consumption yearly is estimated at 1341 kWh resulting in 235 tons of CO^2. Most of this energy (54%) is used for thermal comfort. When considering indoor spaces, a large proportion of this energy is used in the exhibitions rooms (63% spreading over a total area of 6367 m^2), followed by departmental offices (16% spreading over a total area of 1539 m^2). Currently, the total number of employees is 120, divided in seven departments, where the annual consumption per person is 11 kWh.

Since its foundation, the building experienced structural changes, part to optimize energy resources, such as: A) installation of indoor LED (or light emitting diode) bulbs; B) renovation of heating, ventilation and air conditioning system; C) vertical glazing to provide high levels of light transmission whilst cutting down on electrical lighting.

In 2020, the Pavilion of Knowledge, in collaboration with Aleksanda Drewko, an external environmental consultant from Stravillia Hub, developed a Sustainability Strategy and, solid Sustainability Plan encompassing environmental, social and economic dimensions, spread over distinct thematic axes (green energy, saving resources, resources sustainability, waste management, transports, well-being and sustainability of human resources and internal/external awareness). In total, the plan defined 72 measures to be implemented, of which 13 are related to energy savings: 1) Obtain energy from all renewable sources (i.e., 100% green energy) 2) Install solar panels for energy production for internal consumption. 3)Study a green energy option for external space. 4) Reassess the opening hours of the Pavilion of Knowledge regularly. 5) Reconcile cleaning schedules with schedules for lighting the Pavilion of Knowledge, avoiding periods of unnecessary lighting. 6) Introduce a purchasing policy that opts for more ecological equipment, namely with sustainability certification. 7) Check and explain the air conditioning system settings to the team. 8) Evaluate the option of insulating some areas of the Pavilion of Knowledge, to avoid heat loss. 9) Introduce motion or presence sensors where is possible and reassess the timing of current motion sensors 10) Evaluate and adjust the operation of the windbreaker at the entrance of the store. 11) Insert lighting switches into large areas. 12) Check and explain system electric settings to the responsible team 13) Optimize water pumps to improve energy efficiency. We note that most of these measures were implemented (5, 6, 9, 12, 13) or have been identified for short-term implementation (1, 2, 3, 11).

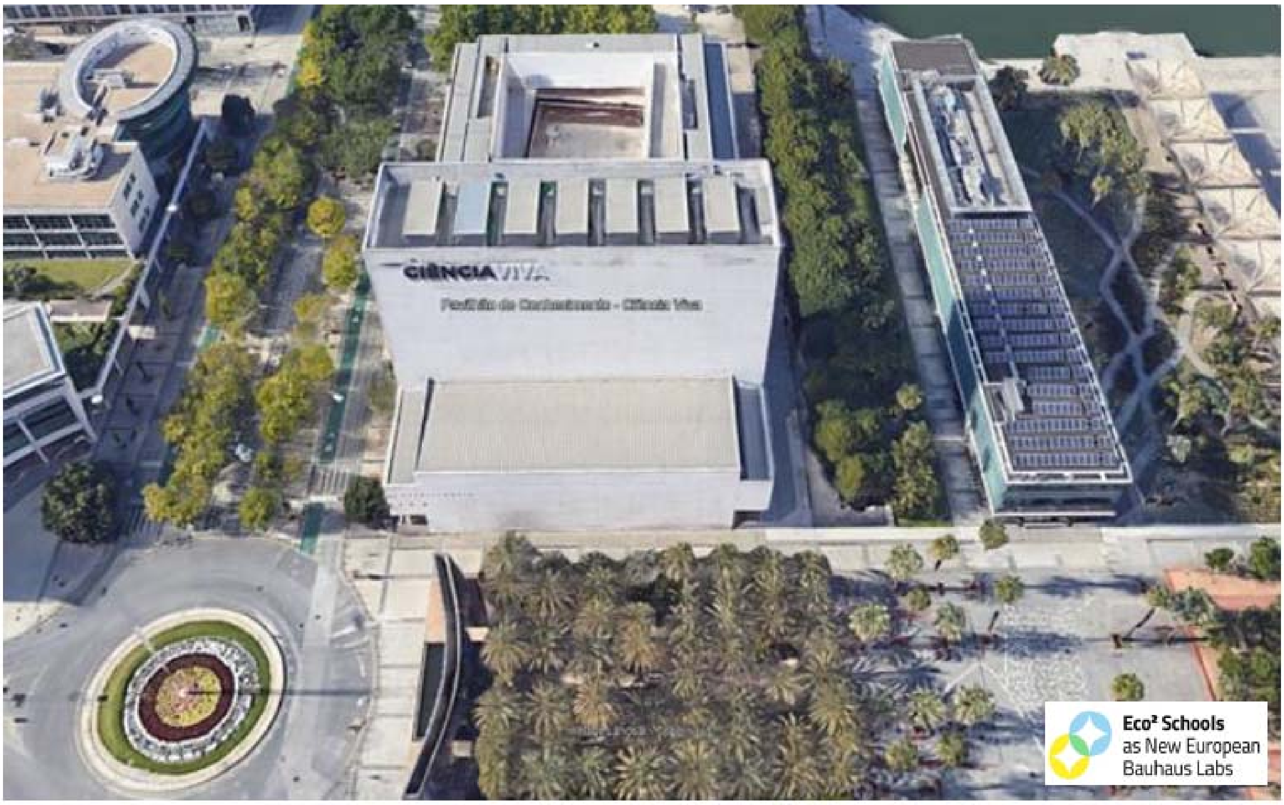


Figure 8. The Pavilion of knowledge – aerial view

More recently, in 2022 the building had an Energy Performance Assessment, were a set of energy rationalization measures are mentioned to maximize energy savings in the operation of future installations and equipment. These measures are related to:

1) Air conditioning and ventilation systems:
   1.1. Renovation of the heating, ventilation and air conditioning (HVAC) system with guaranteed reduction of fresh air flows.
   1.2. Regulate A/C to comfort temperatures of 25 ºC (in summer) and 20 ºC (in winter).
2) Change of external lighting into LED´s.
3) Installation of autonomous photovoltaic solar system.
4) Acquisition of energy-efficient equipment, the introduction of adequate energy management systems and the choice of good practices in the use of equipment.

Following the Sustainability Plan and the Energy Performance Assessment, throughout a national funding programme to support environmental projects ("Fundo ambiental"), the Pavilion of knowledge have been successfully granted funding to execute the measures listed above (specifically 1.1, 2 and 3). The programs and projects, to which Ciência Viva is dedicated, are aligned with the growing global environmental concern together with the 2030 Agenda for Sustainable Development, adopted by all UN members in 2015. Furthermore, the current renovation plant towards a Green Zero Energy Science Center aims to act as a reference renovation project for the area, at national and international level.

TYPE OF PLANNED RENOVATION

Lisbon is one of the sunniest capitals in Europe. Therefore, taking full advantage of solar power in such a sunny city ensures that no greenhouse gas emissions are released into the atmosphere with a renewable energy source. In the Pavilion of knowledge, there is a planned installation of a photovoltaic solar system for self-consumption. LED lighting is one of most energy-efficient and environmental-friendly lighting technologies. In the Pavilion of knowledge most of the lighting is LED. To complete full transition to LED lighting, the external lighting of the building will be changed into LED. Although the building has been subject to renovation in terms of heating, ventilation, and air conditioning (dating from 2010), according to current regulation (DL 101-D/2020) there is a need to decrease fresh air flows by 30%. In this case, there will be changes in the fan pulleys that make up the air-handling units to fulfil current legislation. The focus of this pilot will be to demonstrate solutions to reduce carbon footprint, reduce thermal needs and reduce energy use. In addition, it will show that being green can have a financial advantage (e.g., low energy bills), reduce energy dependency while tackling climate change and preserving the environment.

MOTIVATION

The Pavilion of knowledge, as a science center, has a commitment to promote biodiversity preservation and enhance environmental sustainability. Throughout its history, education activities programs have been implemented to raise visibility for its mission to protect the natural environment. The science center exhibitions are also a powerful way to understand and communicate sustainability issues, as in the WATER – an unfiltered exhibition (2021-2022). This exhibition arose in the context of the International Decade for Action - Water for Sustainable Development and in the framework of United Nations Sustainable Development Goal 6: Water and sanitation for all by 2030. On the other hand, in the Educational department of the Pavilion of knowledge, many of the activities for students, and formations and training for teachers, aim to increase environmental awareness and literacy. The Pilot Site, as the only science center of this project, presents increased responsibility to foster renovation of buildings as enablers of the New European Bauhaus in the context of informal education. This pilot, by spreading the NEB-LAB approach and its solutions, expects to be an example to replicate in other Ciência Viva Centers in Portugal and in other science centers around Europe. This transformation into a zero-energy building is expected to influence the behavior of employees and visitors from all ages, gender, and social-economic backgrounds, and subsequently, the planned renovation will directly affect the energy grid of the area.

Pilot concept description

The planned interventions in the Pavilion of knowledge provides an opportunity to promote informal science education and activities addressing sustainability. For example, science center visitors can experience real world situations, based on hands-on learning and training opportunities to reduce energy consumption and opt for sustainable choices. Furthermore, this an opportunity to engage their interest in activities related to science, technology, engineering and mathematics (STEM) and demonstrates to the community the commitment of the science center to sustainability, throughout:

THE INSTALLATION OF A PHOTOVOLTAIC SOLAR SYSTEM REDUCING CARBON DIOXIDE EMISSIONS

In a Mediterranean country as Portugal, solar energy is a source of energy that is abundant, sustainable and renewable. The installation of a photovoltaic solar system in the Pavilion of knowledge allows significant savings in electricity bills of the building and overall carbon footprint of the community will decrease. Although the initial investment is high, the energy produced can pay for the system within a few years. At the same time, usually open-spaces such as the roof of the Pavilion, with no use, are ideal to install higher numbers of solar panels and increase energy production.

THE CHANGE OF EXTERNAL LIGHTING INTO LEDS REDUCINELECTRICITY USE AND COSTS

LED lights are one of the latest developments in the lighting industry and are up to 90% more energy efficient than incandescent light bulbs. The energy efficiency and longer lifespan of LED technology holds the potential for changing the way Educational Buildings brighten their facilities by reducing the cost of electricity and overall energy use. LEDs also perform better in cold temperatures during winter, emit almost no heat, and most of the light they emit is within the visible spectrum. LED lights are more expensive than traditional lighting, but the investment in LEDs can be paid within a few years. The Pavilion of knowledge will be fully equipped with LED technology, securing a better indoor lighting environment together with better environmental performances.

OPTIMIZATION OF HVAC SYSTEM TO REDUCE THERMAL NEEDS (COOLED AND HEATED WATER)

The main purpose of HVAC systems is to provide good, healthy and comfortable indoor environment. However, HVAC energy consumption accounts for great part of the energy use in buildings. The renovation of this system in the Pavilion of knowledge, based on technological improvements, can significantly contribute to energy reduction, while indoor air quality is maintained or improved.

ADOPTING THE NEB-LAB CONCEPT: Overall, the renovation of the Pavilion of knowledge pretends to improve the sustainability of the building and reduce both greenhouse gas emissions and resource use, contributing to climate neutrality and a net-zero emissions balance by 2050. On the other hand, building on these interventions, the Pavilion of knowledge will work as an "open innovation ecosystem" integrating research and innovation processes to: A) Empower citizens with the knowledge, skills, values and attitudes needed to contribute to environment protection and to a more sustainable society; B) Inform citizens about European initiatives, such as the The European Green Deal and The New European Bauhaus; C) Encourage schools, local communities and stakeholders to work together for mobilizing resources to foster environmental actions. D) Develop hands-on experiences/activities/actions that show the transformation of the Pavilion of knowledge into a green building.

Existing technologies / systems / infrastructure (incl. Energy Metering Systems, sensors, monitored data, etc.)

The building uses electric power, provided by the Portuguese company Alfa Energia, and most of the bulbs are LED. There is a Maintenance Plan to guarantee proper and periodic maintenance of the various existing systems and installations. Carrying out regular maintenance interventions on air conditioning and ventilation equipment, defined according to the needs of the installed equipment, allows extending the useful life and reduces the energy consumption of the equipment. The consumption billing is also evaluated every year to monitor energy consumption. There is recent scientific evidence that green roofs make solar panels more efficient. Combining the two technologies (*biosolar roof*) generates energy, as well as, providing all the benefits of a green roof. In fact, green roofs provide shade and lower the surface temperature of buildings and the surrounding air, helping to reduce energy consumption. They can also make buildings visually pleasing and help preserve urban biodiversity by providing habitat and resources for urban dwelling fauna. Thus, biosolar roof contributes to improve the quality of the urban environment. In the long-term, the Pavilion of knowledge will be evaluated with the Portuguese association for green roofs the installation of this green system. In collaboration with researchers from Center for Nuclear Sciences (C2TN) at Instituto Superior Técnico, there will be an evaluation for the installation of smart multi-sensor systems, for both indoor and outdoor air quality monitoring.

Technologies to be integrated in the building's renovation

a/ The installation of a photovoltaic solar system for self-consumption consists of 164 panels, with a total photovoltaic generator power of 61.5 kWp. This measure and improvement will save about 10% of the building's primary energy and the return on investment is expected up to 10 years. **b/** The external lighting

of the building will be changed into LED with 8.5 W/m power. In total, the electrical power will be 0.62kW. This measure and improvement will save about 0.5% of the building's primary energy and the return on investment is expected up to 6 years. **c/** To fulfil current legislation, there will be changes in the fan pulleys that make up the air-handling units (HVAC system) to decrease fresh air flows by 30%. This measure and improvement will save about 2.8% of the building's primary energy.
Technologies to be used in the design and construction workflow
Coupled with solar panels, an innovative technology of Smart PV will be incorporate to enable remote track of the operation and health of photovoltaic solar system. Overall, the renovation plan will be executed in 2023/2024 with expected energy savings.
Value added for the target groups and market potential
a/ *A real-life environment experience* offered by The Pavilion of knowledge as a living lab by using iterative and innovative technologies to engage citizens, schools, the local community and stakeholders into better sustainable practices. **b/** *Being an example for other science centers and agents of informal education,* since The Pavilion of knowledge, as a green building, aims. **c/** The stakeholders involved in the project will be part of communication and dissemination activities (workshops and related events). **d/** *Sustainable behavior change* that starts with a better understanding of sustainability challenges and its solutions (e.g., digital technology with strong market potential). The promotion of pro-environmental behavior may empower citizens with the knowledge, skills, values and attitudes needed to environment protection and to a more sustainable society. This is critical to achieve sustainable resource use and zero-energy buildings. **e/** *Overproduction of energy from the solar panels* might be an option for selling electricity back to the company's grid is an option.
How you intend to address horizontal enablers (social innovation, circular economy, interoperability)
a/ *Dissemination and awareness activities* related to zero-energy building will encourage new and sustainable solutions that bring benefits to society and enhance society's capacity for action. **b/** *Promoting the circular economy model of production and consumption*, that ensures sustainable growth over time, through sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. Following these principles, at the end of their useful life, solar panels and LED bulbs will be recycled. **c/** In the Pavilion of knowledge, planned interventions are linked by solar panels that convert sunlight into electrical energy, to be used in the lighting and HVAC system. **d/** Energy savings predicted for the building ensures more financial capability to invest in other innovative systems and projects related to Science Education for Sustainability. **e/** *Dissemination activities* where the communication office of the Pavilion of knowledge will share information about the development of the project, on a regular basis, in newsletters and other digital communication channels, such as social media.
Expected Results / Outcomes
-Significant reduction of energy use (around 13% reduction in electricity consumption). In particular, the installation of a photovoltaic solar system for self-consumption will produce an estimated annual energy supply of 91,009 kWp per year, largely contributing to overall energy saving - Reduction of building carbon footprint - Creation of living-labs and related dissemination activities - Replication of this project in the national network of science centers.
Organisations involved
JA Solar: Solar Park Construction; Mauser: LED bulbs. Alfa Energia: energy providing company.

3.4 University College Cork, Ireland: Green Univeristy Campus

University College Cork	Cork, Ireland
Sector: Tertiary	
District buildings portfolio: University building comprising teaching, laboratory and canteen area (N.B. this Pilot Site is one of a number of campuses that comprise University College Cork, it houses the School of Applied Psychology and School of Biological, Earth, and Environmental Sciences).	
Target groups: Staff, students, local community and visitors	
Link: https://www.ucc.ie https://www.ucc.ie/en/build/projects/current/deepretrofitoftheenterprisecenternorthmallcampus/	

Main characteristics (area (squared meters), type of planned renovation, number of buildings, yearly energy consumption, etc.) – Motivation

MAIN CHARACTERISTICS

University College Cork is a comprehensive, research-intensive University in the southwest of Ireland, with over 22,000 students and 3,000 staff. UCC's campus (Figure 9) is made up of 131 buildings, the oldest of which was constructed in 1846. This Use Case refers to one campus site, UCC's Enterprise Center. The building houses the School of Applied Psychology and the School of Biological, Earth, and Environmental Sciences.

Figure 9. An aerial view of the campus of University College Cork

The Enterprise Building, constructed in 1980, was originally used by the Irish Development Association as an enterprise / industrial center for small to medium size enterprises. Located at the Distillery Fields, North Mall, the building was purchased by UCC in 1998. The building archetype would be classed as a mixed-use type. The 2-story building accommodates small to medium sized classrooms, teaching and post graduate labs, single and multi-occupancy offices as well as accommodating the main cafeteria space for the buildings located in the North Mall. Most of the internal spaces are naturally ventilated while the largest sized classroom is fitted with a mechanical ventilation system. Several standalone AC units are fitted in rooms with high heat loads. Heating is supplied via gas fed condensing boilers, controlled locally. The gross internal floor area is 2837m^2.

Figure 10. Energy efficiency upgrade diagram

In 2017, the Enterprise lighting was upgraded to LED. In 2021, the Enterprise building was selected for the Irish Higher Education Authority's Pathfinder Programme to explore the deep retrofitting of a 1980's building with a geothermal source heat pump (GSHP). Sitting on the banks of the River Lee, UCC already has extensive experience in the design and operation of GSHP units, with units fitted in the Lewis Glucksman Art Gallery (2004), the Environmental Research Institute (2004) and the Western Gateway Building (2009). While these buildings were designed and fitted out to accommodate a GSHP, this project represents UCC's first foray into retrofitting an existing building to take a GSHP and provides an opportunity to bring the practical learnings from the existing GSHP installations to a retrofit project.

TYPE OF PLANNED RENOVATION

The project includes the installation of a Ground Source Heat Pump (GSHP) (Figure 10) with a borehole, replacement, and upgrade of existing heat emitters, if necessary, installation of Heat Recovery Units, replacement of single glazed PVC window units, roof and external wall insulation, improvements on building air tightness levels, and an upgrade of building controls including SMART controls. The project aims to deliver a BER B rated building, a 50% reduction in emissions, a heat demand of less than 55 W/m^2, and at least 90% of annual space heating from Renewable Energy Sources for Heating (RES-H)

MOTIVATION

The project is also linked with another Sustainable Energy Authority of Ireland research programme assessing the impact of building retrofit projects on indoor air quality and occupant comfort. The retrofit project is part of a large suite of environmental projects being undertaken at UCC as part of the University's overall Sustainability and Climate Action Plan, which commits UCC to be carbon neutral across all three scopes of emissions by 2040. The project will also form a key part of UCC's engagement with Cork City Council in its ambition to be carbon neutral by 2030 as one of the 100 EU Mission Cities. The Living Laboratory Concept is further enhanced by UCC's engagement with the national Pathfinder programme, which will assess different approaches to decarbonisation on campuses across the country.

Pilot concept description

EXTERNAL WALLS

The design proposal is to install an insulated render system over the existing brickwork. The existing 50mm cavity will also be pumped with insulating beads to improve the thermal performance and reduce air leakages through the walls. The specification for the insulation includes non-flammable, dense mineral wool panels. The render will be acrylic, silicon based to ensure good resistance to water damage, staining, moss growth and shrinkage. The perimeter walls to be insulated are highlighted in green on the plans included.

WINDOWS / EXTERNAL DOORS & OVERHEATING

All existing single glazed windows will be replaced by aluminum powder coated, thermally broken windows and curtain walling. All units will be double glazed, with solar protection layer integrated where required. Windows will be connected to room sensors to coordinate with radiator valves and ventilation fans. A detailed overheating analysis in accordance with the Building Regulations will be carried out in order to determine the amount of ventilation required, the exact specification of the glass and the requirement for internal blinds (currently existing).

WATER SOURCE HEAT PUMP

The upgraded fabric measures mean the heat load intensity will be low enough to make a heat pump viable/efficient to operate. As the existing plantrooms are not large enough to accommodate the heat pump, buffer vessels and other associated items of plant a new plantroom is envisaged, located across the road from on the existing plantrooms, taking up a parking spot. The intention is to maintain approximately 100m between the extraction and injection wells to ensure adequate thermal separation. A trench will be dug across the tarmac and pipework and cabling will be connected. As the peak heat load is approximately 100kW, to offset 90% of the annual heat demand a heat pump sized at 60kW would suffice. However, as the marginal cost of going from a 60kW water source heat pump to 100kW is small, and it allows the potential to completely decarbonize the heating system UCC have decided to adopt this strategy. This means the project will surpass the requirement of 90% of the annual heat being supplied from the heat pump. A water source heat pump also operates efficiently no matter what the outside temperature is unlike an air source heat pump which has reduced output and a poor COP on the design day.

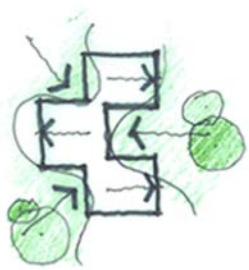
MECHANICAL HEAT RECOVERY VENTILATION

As the building becomes more airtight there is an increased requirement for MHRV. The need for fresh air in our buildings has come into sharp focus during Covid and UCCs experience is that natural ventilation through trickle vents in winter cannot be relied upon to deliver enough fresh air to occupants. UCC has advised the design team that their requirement is to have MHRV in all normally occupied areas of the building linked to occupancy and CO_2 control.

BMS CONTROLS

There is currently no BMS system on the site. It is intended to install a new BMS system off the UCC IT network with cloud-based access. The new system will be BACnet enabled and this shall be utilized wherever possible to ensure we get as much data back as possible and to reduce the number of 'hard' BMS points required. A new MCC panel will be in the heat pump plantroom and a total of 4 other MCCs will be in the building, one per floor for the East and West sides. It is proposed to incorporate indoor air quality sensors in each of the occupied rooms which will have a BACnet protocol and can communicate the space temperature, CO_2 levels, % relative humidity and potentially other parameters depending on the final selection. They can also take inputs from;

- The lighting PIR so occupancy can be detected and linked to the space heating implementing a setback temperature when nobody is present and allowing the MHRV to switch off if the CO_2 levels are low.
- Window sensors to allow the BMS to turn off the radiators if the window is open.



ADOPTING THE NEB-LAB CONCEPT: The retrofit project is part of a large suite of environmental projects being undertaken at UCC as part of the University's overall Sustainability and Climate Action Plan, which commits UCC to be carbon neutral across all three scopes of emissions by 2040. Several "Living Laboratory" projects have been undertaken on the site to date including:

- Outdoor classroom sessions with children from local primary schools, the schools have very little access to green space on their grounds and can benefit from the ample green space at this campus site.
- An urban farm utilising green tower technology has been established at the glasshouses on the grounds of this site.
- An apiary, managed by a local beekeeper and providing honey for use at the university has been in operation at the site since 2018.

- The café at the site is part of UCC's overall "Single-Use Plastic Free" initiative and does not sell any disposable coffee cups or plastic water bottles.
- The green space at the site is part of UCC's Biodiversity Action Plan and no-mow policy.

It is intended that these existing initiatives will be built upon through the NEB-LAB project and incorporated into one overall sustainability and climate action engagement programme for the site. The project will also form a key part of UCC's engagement with Cork City Council in its ambition to be carbon neutral by 2030 as one of the 100 EU Mission Cities. The Living Laboratory Concept is further enhanced by UCC's engagement with the national Pathfinder programme, which will assess different approaches to decarbonisation on campuses across the country.

Existing technologies / systems / infrastructure (incl. Energy Metering Systems, sensors, monitored data, etc.)

Most of the lighting was upgraded to high efficacy LED fittings in 2018, with Dali dimming controls. The emergency lighting was also upgraded to LED. This includes standalone pin spots, exit boxes, blades, and bulkheads. The control strategy varies depending on the area, i.e., offices, corridors, stairwells, or labs, but in general:

- Existing manual switches were retained to allow for manually switching off.
- They operate at 100% output when occupancy is detected.
- They dim to 25% after 10 minutes when no occupancy is detected.
- In offices only they will switch off after a further 5 minutes of no occupancy.

Technologies to be integrated in the building's renovation

The building's renovation will integrate several technologies, including **a/** An insulated render system for external walls and double-glazed windows with integrated solar protection. **b/** A water source heat pump will be installed for heating, with a mechanical heat recovery ventilation (MHRV) system for air quality management. **c/** Building management system (BMS) will be established for effective monitoring and control of all integrated systems.

Technologies to be used in the design and construction workflow

The key challenge in implementing this programme of work is the need to "decant" the building for the retrofit to take place. The construction has been timed to occur over two summers, so that the buildings will continue to be operational during the academic year. This is a key consideration for wider decarbonisation efforts in the higher education sector.

Another challenge is the issue of construction inflation. Since submitting the original proposal for funding to the Higher Education Authority, the cost of the works have increased significantly, and this severely impacts the potential to enhance or go beyond what is currently planned in any way.

Value added for the target groups and market potential

a/ Experiential learning opportunities for building users during the renovation project and the potential for them to engage further with the Living Lab concept that has been developed in UCC over the last number of years. **b/** Determining the scalability or replication of this type of renovation in other contexts. **c/** UCC's wider engagement in sustainability. In the project context will be included parts including regular lunch and learn activities, public seminars and optional "digital badge" courses for staff and students, along with a recently launched course on "carbon literacy". There is also an opportunity to link this project directly with learning at this site as the School of Applied Psychology in UCC has significant expertise in pro-environmental behavioral research.

How you intend to address horizontal enablers (social innovation, circular economy, interoperability

a/ *Impact to other entities.* As a pathfinder project the retrofit has huge potential to influence other entities including schools, universities, and public sector entities to undertake deep retrofit renovations. The project will entail significant engagement activities both with the community using the site, and the wider university and city communities. **b/** *Sustainable Procurement.* UCC has established a procurement strategy for all services and goods for this site will fall under overall, which includes sustainability specifications. **c/** *Integrated Interoperability* that will be ensured through the new Building management system and the link between this project and the wider UCC 1SO140001 programme of energy management.

Expected Results / Outcomes

- Reduction in carbon emissions of 60% (based on 2030 projections) - Significant impact on the indoor air quality and thermal comfort for building users - Students and staff engagement with more environmental programmes through which they might gain a greater understanding of building retrofits and energy efficiency.
Organisations involved
PROJECT TEAM UCC: Tim Cronin (Capital Projects Officer), Finbarr Wall (Deputy Capital Projects Officer), Pat Mehigan, (Energy & Utilities Manager). DESIGN TEAM: Butler Cammoranesi (Architect), Cantwell Keogh & Associates (Fire Safety) Powertherm (Mech & Elect), AECOM, (Quantity Surveyor).

3.5 Sigtunaskolan Humanistiska Läroverket (SSHL), Sweden

	**SSHL**	**Sigtuna, Stockholm,Sweden**
	Sector: Secondary Education	
	District buildings portfolio: School buildings	
	Target groups: Building owner and users, municipality	
	Link: https://sshl.se	

Main characteristics (area (squared meters), type of planned renovation, number of buildings, yearly energy consumption, etc.) – Motivation

MAIN CHARACTERISTICS

Sigtunaskolan Humanistiska Läroverket or SSHL (Figure 11) (https://sshl.se) is a boarding school in the municipality of Sigtuna, Sweden's oldest town, which is part of Stockholm's wider administrative district. It arose from the merger of two historic Swedish boarding schools in Sigtuna in 1980. These schools were Sigtunastiftelsens Humanistiska Läroverk, founded in 1925 by Bishop Manfred Björkquist and Sigtunaskolan, founded in 1927 by theologian Harry Cullberg. Since then, the school has become the leading boarding school in Sweden, combining high academic standards with a wide range of recreational activities. SSHL is honored to have on the list of memorable students, Prime Minister Olaf Palme, the current King of Sweden Carl XVI Gustaf, members of the Wallenberg family, Nobel Peace Prize winner Hans Levander, Scientists, Writers, and many more. The school is administered by the Wallenberg Foundation (http://www.wallenberg.org/en) and the SigtunaStiftelsen Foundation (https://sigtunastiftelsen.se/en/)

Figure 11. An aerial view of Sigtunaskolan Humanistika Läroverket

Currently, the school provides knowledge to about 200 boarders and 600 day-students following two curricula: Swedish and International Baccalaureate (IB) from Year 7 - 12 - with 90 teaching staff and 70 administrative and support staff.

Inside the school campus are 22 building complexes of a total area of 15000m^2 (area of buildings), of which 4 are school buildings and offices, 10 are student dormitories and the rest of the buildings are gyms, dining areas, and support areas, as well as staff accommodation buildings. The campus is in an amazing location by Lake Mälaren. The total area of the campus, together with the area of the Sigtuna Stiftelsen Foundation, which is part of the school administration, is about 350 acres (350,000 sqm).

The school already has strategy in place towards energy efficiency of the school campus, that includes the replacement of the lighting system, the replacement of the heating system, the improvement of buildings insulation by changing the windows and doors of most of the buildings, and the replacement of 4 old type modular houses with 4 new bioclimatic energy efficient buildings. The current energy consumption yearly is estimated at 3359MWh (equivalent to 2374MTCO2) and our goal is to reduce this with at least 50%.

TYPE OF PLANNED RENOVATION

The goal of the interventions in the school complex is the energy upgrade of the buildings, which is achieved by the reduction of total amount of energy consumption, the energy production through renewable sources, the storage of energy produced by them, and its use when demand increases. Achieving high energy performance and energy savings using innovative and sustainable energy solutions is done in parallel with the improvement of the environmental quality of indoor spaces for users.

To achieve the above, a series of point interventions are proposed including the replacement of the lighting system (with a smart lighting system), the replacement of the heating system, and the installation of solar panels on the roofs of the buildings in combination with a battery-based energy-saving system. The focus of the pilot program will be the development of energy efficiency solutions in school buildings, through the direct participation of users (school staff and students) in energy-saving practices and interactive activities. There are over 900 daily users of the campus facilities currently, with substantial energy consumption.

MOTIVATION

In a country known for its environmental consciousness, SSHL, a historic school, aims to show how innovative technologies can be used to integrate modern lifestyles with sustainable development respecting the environment. The school has many long-established official student clubs with an emphasis on the environment and sustainability that act as agents of change through the student population. Student participation in these clubs will be integral to the success of this project. In addition, the student leaders of the boarding schools will play an important role in developing an environmentally conscious behavior change among the residents/students in the living spaces of the school complex. The school has prepared a program of activities that gives students opportunities to participate in the project. Educational Departments will integrate the project into their curriculum and interdisciplinary units. Being a point of reference for the local community, our school aspires to inspire the residents of the local municipality through information activities and presentation of the project's progress. Also, as in its almost hundred-year history the school has established strong links and collaborations with other schools at local/national and international levels, the changes that will be made could inspire other schools in Sweden as well, as many of the Swedish schools buildings they are older historical buildings that need corresponding interventions.

Pilot concept description

For the realization of the pilot, a series of interventions is foreseen, which will be articulated around the following plan:

ACTIONS

The following is a description of the actions we have outlined for the coming years to gradually reach the desired outcome, which is the creation of an environmentally friendly bioclimatic campus while respecting the history of the buildings and the historical character of the wider local area. In the first phase, we will focus on the energy effectiveness upgrade of buildings; which can be broken down into two main actions a) energy saving. b) "clean" energy production for the needs of the school.

ACTION A. ENERGY SAVING: REPLACEMENT OF THE LAMPS AND LIGHTING SYSTEM

An important part of the process of converting buildings from conventional to environmentally friendly, is to save energy, and a large part of this project is changing the lighting system of the buildings. This involves 1) changing the lamps and light bulbs and 2) effectively managing the lighting operation time in buildings through a smart lighting system.

All campus facilities are lit by incandescent and fluorescent lamps. This means that while their efficiency is the same as a modern technology lamp (led), the electricity consumption is from 4 (for fluorescent lamps) to 10 (for incandescent lamps) times higher. The lighting in many areas of the campus is in operation at times that are not necessary (for example the classrooms are often lit without people in them, or the lighting in many areas is active even when there is plenty of sunlight). In a total area of about 170,000sqm of the school (about 150 acres is the area of Sigtunastiftelsen), this means huge amounts of extra electricity consumption. Proper lighting management through innovative control systems can result in a significant reduction in energy consumption and consequently save money and become a positive sign to the environment.

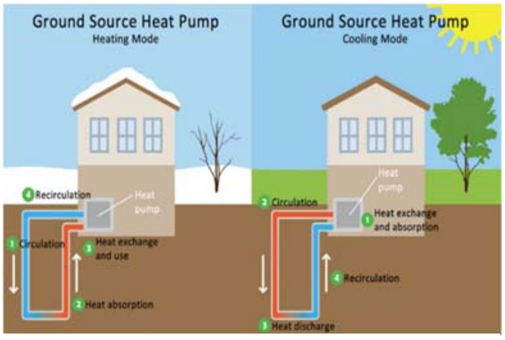
SpaceWise is an -easy to use- light management system including a flexible, wireless lighting system that allows the user to create customized light zones in office space, achieve high savings through LED technology and different dimming options, and increase employee comfort through better quality of light and option to personalize light settings. SpaceWise saves energy and reduces costs using embedded sensors, which reduce energy usage by up to 70%. Automatic dimming ensures that the system user only pays for lighting when and where it is needed. The lighting level can be adjusted to optimize employee comfort. The system is quick and easy to install through a ‘plug-and-play’ setup, which reduces cost in man-hours. As the system is autonomous, there is no added cost through adding networks, computers, or light meters. Sensor configuration patterns are easy to alter, and operators can reconfigure lighting groups or individual luminaires to meet the location user needs. In Sweden, the use of LED technology helps keep the buildings energy compliant and may make the campus eligible for tax benefits. As a partner in our efforts, we have the pioneering company *Signify*, which will provide innovative solutions to the above problems.

The total amount of the electric energy consumed for lighting purposes is estimated at about 1250MWh (≈153MWh measured and ≈ 1097 estimated/projected) annually. According to Signify’s proposal, this amount can be reduced from 62% (to 38% of the current consumption using a new lighting system or 475MWh) and up to 84% (to 16% of the current consumption or 200MWh) using a new lighting system in a collaboration with a lighting control system. For the whole campus, the reduction of the electric energy consumed for lighting purposes can be at least 810,5MWh annually or 65%. The CO_2 reduction (carbon savings) is 9726 kg. In Figure 12 is provided the project summary for the main building.

Figure 12. A brief summary of the project for the main building of SSHL

CHANGE OF THE HEATING SYSTEM

Another energy-intensive parameter that must change in the effort made for the energy upgrade of buildings is the heating - air conditioning system (HVAC). The warm season in Sweden lasts for 3 months with temperatures ranging from 12 to 22 degree Celsius. The cold season lasts 4 months with temperatures ranging from -6 to -1 degree Celsius. The heating of all the building installations today is done through two central heating stations whose operation is mostly with electricity oil and pellets, and in addition, in a very small percentage with a small geothermal installation (14%). Given the great distance from the central heating stations to the campus buildings, the heat losses during transportation are very large, which makes the system energy-intensive, cost-effective, and inefficient. In the context of the energy quality of buildings, our main objectives are the following:



- 1) Change of the heating system to geothermal at a rate of> 80% at the time when the geological conditions of the area allow it for most of the building installations (Figure 13). SSHL is in contact with two companies for the thorough preparation of the study. The use of geothermal energy in combination with heat pumps (air water) (Figure 13 & 14) gives the advantage of complete management of the air conditioning of the buildings both in the cold months (heating) and in the warm months (cooling).

Figure 13. Diagram of the heat pump system

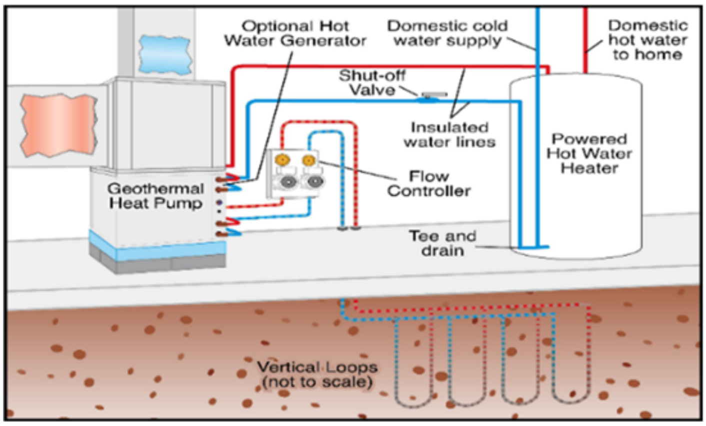


Figure 14. The heating management system

2) Secure the autonomy of the buildings to zero the losses during the transfer of heating from the heat production stations to the buildings.

3) Installation of a smart heating management system (smart thermostats) that will regulate the room temperature according to some parameters (for example if there are no people in the room, or if the classroom is not used during the weekends etc.).

The annual energy consumption for the heating needs of the buildings is 2109MWh and is distributed as follows: 1220MWh Electric, 400MWh Oil (petrol), 190MWh pellets, 299MWh Geothermal. According to our investigation, replacing partly the heating system (using geothermal units and thermal pumps) we can save 615MWh annually, or 29%. The CO_2 reduction (carbon savings) is 7380Kg.

ACTION B. "CLEAN" ENERGY PRODUCTION FOR THE NEEDS OF THE SCHOOL.

The objective of this project is to install a 500-kilowatt photovoltaic (PV) system and implement a smart energy storage system in our school. By combining renewable energy production with advanced energy storage technology, this action aims to achieve significant environmental, economic, and educational benefits (Figure 15).

Renewable Energy Generation: The installation of a 500 kW PV system will provide a reliable and sustainable source of electricity for the school. By harnessing sunlight, the system will generate clean and renewable energy, reducing the reliance on fossil fuels and lowering carbon emissions.

Cost Savings: The utilization of solar power will lead to substantial cost savings for the school in the long run. By reducing dependence on the grid and utilizing self-generated solar energy during the day, the school can significantly lower its electricity bills and allocate those funds to other educational resources.

Educational Opportunities: The PV system installation will serve as an excellent educational opportunity for students to learn about renewable energy and sustainability. Through firsthand experience with solar energy generation, students can develop a deeper understanding of clean technologies, fostering environmental consciousness and responsible energy consumption habits.

Environmental Impact: The project will contribute to mitigating climate change by reducing greenhouse gas emissions. By adopting solar power, the school demonstrates a commitment to environmental stewardship, setting an example for students, staff, and the local community.

Energy Independence: The combination of the PV system and smart energy storage enables the school to achieve a degree of energy independence. Excess solar energy generated during the daytime will be stored in 250-kilowatt battery bars installed in each building. This stored energy can be utilized during periods of low sunlight levels or high energy demand, reducing reliance on the grid and providing a reliable and sustainable energy supply. According to the suppliers, the total average energy production could be approximately 440 MWh per year, depending on sunlight levels. The electricity generated from this, equivalent to 440 megawatt hours, currently accounts for about 15% of the consumption. With future improvements in the lighting system, this proportion could increase to cover up to 40% of the total energy consumption.

Figure 15. Installation of solar panels on the roofs of some school buildings with a meridian orientation. In this way we achieve the high performance of the system without using the functional space of the school.

On the other hand, the use of smart batteries has multiple benefits both environmentally and economically as by regulating their load (saving energy) in hours of high production and consequently low purchase costs, on the one hand it has multiple benefits for the environment because this energy is produced by renewable energy sources, on the other hand it significantly reduces the cost of the kilowatt-hour price (Figure 16).

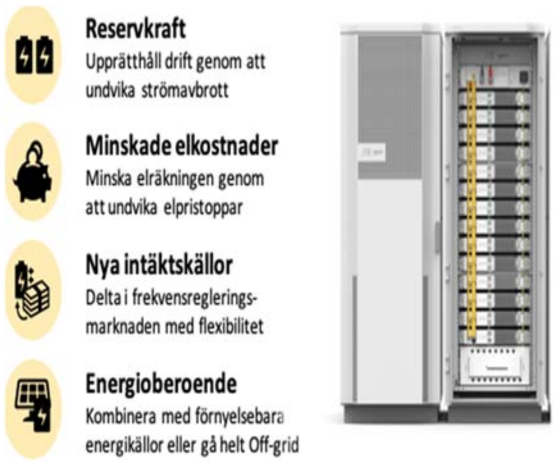
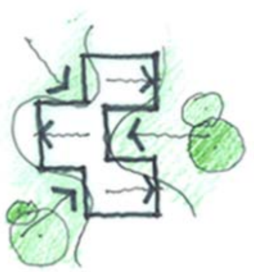


Figure 16. Smart battery array cage to store electricity produced by photovoltaics, but also store electricity from the grid when the kilowatt hour price is low and use it when there is a need or when the kilowatt hour price is high. With the use of smart batteries, we significantly reduce the cost of use, and the production of carbon dioxide, reducing the energy footprint of the school.

Finally, the possibility of supporting the building facilities with electricity for up to 2 hours in the event of a power outage from the grid, which is not so rare, ensures the smooth operation of the school's activities, helps the environment as the required energy would have to be produced from power generators that operate on liquid fuels, so they produce significant amounts of carbon dioxide and of course it significantly reduces costs as the cost of fuel is relatively high. The installation of a 500 kW PV system and smart energy storage in our school in Sweden presents a unique opportunity to advance sustainability, energy efficiency, and educational initiatives. By embracing renewable energy, the school can reduce carbon emissions, achieve cost savings, foster environmental awareness, and enhance energy independence. This project aligns with the EU's goals of promoting clean energy, combating climate change, and fostering sustainable development. A brief overview of the current energy consumption and the expected savings for SSHL is shown on Table 3.

Table 3. Energy consumption rates and expected savings of SSHL

Action	Current consumption (MWh)/year	Future consumption (MWh)/year	Energy saving (MWh)/year/%	Carbon Saving Kg/year	Cost (euros)
Change of the Lights	1250	440	810 / 65%	9726	1.000.000
Heating change	2109	1494	615 / 29%	7380	600.000
Solar panels		-440	440	5288	450.000
Total /average	3359	1454	2295 /43.3%	27644	6.950.000



ADOPTING THE NEB-LAB CONCEPT: The above initiatives will join the efforts of the school's student associations to raise awareness among students and the local community about the energy efficiency of buildings. SSHL through actions and partnerships with Sigtuna Municipality has proven that when schools can inspire the local community, pass on knowledge and demonstrate that its practical application through innovative practices and technologies can improve the lives of residents while contributing to the sustainable development of society. Our philosophy is that the school is not just a place to offer knowledge, but a point of reference and interaction between it and the students, the students' families, and the local community. Our ambition is that in the future the school will be able to function as a consultancy/guide, becoming a beacon of knowledge and inspiration for the residents, for the further improvement of their quality of life and sustainable development. SSHL students will develop civic awareness by increasing activities that spread the concept of energy-efficient building and renovation and promote sustainability education and training.

Existing technologies / systems / infrastructure (incl. Energy Metering Systems, sensors, monitored data, etc.)

The buildings of the school campus use electric power, provided by the Swedish Public Electricity providers. For the lighting incandescent bulbs (mostly) and fluorescent lamps are being used. The energy sources used for heating is electricity and petrol (oil).

Technologies to be integrated in the building's renovation

a/ Innovate lighting system (SpaceWise) by Signify that provides energy reduction up to 70% compared to the current situation. **b/** Geothermal energy (heating/cooling) in some of the school buildings. **c/** Indoor and outdoor atmosphere control with energy use reduction/optimization. **d/** Development and use of innovative digital solutions solutions for energy monitoring, analytics, and recommendations platform. The school will install sensors for lighting, temperature etc. in most of the buildings. **e/** *Energy production and saving system u*sing a combination of **solar** panels and batteries. **f/** Resource Efficiency: Use of smart devices, integrated with a dedicated platform

Technologies to be used in the design and construction workflow

Geothermal System (GS): A geothermal system utilizes the Earth's stable underground temperature to provide heating and cooling for buildings. It transfers heat between the ground and the building through a

network of pipes, promoting energy efficiency and sustainability; Heating, Ventilation, and Air Conditioning (HVAC): HVAC refers to the system responsible for providing heating, cooling, and ventilation within a building. It ensures a comfortable indoor environment and regulates air quality for occupants; Photovoltaic Panels (PV): PV panels convert sunlight directly into electricity through the photovoltaic effect. They generate clean and renewable energy, reducing the school's reliance on conventional power sources and minimizing its carbon footprint; Battery Energy Storage System (BESS): A BESS stores excess electricity generated by the PV panels during sunny periods. It allows the school to utilize stored energy during periods of low sunlight, enhancing energy self-sufficiency and grid independence. Smart Lighting System (SLS): A smart lighting system employs advanced controls and sensors to optimize lighting usage based on occupancy, natural light levels, and energy demands. It enhances energy efficiency and reduces electricity consumption; Smart Sensors for Atmosphere Control: Smart sensors monitor indoor air quality, temperature, and humidity, as well as outdoor weather conditions. They enable precise and real-time data collection, leading to informed decisions for optimizing the indoor and outdoor atmosphere, promoting occupant comfort, and ensuring efficient resource usage. This combination of GS, HVAC, PV panels, BESS, SLS, and Smart Sensors for Atmosphere Control creates a sustainable and technologically advanced approach to renovating the school, fostering a greener environment and enhancing the overall well-being of its occupants.
Value added for the target groups and market potential
a/ The school as a place of inspiration and provider of knowledge for the local community about sustainable development. **b/** Development of information and training programs on sustainable development for students and the local community. **c/** Development of citizen awareness activities that spread the concept of energy upgrading of buildings through the application of innovative technologies. **d/** The interventions that will be carried out are applicable to respective school complexes but also on a larger or smaller scale. **e/** Practical implementation of innovative energy management technologies in a school complex that will be a model for similar projects in the future.
How you intend to address horizontal enablers (social innovation, circular economy, interoperability
a/ *Social Innovation* by engaging the school community in sustainable practices, promoting a culture of environmental awareness and empowering individuals to actively contribute to a greener future. **b/** The collection of data through ICT allows optimized energy management in school buildings. **c/** The energy savings generated by green technologies create capital reserves, which are reinvested in further eco-friendly projects such as building thermal insulation, changing the frames, and fostering a self-sustaining circular economy model. **d/** Leveraging interoperability to enable data-driven energy management decisions, ensuring efficiency and evidence-based practices.
Expected Results / Outcomes
- Energy saving (at least 50%) by implementing new innovative technologies and energy management applications - Simultaneously reducing the carbon footprint - Creation of a sustainable development planning and implementation model focusing on the energy upgrade of buildings adapted to the special climatic characteristics of the region - Improving indoor environment quality for users
Organisations involved
PARTNERS: SSHL: Building and infrastructure, Educational Departments, Design and Technology Group (DTG), SSHL Think Tank, SSHL Environmental Group, Life Link, Signify: Smart lighting system and indoor environment controllers, SVEA Solar: Infrastructure (Solar panels), Energy consulting engineers, DELOITTE and NTUA: City Synergy Strategy and Green Neighborhood Development Planning, Sigtuna Municipality.

4 Contribution of Use Cases in the project

4.1 Environmental Impact of Retrofitted Educational Buildings

The 5 Educational Buildings participating in the project and demonstrated in the Use Cases represent a wide part of Europe across Greece, France, Portugal, Ireland, and Sweden. Buildings with such a use are significant consumers of energy since they have very increased needs for their users.

Consequently, they have a significant impact on the environment. In the Use Cases Template for each Pilot Site have been described their retrofitting plans. Retrofitting these buildings, offers a viable solution to mitigate their environmental impact. By incorporating advanced technologies and systems, the energy consumption of these buildings is reduced drastically. The Pilot Sites have decided to proceed to various infrastructure Interventions such as smart lighting systems, geothermal heating and cooling, innovative energy monitoring and management, PV panels, and battery energy storage systems which do not only save energy thus providing profit to the building owner but they also contribute to the decarbonisation of the energy sector.

The retrofitting of Educational Buildings as described in the Template presents a unique opportunity for a significant reduction in environmental footprint, while also promoting the integration of sustainable practices and innovation. This aligns directly with the European Green Deal's objectives, advocating for a climate-neutral continent by 2050.

4.2 Use Cases contribution to the project

The development of the Use Cases for the 5 Pilot Sites across Greece, France, Portugal, Ireland, and Sweden are pivotal for advancing Demand-Response Forecasting and the Climate Action Plans. The implementation of energy efficient solutions is designed based on a framework that focuses on the creation of high-performing, energy-efficient buildings. In the 5 Use Cases it was shown that key aspects such as Energy Storage and Energy Management have been thoroughly discussed leading to the proposal of tailored solutions that meet the diverse needs of the educational communities.

Moreover, Pilot Sites promote basic principles such as open schooling thus transforming educational facilities into innovation hubs within their local communities. This means that they should not be regarded just as technical infrastructure but rather as places promoting social innovation and advocating for resource efficiency and environmentally responsible energy use. For this reason, they hold a central role in the development of zero-energy neighborhoods, where schools are key parts of a culture that promotes zero-energy objectives. This process fosters synergy among all stakeholders involved in planning, design, construction, operation, and maintenance. These principles are incorporated successfully into the process of designing and implementing zero-energy strategies.

The next and step and a major challenge for the project is shaping the Climate Action Plans that will show the road for implementing innovating solutions and applications. Additionally, the study of Demand-Response Forecasting leads to the design of a framework for implementing Energy Efficient Solutions. By focusing on the development of high-performing buildings, issues related to Energy Storage and Energy Management are thoroughly addressed. Specific solutions are proposed and adopted to meet the educational communities' needs.

From the previous is obvious that considerable energy savings can be achieved with limited additional costs, thus motivating building owners to abandon the skepticism towards innovative energy-saving retrofit concepts. The Use Cases present a concrete and replicable pathway ("climate action plans") towards cutting-edge, energy-saving educational buildings that integrate design, sustainability, and learning seamlessly. As pedagogy, technology, instructional programs, and enrolment evolve, educational environments need to be adaptable to accommodate these changes with minimal disruption and cost. Factors such as Indoor Air Quality, Thermal Comfort, Visual Comfort, Daylighting, and technology infrastructure for low and zero-energy buildings all consider this need for adaptability.

For each demonstration site, an energy master plan will be developed following a Demand-Response Forecasting exercise. This energy master plan is a comprehensive strategic plan that aligns the short, medium, and long-term energy goals of a building or a campus with its educational and facilities master plans. It also coordinates with ongoing campus building and modernization programs. Key features of an effective energy master plan include the documentation and validation of the current energy consumption of each building through building energy simulation, the establishment of Energy Use Intensity (EUI) goals for each building, and the coordination with the energy priorities of local regulatory and utility policies, including incentives and rebates.

5 Conclusions

In conclusion, this Deliverable has shown the strategic renovation in transforming Educational Buildings into energy-efficient, high-performing structures, contributing significantly to the broader objectives of environmental sustainability and the decarbonization of the energy sector. Through the application of the Use Case Template at various pilot sites across Europe, we have demonstrated the capacity for local adaptations and innovations to meet the unique challenges and needs of diverse educational communities. Furthermore, was highlighted the critical role of stakeholders in shaping these solutions and driving the data collection and analysis processes that inform strategic decision-making. A key parameter was the role of the Pilot Site Representatives who took over the task of gathering and studying the data from the Pilot Sites.

The work that was done during the Use Cases Definition process illustrates a clear, feasible, and replicable pathway towards creating zero-energy educational buildings and neighborhoods, highlighting the key role of Educational Buildings in fostering a culture that supports sustainable practices and contributes to the objectives of the European Green Deal. As we move forward, the lessons learned from these Use Cases will continue to inspire and guide the transformation of more Educational Buildings across the continent, underscoring the crucial link between education, innovation, and environmental sustainability.

In conclusion, this deliverable has made a compelling case for the multiple advantages of energy efficiency in building renovations. It has provided valuable insights since the 5 Pilot Sites should be regarded as practical examples that can inform and inspire other buildings and their communities and other stakeholders involved. The Use Cases serve as a roadmap, demonstrating that with the right strategies and technologies, it is possible to transform our buildings into sustainable, energy-efficient structures that contribute to environmental sustainability and improve the quality of life for building users. The deliverable has underscored the importance of continued research, innovation, and collaboration in this field to achieve our shared sustainability goals.

The next challenge is the shaping of Climate Action Plans for the Pilot Sites in close cooperation with the Chamber of Quality (WP3).