ECO² -SCHOOLS as learning-action living labs

Deliverable 2.2: Green Action Plans and KPIs

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Abstract	Considering the use cases definition (D2.1), the design team of the project has performed a scan the horizon exercise to identify barriers and opportunities to incubate or even to accelerate the transformation plans of the demonstration sites stakeholders. Through continuous interactions between the design team (WP3) and the user communities a series of test activities have been developed (D3.1) to offer a glimpse to future developments in order the appropriate mitigation plans to be prepared and the opportunities to be investigated and explored further. By building on the concept of Open Schooling the pilot sites will transform to innovation hubs in their communities, raising citizen awareness activities to facilitate social innovation, promote education and training for sustainability, conducive to competences and positive behavior for a resource efficient and environmentally respectful energy use. Two fundamental principles distinguish the mindset required to develop a neighborhood living lab around a zero-energy school. The first principle is that zero-energy schools can create and reinforce a culture for zero energy among those who use and operate them. The second principle is that zero-energy schools demand highly collaborative synergies among those who plan, design, construct, use, operate and maintain them. Strategies to incorporate these principles successfully into the process of conceiving, planning, designing, and implementing a zero-energy neighborhood around a zero-energy school will be discussed and analyzed. Specific KPIs have been set for a series of critical parameters in the process to allow for easy monitoring of the related developments. The monitoring is based on energy master plan. Key features of an effective energy master plan include the following: • Document and validate the current energy consumption of each building through building energy simulation; • Establish EUI energy goals for each building; • Coordinate with energy priorities of local regulatory and utility policies, including incentives and rebates; • Incorporate demand management and demand response strategies; • Balance energy conservation with renewable energy production and distributed generation; • Develop a menu of appropriate energy conservation strategies for both modernization and new construction projects; • Prioritize energy conservation projects in alignment with the campus or district facilities master plan; • Specify an appropriate building energy management system to ensure long-term energy tracking and performance.
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Executive summary

Deliverable 2.2 (Green Action Plans and KPIs) aims to provide an in-depth exploration of the methodology, development, and application of the pilot sites' Action Plans. This is the critical tool designed to foster energy-efficient renovations in educational buildings across the pilot sites 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 pilot sites Green Action Plans 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. The deliverable is organized into seven chapters.

Chapter One includes an introduction to the document's scope and structure with a description of its objectives. Moreover, it highlights the key parameters of the Deliverable particularly the Green Action Plan Template Creation, which is essential for monitoring the development of the Use Cases (D2.1) for each Pilot Site.

Chapter Two focuses on the process of developing Effective Green Action Plans for the pilot sites and defines the keys to Success. By building on the concept of Open Schooling the pilot sites will transform to innovation hubs in their communities, raising citizen awareness activities to facilitate social innovation, promote education and training for sustainability, conducive to competencies and positive behavior for a resource-efficient and environmentally respectful energy use. Two fundamental principles distinguish the mindset required to develop a neighborhood living lab around a zero-energy school. The first principle is that zero-energy schools can create and reinforce a culture of zero energy among those who use and operate them. The second principle is that zero-energy schools demand highly collaborative synergies among those who plan, design, construct, use, operate, and maintain them. Strategies to incorporate these principles successfully into the process of conceiving, planning, designing, and implementing a zero-energy neighborhood around a zero-energy school will be discussed and analyzed in this chapter.

Chapter Three describes the key steps for the development of the Green Action Plans through an integrated design process. It provides the framework and guidelines to the design teams of each pilot site to accelerate the transformation plans of the demonstration sites. A Green Action details the work that different members of the organization will need to take to achieve the goals that were established in the overall organization’s sustainability policy. The best plans delve into the specific tasks required, with actions that are: Specific, Measurable, Achievable, Relevant, and Time-limited (SMART). At the same time, the chapter highlights that the overall aim of the proposed intervention is the development of the sustainability citizenship competence of the users of the building and a behavioral change that will be monitored through the project’s impact assessment mechanisms.

Chapter Four highlights the opportunity to move beyond the Educational Building and to create neighborhood living labs around a zero-energy educational building. This section presents the benefits of such interventions and calls the education stakeholders to consider these opportunities and challenges while they are developing their Green Action Plans.

Chapter Five highlights that specific KPIs will be set for a series of critical parameters in the process to allow for easy monitoring of the related developments during the realization of the Green Action Plans.

The monitoring will be based on the energy master plan. Key features of an effective energy master plan include the following:

- Document and validate the current energy consumption of each building;
- Establish energy goals for each building;
- Coordinate with energy priorities of local regulatory and utility policies, including incentives and rebates;
- Balance energy conservation with renewable energy production and distributed generation;
- Develop a menu of appropriate energy conservation strategies for both modernization and new construction projects;
- Prioritize energy conservation projects in alignment with the strategy of the organisation;
- Specify an appropriate building energy management system to ensure long-term energy tracking and performance.

A successful energy master plan will maximize the return on investment, delivering the greatest long-term energy savings, and thus reducing the operating cost for the buildings.

Chapter Six presents the core part of the Deliverable since it provides a detailed description of the methodology described in previous chapters across the 5 Pilot Sites of the project. The chapter provides a description of the five Pilot Sites, demonstrating not only the implementation of the Green Action Plan 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 Seven describes the key role of the Green Action Plan for the development of the project. It highlights the collaborative effort that was necessary for their development and their key role for the upcoming actions in WP4 (NEB-LAB Demonstrators) and in WP5 (Social Value Framework).

Chapter Eight includes the 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

NEB-LAB project aims to promote five exemplary "climate action plans" on how to design high-performance educational buildings in line with the New European Bauhaus priorities (increase the energy efficiency of the building operation; transition to energy positive buildings producing electricity, covering their heating and cooling needs and contributing to the energy grid stability with sustainable, renewable energy technologies). By building on the concept of Open Schooling (Designing project-based, experiential learning led by schools with parents, local businesses, the wider community) the pilot sites will develop concrete and replicable climate action plans to be transformed to innovation hubs in their communities, raising citizen awareness activities to facilitate social innovation, promote education and training for sustainability, conducive to competences and positive behavior for a resource efficient and environmentally respectful energy use.

Deliverable 2.2 is the reference 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:

- The necessity of a whole school approach and the establishment of an open schooling culture.
- The key role of external stakeholders who share responsibility on students learning.
- Focus on the development of sustainability citizenship.

In summary, Deliverable 2.2 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 the necessary details about the Green Action Plans of the project's pilot sites. This will also form a reference document for the Testing Activities that are currently implemented in WP3. It could also serve as a reference document for related projects in the field or future actions.

2 Developing Effective Action Plans: Keys to Success

NEB-LAB is considering schools as "*learning organizations*" and "*core social centers*" [1,2] that can react more quickly to changing external environments, embrace innovations in internal organization, and ultimately improve student outcomes. Such school environments promote **Open Schooling**[3]: where schools, in cooperation with other stakeholders, become an agent of community well-being; the walls around schools come down but they remain strong, sharing responsibilities with other community bodies. Non-formal learning, collective tasks, and intergenerational activities are strongly emphasized; school projects are revitalized around a knowledge agenda in cultures of experimentation, diversity, and innovation.

It is an open system, welcoming approaches from potential external collaborators; The school scans its external environment to respond quickly to challenges and opportunities; families are encouraged to become real partners in school life and activities; professionals from enterprises and civil and wider society are actively be involved in bringing real-life projects to the classroom. Partnerships are based on equality of relationships and opportunities for mutual learning; Relevant policy makers encourage policy buy-in and the mainstreaming of good practices and insights into policies, and hence sustainability and impact. Such partnerships foster expertise, networking, sharing, and applying science and technology research findings across different enterprises (e.g., start-ups, SMEs, and larger corporations). The overall process is described schematically in Figure 1.

Such environments hold a great potential **to act as drivers in the Green Renovation Wave to enhance the social acceptance of energy efficient solutions** and create sustained and meaningful engagement of local communities. In this chapter we will a) describe the process for establishing an open culture in the pilot sites and b) define the key characteristics of the Pilot Sites.

2.1 Adapting an Open Schooling Approach

Throughout the Recast Energy Performance of Buildings, Directive (EPBD)[4] it is requested that "*the public sector in each Member State should lead the way in the field of energy performance of buildings*" and "*buildings occupied by public authorities and buildings frequently visited by the public should set an example*".

Among the most promising building types to act as lighthouse projects are school and educational buildings in general. They are visited by people belonging to different age groups such as pupils, teachers, and parents. Classes can offer pupils first-hand experience of visible improvements to the building envelope and the technical services systems; they can learn how to support energy savings by responsible user behavior; students are developing sustainable and responsible citizenship skills and attitudes. Furthermore, students can actively participate in the renovation process and transfer what they have learned to their parents. NEB-LAB will design and develop five real-life demonstrations of energy-efficient educational buildings. Based on the innovations in place, the pilot sites will be supported to develop climate action plans with the support of the NEB-LAB Chamber of Quality and in cooperation with local stakeholders.

[1] https://www.oecd.org/education/school/school-learning-organisation.pdf

[2] https://www.oecd.org/site/schoolingfortomorrowknowledgebase/futuresthinking/scenarios/overviewofthesixsftscenarios.htm

[3] https://www.researchgate.net/publication/325284276_Open_Schooling_Roadmap_A_Guide_for_School_Leaders_and_Innovative_Teachers#fullTextFileContent

[4] http://www.buildup.eu/en/practices/publications/directive-201031eu-energy-performance-buildings-recast-19-may-2010

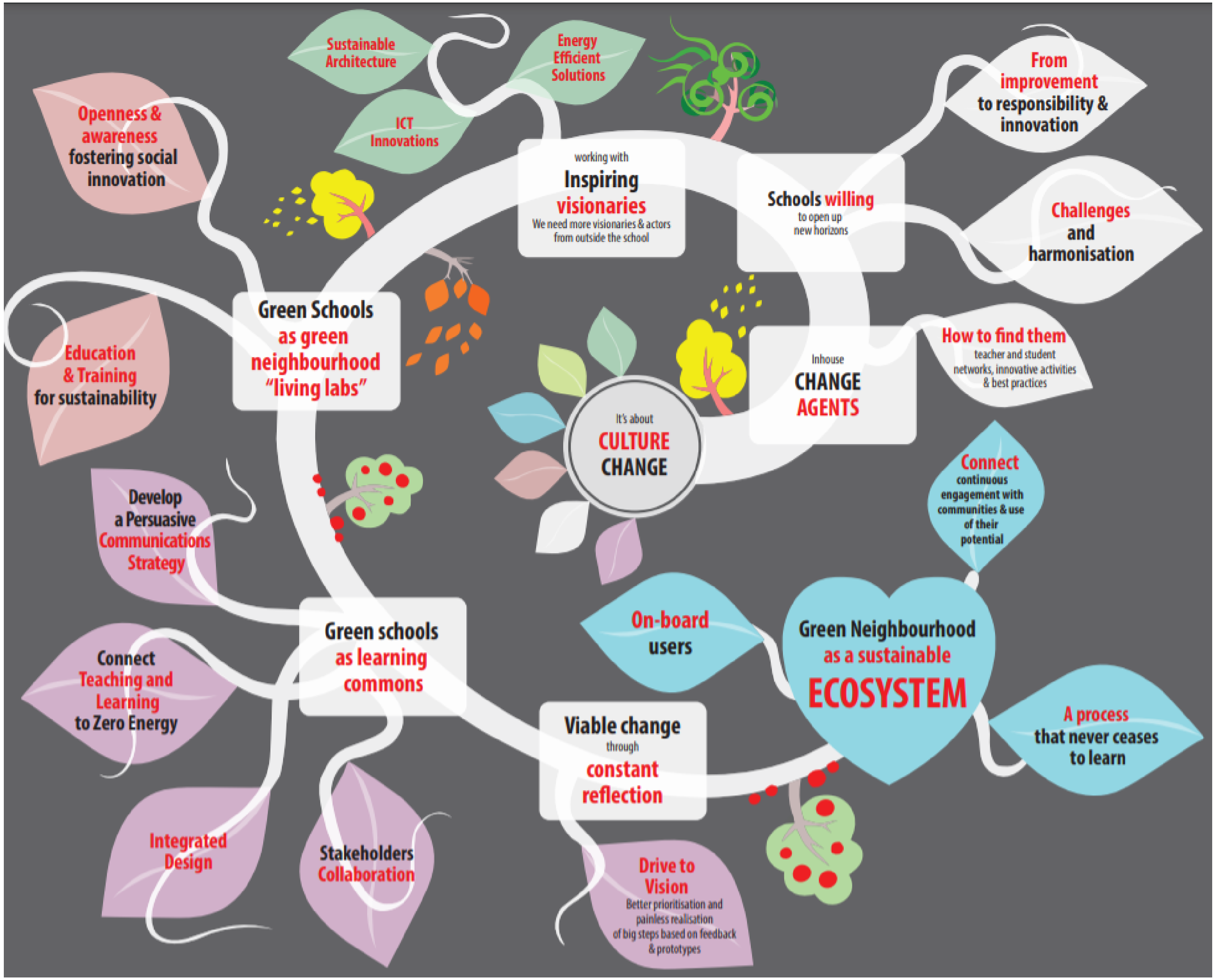

Figure 1. *The full cycle of the NEB-LAB process for the development of the Green Neighborhood Living Labs: The process starts with the pilot sites acting as Change Agents in their local communities presenting innovative ideas (energy efficient solutions, sustainable architecture and ICT-based systems to optimize the building operations). The pilot sites are becoming Drivers of change in the local settings: School Buildings are becoming Learning Commons, by spreading best practices, by supporting the development of positive behaviors and habits for resources efficient energy use, by acting as research and innovation hubs and epicenters of social change. The mechanism is based on continuous interaction with the citizens based on the living lab participatory approach. Finally, the Green Neighborhood acts as a sustainable ecosystem by adopting the same process in future developments*.

The innovations will be adopted to the local environment and will demonstrate their potential to provide energy efficient solutions which at the same time are reducing the energy consumption of the buildings. The NEB-LAB approach will be deployed in two phases:

- **NEB-LAB Incubation Phase – Educational Buildings as Agents of Change:** In this phase, NEB-LAB will deploy feedback mechanisms to notify the students/faculty/staff/parents on current energy consumption at the building. Raise awareness regarding the environmental effects of energy spending, provide evidence about the effectiveness of the installed solutions (energy consumption before and after the installations) and promote energy literacy by educating the users. Continuously monitor their progress towards reducing energy consumption and successful behavior change. For example, we will monitor and analyze the buildings energy consumption during their school/university hours and when in their homes using multiple input methods. Internet of Things (IoT) sensing elements such as embedded sensors monitoring environmental conditions, building occupancy and activity monitoring sensors, sensors monitoring the performance of micro-generation electricity modules and smart energy metering installations in the premises of the pilot buildings will be used to automatically collect energy related information. We will also incorporate participatory sensing technologies for semi-automatic periodical collection of energy usage to acquire information in buildings where no IoT sensing elements are available, e.g., utilizing web/smartphone/social networking applications for acquiring information on room occupancy, usage of cooling systems or special machinery, opening of windows, etc. Our goal is to include the users in the loop of monitoring the energy consumption in the buildings during the renovation process, thus making the first steps towards raising awareness, connecting the educational activities carried out at schools with their activities at their home environment and engaging the parents and relatives at home.

- **NEB-LAB Acceleration Phase – Educational Buildings as Drivers of Change in the Green Neighborhoods:** By building on the concept of Open Schooling the pilot sites will transform to innovation hubs in their communities (see Figure 8), raising citizen awareness activities to facilitate social innovation, promote education and training for sustainability, conducive to competences and positive behavior for a resource efficient and environmentally respectful energy use. Two fundamental principles distinguish the mindset required to develop a neighborhood living lab around a zero-energy educational building. The first principle is that zero-energy building can create and reinforce **a culture for zero-energy** among those who use and operate them. The second principle is that zero-energy building demand highly **collaborative synergies** among those who plan, design, construct, use, operate and maintain them.

2.2 Key Strategies

The strategies to incorporate these principles successfully into the process of conceiving, planning, designing, and implementing a zero-energy neighborhood around a zero-energy educational building are described here:

Creating the Culture: There are two crucial components in this process:

a) **Develop a Persuasive Communications Strategy:** A clear but flexible communications strategy is essential to educate, generate enthusiasm, develop new proponents for zero-energy, and establish the key expectation that zero-energy will be achieved and maintained. The benefits of zero-energy are likely to appeal to different stakeholder groups in the following different ways:

- Creative educators will readily grasp the opportunities for learning that zero-energy schools/universities/museums offer as they seek innovation in pursuit of student success.
- Students, many of whom are already committed advocates for the environment, will enthusiastically embrace their new zero-energy school's capacity to improve the quality of their environment and that of the surrounding community.

- School board members and local administrators and educational authorities, though concerned about initial construction cost and equity with other schools in the district, will find the long-term savings in operating and maintenance of a zero-energy school fiscally responsible, and should also be encouraged by the opportunities for student learning and success.
- Citizens who typically vote for new schools/universities in bond referenda will likely also support a zero-energy school if the life-cycle savings and risk mitigation are clearly articulated, if it is demonstrated that the low EUI needed for zero-energy may be provided for the same or little more cost than a regular school, and if they are aware that other means of funding the renewables will be available if necessary

- Municipality officials may be encouraged to see the value of a zero-energy school/university/museum in helping to achieve overall community energy goals and in demonstrating the commitment of their community to sustainability and mitigation of climate change, especially if faced with aging energy infrastructure.
- Members of community associations and residents near a proposed zero-energy building may be unfamiliar with zero-energy concepts, but once educated are likely to embrace them.

▶It is necessary from the outset to address head on those who believe that a zero-energy educational building will automatically cost more than a typical school, and that the risks of cost overruns, delays and eventual failure to achieve zero-energy are too great.

b) Connect Teaching and Learning to Zero-energy: Planning, designing, constructing, and operating a zero-energy school signals true culture change and a fundamental shift toward recognizing and mitigating climate change to all the students, teachers, administrators, staff, parents and members of the community in which it is located. It can help to make all of them owners of zero-energy performance and help them all to understand their individual and collective roles in sustaining zero-energy performance for the long term. Most importantly, it supports student learning and student success by integrating learning, design, sustainability, and environmental stewardship in a more comprehensive way than a typical school.

Active Participation and Deeper Learning on Energy Efficiency

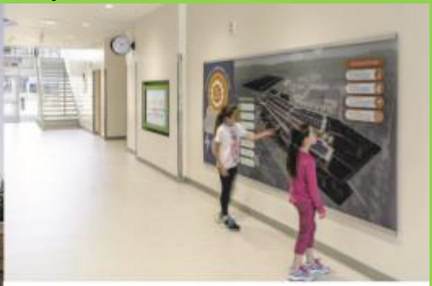

Figure 2. *Renewable Energy Labs and Interactive Energy Dashboards will be used to facilitate the buildings development to the school curricula.*

Innovative installations during the renovation period recreate the experience of watching a zero-energy school come to life for each new cohort of students. For example, using interactive energy dashboards, students can experience the energy-efficient features and the varying conditions of season and weather. The dashboard gives students a synergistic view of how the pilot site operates as an integrated system of which they are an essential component. Another example could be the development of a portal to the inner workings of their school creates pride and a sense of collective responsibility for their environment. After understanding the why and how of zero-energy, and the uniqueness of their school students are more likely to engage in other green initiatives.

▶Zero-energy champions should consider establishing the expectation from the outset that the school will become and remain an integrated learning tool through which the students themselves will become the greatest advocates for environmental stewardship as they carry what they have learned in and from their school with them through their lives.

Developing Collaborative Synergies: There are two crucial components in this process:

a) Integrated Design: The advantages of integrated design in maximizing synergies across program, site, and system requirements have been noted for many building types, whether the goal is zero-energy. For zero-energy schools, finding synergies through integrated design is not just an enhancement but an essential strategy for achieving the low energy use intensity (EUI) needed within the budget available. Applying integrated design synergies to a zero-energy school creates a single integrated system, from which no major component can be removed or substantially altered without raising the EUI. While prescriptive design guidance is useful to achieve many energy goals, to achieve zero-energy as cost effectively as possible prescriptive strategies may no longer suffice.

▶ Rather, integrated design is required to reconcile the specifics of microclimate, site, program, available construction options and available renewable energy to develop an optimal solution that balances energy consumption with energy generation. With the development of zero-energy buildings from performance-based rather than prescriptive criteria, the use of building simulation tools is essential as part of an iterative process of optimizing each system and component.

b) Stakeholders Collaboration: Collaborative synergies for zero-energy extend to all the community stakeholders who will use and operate the school and the interconnected facilities: the students, parents, teachers, municipality officials and leaders, local educational authorities, facility and energy managers, and members of the larger community, who will use the facilities from time to time. It will require the leverage of numerous diverse relationships to help communities to establish a collaborative and effective ecosystem composed of numerous partners. These relationships will help select vendors who share a similar vision, with a goal of enabling it to achieve its green neighborhood goals faster and more cost effectively. In this way NEB-LAB will present scalable designs of the green, positive energy neighborhoods of the participating pilot sites, well embedded in their spatial, economic, technical, environmental, regulatory, and social context.

▶ They too should be encouraged to engage, integrate, and collaborate with the school team during the various stages of design, and experience the culture change that zero-energy inspires. They too will contribute to achieving the school's zero-energy performance, and once it been achieved and verified to maintaining it year after year. If they do not, all the collaborative efforts of the integrated team will have been wasted.

The energy-saving measures that will be described in the next sections are therefore intended to complement teaching and learning in zero-energy educational buildings. For a culture of transformative innovation to flourish, it needs to be allied with, or develop from, challenges or ideas that are central to the core values and goals of a school, its community, and the people within it. With the initiative and drive coming from within a school itself, external support is recast as an aid to innovation and the innovation is supported by the momentum of the organization.

2.3 Criteria for selection of the five pilot-sites

At the core of the project's approach are the five NEB-LAB Demonstration sites. They **have in place large scale eco-renovation projects** that are introducing significant innovations towards zero-energy buildings. Table 1 summarizes the criteria for the selection of the five sites.

Table 1: *Criteria for the selection of the NEB-LAB Demonstration sites*

C1	**An existing eco-renovation project, that will act as the starting point to mobilize the community.**
C2	**A culture of cooperation and will to codesign and implement a systemic eco-renovation approach based on the concept of the** zero-energy retrofitted educational building, changing attitudes and habits with systemic impact, in close cooperation with a learning-acting

	community, families and the neighborhood and ready to get involved and drive intergenerational dialogues.
C3	**Ready to cooperate for realizing an open scalable proof of concept in New European Bauhaus.** Co-designing of the demo-sites with help of a chamber of quality (advising board, test-learn-consolidate-upscale) based on Sharing connecting and capitalizing.
C4	**Projects in the demonstration sites are complementary (focus on energy production, lighting, ventilation and air quality, food systems) for co-enlightening the NEB-LAB proof of concept as described in the previous session.**
C5	**Projects in the demonstration sites are complementary (focus on educational use, formal education, informal education). Three schools, one university campus and a science center have been selected as pilot sites.**
C6	**Projects are following a 3-level true ambitious implementation:** • **make a sidestep switching offers-habits** (self-reflection, carbon handprint), • **change education with implementing a local "climate action plan"** (open schooling, learn-landscape design), • **a zero energy retrofitted building and circular neighborhood approach.**

Practical Example: A localized Climate Action Plan focusing on Sustainable Food Systems

A **bioclimatic zero-energy School Canteen** is currently under construction in Ellinogermaniki Agogi School in Athens. The energy used for catering facilities amounts to around 10 per cent of a school's energy costs. However, energy savings of up to 60% have been found in some school kitchens by enhancing the efficiency of a school's catering equipment[5]. 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. The building embedded photovoltaics will generate enough renewable energy on-site to cover 100% of its energy needs on a net annual basis. A heat pump will be used to cover the refrigeration requirements and the heat demand. As the heat demand lasts for limited time during the day the heat waste of the refrigeration will be pumped to the swimming pool of the campus to reduce the costs of its operation. The aim of the school stakeholders is **to transform the canteen to a learning hub** for the students to test solutions for reducing energy, water use and for interacting with the food systems. Through making these efforts highly visible, this leadership inspires a larger movement that significantly accelerates the adoption of a sustainability lifestyle – first around energy, but also around other critical areas like food, use of resources, and relationship to the natural world. Ellinogermaniki Agogi is one of **the nine FoodSHIFT Accelerator Labs**[6], established in partnership with engaged citizens, NGOs, SMEs, researchers, local administration, and policy makers to incubate local food system innovations. Through events, tools and resources, we'll share these innovations and inspire everyone to join food systems shift.

In this chapter, we have highlighted the key features for the establishment of an integrated approach towards openness in the pilot sites. This approach was introduced and adopted for shaping the Use Cases (D2.1) 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

[5] https://betterbuildingssolutioncenter.energy.gov/sites/default/files/slides/4-7-15-Zero-Energy-Buildings-Slides.pdf

[6] https://foodshift2030.eu/

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 provides a holistic understanding of the methodology that must be implemented for the development of the Climate Action Plans. The next chapter provides the framework and the guidelines to the design teams of each pilot site to accelerate the transformation plans of the demonstration sites, while at the same time highlights that the impact on the user communities has to be monitored during the whole phase of the Green Action Plans realization.

3 Creating a Green Action Plan

The methodology for the design and the integration of the solutions proposed by the Chamber of Quality (WP3) to the Green Action Plans (involving students, teachers, school heads, trainers, education leaders, local business, museums, art and science bodies and sport centers) of the pilot sites is described in this Chapter. It focuses on the Integrated Design Process for the development of the Green Action Plans. A solid plan will help the building stakeholders to ensure that the project will continue to be supported, making sustainability a part of the culture of the organisation. In other words, it will help to ensure that the efforts that are made towards sustainability are also sustainable. This open-innovation methodology that was described in the previous chapter puts people in charge of the innovation process. It involves different kinds of partners in a private-public-people partnership and integrates research and innovation processes in real-life communities and settings. This methodology has been widely tested and has proved to be capable of nurturing meaningful collaborations between actors with diverging interests but with common objectives. Together, they build new products, new services, new uses, etc. through a cycle that typically comprises: Co-creation, Exploration, Experimentation, Evaluation phases. In this Chapter we will present a series of proposed steps for the development of the Green Action Plans, we will describe the proposed integrated Design Process and we will describe the Sustainability Citizenship model that will be used to monitor the behavioral change and the establishment of a new culture in the organization.

3.1 Key Steps for Creating a Green Action Plan

3.1.1 Get Smart

A Green Action details the work that different members of the organization will need to take to achieve the goals that were established in the overall organization's sustainability policy. The best plans delve into the specific tasks required, with actions that are: **S**pecific, **M**easurable, **A**chievable, **R**elevant, and **Time-limited** (SMART).

Here's an example of how to make an action to increase recycling rates SMART:

- Make the action **specific**, for example, "Analyze energy consumption data for a long period, study the variations, check and validate the infrastructure used, and make concrete proposals for improvements based on evidence-based proof of concept experiments".
- Ensure that the results of the action are **measurable.** In this example, monitor the variations in energy consumption after the proposed modifications and installations and compare them with the previous situation. Make a comparison with the expected values based on the new system specifications.
- Agree with the team that the action has been assigned to that the timescale is **achievable.** Consider if there will be any delays that you will need to bear in mind, for example, the time needed for the new installations. How long will they take to be delivered? Will you need to let staff know why you're making this change in advance?
- Refer back to the sustainability policy and the key areas of the school curriculum related to climate change and environmental protection in general. Does this action help you to reduce one of your main environmental impacts? In this case, the action is **relevant** to reducing waste tonnage.
- Set a completion date so that the action is **time-limited** and doesn't drag on longer than initially agreed.

3.1.2 Make each action accountable!

Your programme will be most successful if each action is assigned to a person (or working group) who has responsibility for its completion within the timeframe and budget. The best way to achieve this accountability is to involve the relevant party in agreeing on the timeframe and budget of the action to begin with. If they have been part of the initial decision-making, it is much harder for them to shirk responsibility at a later stage!

3.1.3 Consider your greatest impacts

Refer back to the main environmental and social impacts that you highlighted in your sustainability policy. Your initial priority actions should be focused on reducing these impacts and you should keep checking back to make sure that they continue to be prioritized throughout the program.

3.1.4 Get ideas from staff

Before you start your action plan, it can be a great idea to ask staff for their sustainability improvement ideas. Whether you put an opinion box in staff rooms or ask each department manager to interview their employees for suggestions, getting ideas from the shop floor will help to secure your project's success. It will make staff feel more involved in the changes that need to be made, and you'll find that many of the best ideas can come from the people who do their tasks daily.

3.1.5 Consider the costs

Whilst it's important to focus your efforts on the actions that have the greatest environmental or social benefits, it is also important to consider the costs (both financial and time-based) involved in the actions, to further prioritize them. You can then work on the low-hanging fruit first and build up to the actions that require a greater commitment, giving your sustainability project time to develop. The quick wins will encourage the staff members who are involved in the program to see the results of their actions. They will also be valuable to win over senior management and/or shareholders who will want to see the positive impacts of their investment in the sustainability program. This will help you to get approval for initiatives that might take longer to complete, or that might require a greater financial investment.

3.1.6 Have a clear starting point and well-defined KPIs

Before you start focusing on actions to reduce your organisation's environmental and social impacts, the first action should be to **establish the baseline data**. For example, to say that you want to reduce waste by 20% (**Key Performance Indicator, KPI**), you will need to know from **where** so that you can be certain when that 20% reduction has taken place. Initial actions may be audits of spend, procedures consumption, etc. so that there is benchmark data to allow everyone to know where they are starting from. It is important to organize the KPIs in different categories, for example technical, pedagogical or to define ones that are related to the users' behavior and attitude.

3.1.7 Break it down

If an action on your plan is too broad, such as "Reduce waste tonnage", then you need to take a step back and consider what smaller actions are required to help you to reach this outcome. In this example, create separate sub-actions for each of the departments that contribute towards the organisation's waste tonnage:

- **Catering**: Audit current food waste volumes over 1 week
- **Operations**: Get waste and recycling tonnages for the previous year from the waste contractor
- **Office**: Put a paper recycling bin next to all photocopiers and printers
- **Marketing**: Create educational posters to show what can go into each bin and with information about the benefits of recycling

3.1.8 What will success look like?

As you draw up each action, consider **how you will measure the impact** that it has, and how you will judge whether it was a success that can be marked as completed. What metrics will you use to track the progress towards completion of each step?

3.1.9 A work in progress

The Green Action Plan is a **living document** that will grow and evolve as the renovation and sustainability project progresses. Some actions will become higher priority than initially planned, and others will drop down the list, or come off it entirely. The important thing is to start with a positive, methodological approach and to keep the plan as clear and concise as possible so that anyone joining the project or who has a role to play in it can easily understand what is entailed. Making sure that your actions are SMART and fully accountable will keep improvements progressing at the agreed rate and will ensure that no important actions drop off due to inactivity or a lack of responsibility.

An important variable that has impacts to the energy performance and overall success of an educational building in its community is its usage. As part of the initial planning for the educational building, the stakeholders (educational authorities, municipalities, private owners) must establish its assumptions and goals for the use of the organisation, both in the short and long term.

- Open Schools and University Campuses that provide extended day programs to support busy, working parents, provide summer support and enrichment programs for students, regularly open their facilities during evenings and weekends to adult education programs, and welcome community use of gymnasiums, theatres, cafeterias, classrooms, athletic fields, and playgrounds outside normal school hours demonstrate sound environmental stewardship.
- Science Centers operate continuously, including the summer period. These stakeholders recognize that their buildings are valuable community assets.

In the next sessions we are defining the key parameters that will facilitate the implementation and the monitoring of the Green Action Plans for the participating organisations.

3.2 Defining Technical KPIs: An Integrated Design Process for a Zero-energy Educational Building

NEB-LAB proposes an Integrated Design Process for the zero-energy and energy positive Educational Buildings, that includes a) the Concept Design, b) the Bidding and the Construction and c) the Development of the Knowledge Base to act as a reference for the school community and for the neighborhood stakeholders (Figure 3).

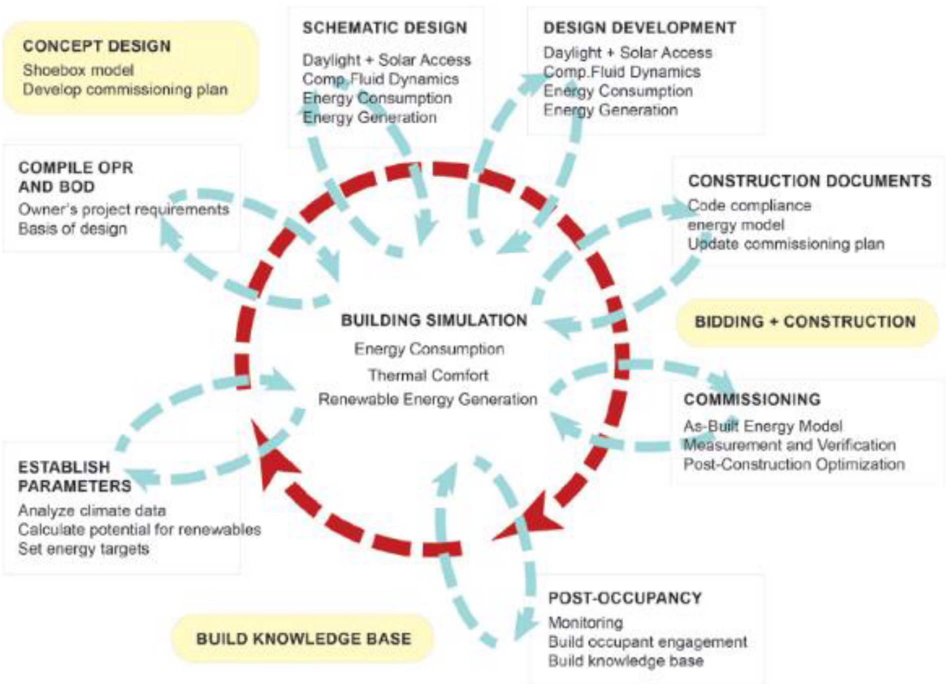

Figure 3. *The NEB-LAB approach is based on an integrated design process towards zero-energy educational buildings.*

3.2.1 Develop the Educational Building Project Requirements

A key step in the development of a zero-energy school is the creation of the educational building project requirements (EBPR). The EBPR establishes the owner's expectations for the project including basic operational expectations, the purpose of the project, and fundamental educational goals. Therefore, it is appropriate that the EBPR also establish building performance criteria, including energy performance goals or targets such as site EUI or zero-energy. A well-written EPPR is a useful instrument for providing the design and construction teams with insight into the true targets they need to achieve and describing the role of zero-energy in achieving that vision.

To facilitate this process, NEB-LAB Methodology will focus on three main workstreams:
1. Auditing the existing estates
2. Solution mapping - developing concept design options
3. Solution development - outline scheme design

3.2.1.1 Audit of building automation systems

A managed diagnostics platform can achieve a 5-15% reduction in energy cost for new buildings, or 10-40% reduction for existing buildings, with RoI (Return of Investment) in the first 12-24 months. Evidence towards FM benefits are less easily quantified but there is growing evidence this can achieve a 10-25% reduction in HVAC maintenance costs, 5-15% in occupant complaints, as well as value in greater operational intelligence.

The first logical step in response to is to understand what existing energy controls are present across building(s) in a real portfolio, i.e., does the building have PIR lighting controls? Have VSDs been installed? What controls are fitted to the boilers? and what return on Investment would these measures bring? The process begins with audit of existing hardware to fully understand the existing configurations and potential of the new controls.

NEB-LAB team has a process termed ‘BMS health check’ which we ‘scan’ the backup files from the existing system to digitally audit the health of system and orientate our approach on a running start. NEB-LAB will use developed tools to assess existing BMS and controls installations for their ability to control energy consumption.

For example, BURO HAPPOLD tool was built up from the basis of an industry British standard BS 15232. This standard is extremely useful to reveal the inefficacies within existing buildings. This standard has been codified and enhanced with more inputs and calculations such as an energy saved forecasting feature to make it far easier to work with and demonstrate the potential value and ROI for making key interventions in an existing installation.

The following describes the proposed scope and key deliverables of the auditing process:
- Working closely with the demonstrations sites teams in Greece, in France, in Ireland, in Portugal and in Sweden the design team will collate data and assess the existing assets for their existing performance, adaptability and longevity of service to provide a clear picture of the existing buildings from which a road map of improvements may begin.
- Using this information, the design team will map out energy flows for each building to allow us to focus on where out proposed interventions can have the most impact.
- Provide a portfolio dashboard of building assets influencing building performance metrics across their estate enabling the buildings stakeholders to understand and prioritize investment strategies across their estate.
- Collate assets information i.e., assets system age, manufacturer and any state of disrepair, remaining service life.
- Generate metrics across portfolio and present via an easy to navigate dashboard.
- Provide a portfolio dashboard of energy building performance metrics across their estate enabling the demonstration sites stakeholders to prioritize investment programs based on the greatest return on investment.
- Collate building data i.e., energy costs, maintenance costs, GIFA per building, design occupancy, space use and space topologies etc. to understand portfolio opportunities and constraints.
- Workshop with FM to confirm the classification of controls within each building and existing state of data storage and remote connectivity of building management systems.
- Generate metrics across portfolio and present via an easy to navigate dashboard including:
- The estimated saving for upgrading the controls (following BS EN 15232: Energy performance of buildings. Impact of Building Automation, Controls and Building Management).

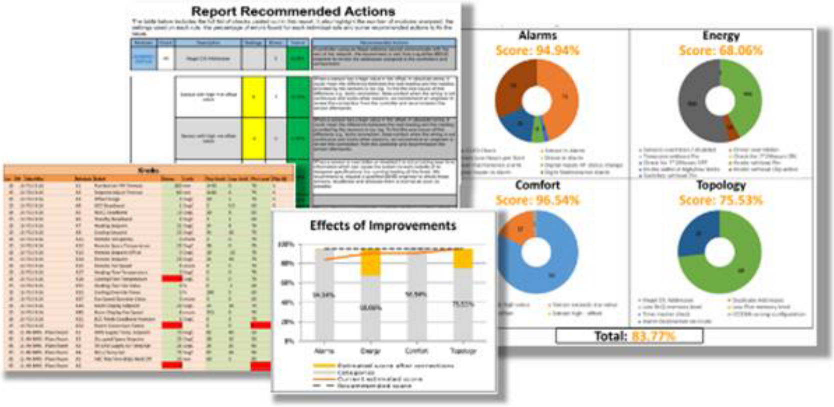

Figure 4. *BMS health check - Dyson College*

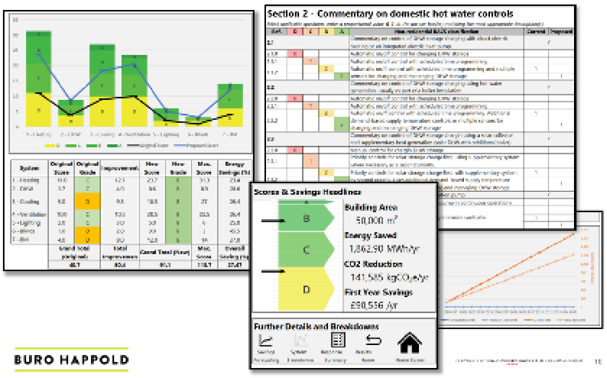

Figure 5. *BMS energy assessment (BS 15232)*

3.2.1.2 Solution mapping

NEB-LAB multi discipline team (Chamber of Quality) brings together experts in their field for driving an integrated design approach and use of tools to help inform design progression to create optimized solutions, delivering low impact, highly sustainable and resilient buildings that deliver excellent health, well-being, social value, and productivity. From the outset of the project and through each stage, the design team will act as sustainability champion and integrator. Dedicated workshops will be organized in each demonstration site, stakeholder engagement methods and use multiple-criteria decision appraisal techniques to review key opportunities, constraints and priorities for the project will be implemented. This qualitative work will be supported by advanced parametric simulations to help deliver a truly integrated design, including use of in-house software to rapidly optimize the key variables.

NEB-LAB design team will work with the demonstration sites stakeholders and team to determine the appropriate objectives and sustainability target levels and manage the process of achieving these targets through ongoing engagement. The design team will act as a design integrator within the team around sustainability and wellbeing issues. With the information gleaned from above, the design team will develop several high-level concepts for each site and the neighborhood as appropriate. Whilst the team may include recommendations for more obvious carbon reduction options which are readily viable (e.g., PV, fabric upgrades, heat recovery etc.). NEB-LAB will recommend what the team believes to be the most viable technology to consider further at the next stage based on consideration of carbon savings potential and any impacts that the design would have on operation during installation, or overall resilience of the buildings.

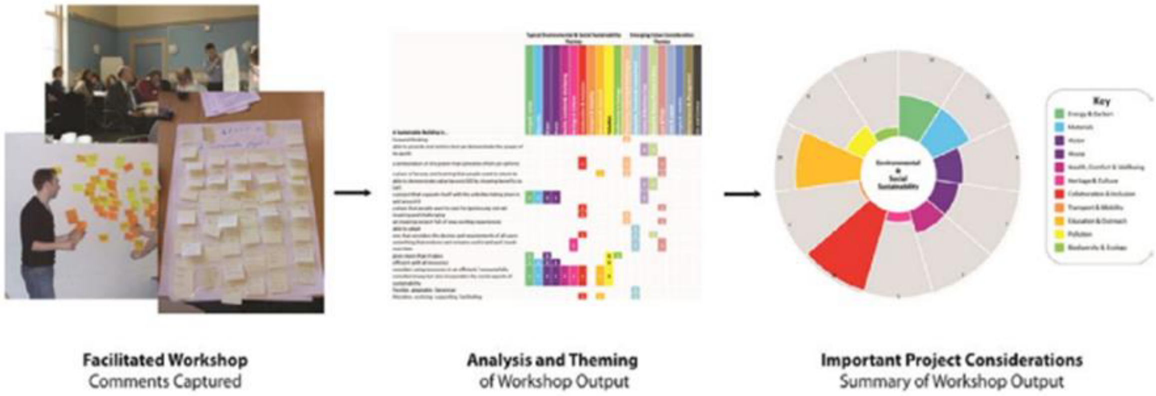

Figure 6. *The NEB-LAB design team will adopt a participatory engagement scheme for the demonstration sites requirements elicitation.*

The following describes scope and key deliverables of the solution mapping process:

- Define with the demonstration site the sustainability aspirations and formalize an agreed strategy for setting sustainability targets and driving design solutions.
- Establish prioritization of sustainability themes and indicators with the demonstration site and design team, review the existing design against these and key opportunities and constraints.
- Explore the key design opportunities for maximizing synergies and creating integrated design solutions.
- Calculate the estimated carbon reduction for the proposed retro fit options and present in a matrix of component value streams (carbon reduction, lean operations, user experience etc.)
- Agree with the demonstration site stakeholders the physical and digital technologies to pursue into the next stage
- Engagement with potential suppliers to inform the project of new approaches and technology roadmaps, whilst readying the market for tender.

3.2.1.3 Solution development

At this phase NEB-LAB Chamber of Quality will take the agreed technologies from the previous stage and develop these further to understand the detailed viability and how these would integrate into the existing buildings.

The EBPRs will be used as a reference to confirm what the proposals should achieve and how they should achieve it, including outline design schematics, integration topologies, building cognition logic, specifications, and layouts as appropriate. It is intended that the output from this stage could be used to secure further funding and to engage a design and build Contractor to develop the proposals from outline scheme to installed product. If any technology is untested in the application that is proposed, the proposed solution may form an outline for a pilot study which could be rolled out wider if successful. The following describes the scope and key deliverables of this phase:

- Systems integration of existing and new, physical, and digital technologies and supporting infrastructure including network systems architecture and interface to base build systems
- Integration of the data layer, identification of data communication protocols and schemes, interfaces, transmission protocols, frequency, and latency of data communication to achieve the objectives defined.
- Supplier Engagement: market research for available and emerging technologies, documenting our gap analysis, and identifying product road maps for supplier development of products.
- EBPRs including outline design schematics, integration topologies, building cognition logic, specifications, and layouts as appropriate.
- Assumed packages to be developed for this stage:

- Upgrade & enhancement works to existing BMS
- Upgrade works for the MEP systems
- New renewable technologies and energy storage systems
- Anonymised occupation profiling for user group personalisation and demand response optimisation
- Metering provisions including physical and virtual metering
- EV charging and utilisation of EV for load sharing with building demands
- Radiant monitoring systems to optimise HVAC response
- An integration platform across the building subsystems
- Geo location and geofencing technologies and predictive conditioning / response
- Local web services integrations; Travel disruption, weather and pollution monitoring and building response.
- Self-learning commissioning / fine tuning optimization
- Applications for user and FM engagement around carbon reduction initiatives
- Integrations for demand response initiatives with utility providers
- Automatic fault detection and diagnostic software with ML / AI modules where appropriate.

3.3 Defining Pedagogical KPIs: Focus on Sustainability Citizenship

NEB-LAB adopts Sustainability Citizenship as its working definition since it captures the more fundamental, more encompassing and active aspects of behavioural change towards more sustainable behaviour.

In our view, **Sustainability Citizenship critically resides on people's dedication and their self-determined motivation to protect the environment.** People's self-determined sustainability motivation is durable against the test of time (see Kaiser, Brügger, Hartig, Bogner, & Gutscher, 2014), and **relevant for people's lifestyles**, visible for instance in their electricity consumption (see Arnold, Kibbe, Hartig, & Kaiser, 2018; indicated by the double-headed arrow between environmental attitude and sustainable lifestyle in Figure 7). Based on their research, Kaiser and colleagues have come to conceptualize people's self-determined motivation or dedication to environmental protection as **environmental attitude** (see, e.g., Kaiser, Oerke, & Bogner, 2007; Hartig, Kaiser, & STRUMSE, 2007; Kaiser, Byrka, & Hartig, 2010; Kaiser, Hartig, Brügger, & Duvier, 2011).

Expectedly, people's environmental attitude discloses itself in the persistence with which people engage in energy-saving (see Henn et al., 2019), which shows in the attitude-moderated effect of behaviour on the resources consumed (the dashed red arrow on the black arrow in Figure 7). Together with **the costs of a specific behaviour** (due to effort, distance, inconvenience, fees, lack of infrastructure, social constraints etc.), people's **environmental attitude** (their self-determined motivation to protect the environment) controls specific protective behaviours. This becomes apparent in the compensatory efficacy of environmental attitude and behavioural costs when they both account for individual behavior in Figure 7 (solid black arrows: for evidence, see, e.g., Kaiser & Byrka, 2011, 2015; Byrka et al., 2017;Taube et al., 2018; Taube & Vetter, 2019; Kaiser et al., 2020). Behavioural costs derive from the **cultural and social context** (i.e., the boundary conditions) in which people act, and they are behaviour-specific (e.g., Kaiser & Biel, 2000; Kaiser & Keller, 2001; Scheuthle et al., 2005).

As such, within the limits of a specific sociocultural context (e.g., Germany), behavioural costs constitute more or less universal "situational thresholds" for engagement (Campbell, 1963). According to Campbell, costs must be counterbalanced by an actor's personal attitude (for experimental evidence, see Kaiser & Lange, 2020).

Expectedly, sustainable citizens generally behave in less resource consumptive and environmental protective ways in their everyday lives (see, e.g., Kaiser, 1998; Kaiser & Wilson, 2004: indicated by the black arrow between environmental attitude and individual behaviour in Figure 7). Because of their raised dedication to protect the environment, sustainable citizens not only vote for representatives with a known environmental protection record, recycle cardboard regularly, and avoid foods that are particularly environmentally harmful (e.g., meat), they also refrain from flying and from owning a car (e.g., Kaiser et al., 2010, 2013; Henn et al, 2020, 2021), and they seize environmental protection-related learning opportunities.

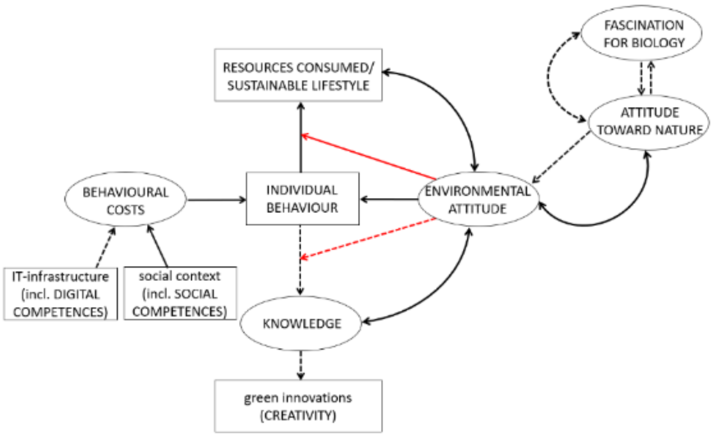

Figure 7: *Proposed Standard-Based Framework. Solid lines reflect evidence-based relations; double headed arrows stand for correlations; single headed arrows for directed relations; dashed lines represent likely or presumed relations; ovals symbolise latent, not directly observable concepts; rectangles stand for manifest, directly observable concepts.*

Consequently, we find sustainable citizens to know more about the processes within ecosystems (system **knowledge**), the things that can be done to protect the environment (action-related knowledge), and about the protective benefits of specific protective behaviours (effectiveness knowledge: see Kaiser & Frick, 2002; Frick et al., 2004; Roczen et al., 2014: double-headed arrow between environmental attitude and knowledge in Figure 7). Accordingly, we must suspect a similar attitude-moderated persistence effect of learning (i.e., the specific behaviour) on the what people know (the dashed red arrow on the red arrow in Figure 7) as was found on people's engagement in energy-saving (Henn et al., 2019).

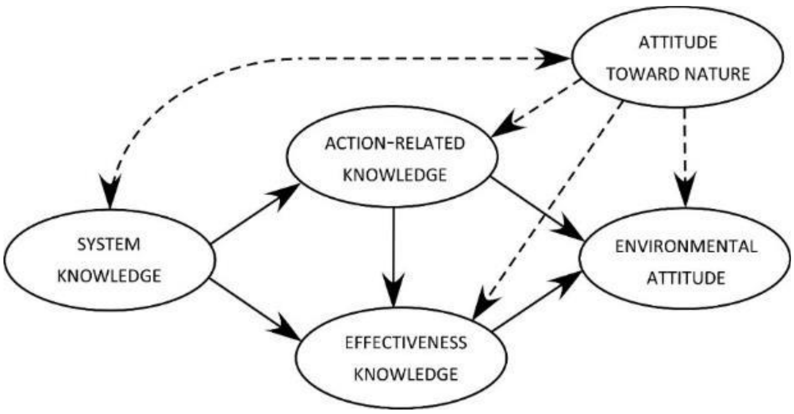

Figure 8: *Competence model by Kaiser, Bogner, and Rozcen (see Kaiser et al., 2008; Roczen et al., 2014)*

The proposed competence framework in Figure 2 originates in the environmental competence model by Roczen et al. (2014) shown in Figure 3. In contrast to their work, we treat environmental knowledge as a single intellectual attainment consisting of the three more or less closely related facets system-, action-related and effectiveness knowledge. Concordant with their suggestion, we also regard people's appreciation for nature (i.e., **attitude towards nature**) as a promising experience to instigate people's environmental attitude (their dedication for environmental protection: see, e.g., Kaiser et al, 2013, 2014). The **attitude towards nature** or appreciation of nature is conceptualized as a positive attitude towards nature (Kibbe et al. 2014). Within the concept of environmental attitudes, it represents one of the two opposite poles of utilization. While an exploitative usage of nature is on the one end of the utilization spectrum, an appreciative usage of nature is the counter on the other end of the spectrum (Kibbe et al. 2014). Hence, this appreciative component of utilization includes the sustainable and conscious use of nature e.g., for recreational reasons, inspiration and connection with nature causing minimal or no exploitation of the natural resources (Brügger et al. 2011; Kibbe et al. 2014; Kaiser et al. 2014). Even though appreciation of nature includes self-interest and is based on personal benefits (Kaiser et al. 2013), it is expected to favor environmental protection and pro-environmental behaviour (Kibbe et al. 2014) Therefore, the concept of appreciation monitors the enjoyable utilization of nature by measuring self-reported past behavior (Brügger et al. 2011; Kaiser et al. 2014; Kibbe et al. 2014). The interaction of the appreciation of nature with other variables in connection with education sciences is of high relevance. Bogner (2018) and Raab et al. (2018) reported a positive association to preservation of nature indicating that people who appreciate nature have a preservative attitude. Between appreciation and utilization, no relationship was detected (Raab et al. 2018). Similarly, even though measured in different ways, this attitude variable has repeatedly been found to interact with ecological behaviour (Clayton 2003; Mayer und Frantz 2004) and serve as the basis for a more self-interested motivation for environmental protection (Hartig et al. 2007).

As this first basic model secured the principal foundation, the empirical formulation of the lifelong learning competence framework requires many more input variable to fine-tune any assessment approach. Lifelong learning requires that people are not only able but also motivated to continuously and actively learn about and engage in environmental protection throughout the various stages of their personal lives. **Fascination** for science in general and **fascination in biology** in particular, **creativity** and **digital competencies** play an important role in the overall framework:

3.3.1 Fascination for science

Fascination for science conceptually is rooting in the Campbell paradigm (Kaiser & Wilson, 2019). As a new variation of the tripartite model of attitudes (Rosenberg & Hovland, 1960), the Campbell paradigm proposes an attitude based on three dimensions: an affective, a cognitive and a behavioural component. The affective dimension is characterized by positive feelings and emotions towards a subject area, here science in general or specific scientific fields (Otto et al., 2020). The learning topic "aquatic ecosystems", for example, is supposed to trigger positive emotional reactions in a person who is fascinated with biology and who would enjoy learning more about marine wildlife. The cognitive component is reflected in the willingness to solve even complex scientific problems as well as to develop necessary skills, knowledge, and competences. The behavioural dimension manifests itself in the repeated and voluntary exercise of extracurricular activities and experiences. For example, students fascinated with biology will frequently watch TV documentaries about animal behaviour or observe garden birds.

3.3.2 Engagement with science

Ideas of engagement with science are comparable to school engagement theory (Fredricks, Blumenfeld, & Paris, 2004). Emotional engagement with science is supposed to be reflected in students' positive feelings and attitudes towards science and emotional reactions connected with scientific topics. This affective dimension of fascination can be expected to reflect in the enjoyment of learning scientific contents. Cognitive engagement can be defined as "thoughtfulness and willingness to exert the effort necessary to comprehend complex [scientific] ideas and master difficult [science] skills" (Fredricks et al., 2004). Thus, cognitively engaged learners are perceived as willing to gain new and deeper insights into scientific topics, and they appreciate the opportunity to deepen their scientific knowledge. Additionally, cognitive engagement becomes obvious when a learner expresses the importance of science and scientific knowledge. Behavioural engagement as the third dimension "draws on the idea of participation" (Fredricks, et al., 2004). It is characterized by the performance of voluntary, extracurricular activities and experiences relating to science, for example, reading science magazines or watching TV documentaries on scientific issues.

3.3.3 Creativity

Creativity seems to be one of the most difficult psychological constructs to explain (Corazza, 2016). It is easier to notice creativity and its effect when absent, for example, in unimaginative attempts at problem-solving. Because the more complex the problem becomes, the more creativity is needed. Risen degree of environmental degradation and climate change with the ineffective policy so far prioritize individualization of responsibility. Consumers need to develop sustainable consumption to contribute to sustainable development. Sustain living may require entirely new approaches and ways of living. However, since sustain behaviour has no traditional solutions, in addition to the broad social recognition of such behaviour, creative problem-solving skills of exceptional complexity and creativity is needed. It can be observed that people feel socially encouraged to participate creatively in problem-solving in appropriate communities (Kinga Polynczuk-Alenius, 2015). In the context of a globalised society with massive climate degradation, creativity has been identified as a key skill for the 21st century (Wagner, 2010). However, the school environment has been accused of neglecting this part of education: school seems to discourage children for more creativity, although school could also promote creativity (Barbot, Besançon, & Lubart, 2015). Since gender differences in creativity are found only in some cultures (e.g., Matud, Rodríguez, & Grande, 2007; Archer et al., 2013; Shen, Liu, Shi, & Yuan, 2015), school education seems to have a decisive influence (Csikszentmihalyi, 2000). Creativity is supposed to keep a balance between fear and boredom, which may explain the evolutionary advantage of creativity (Csikszentmihalyi, 2000): When people face a new problem, they experimented with solutions, maintaining the balance between mindfulness and risk to survive. With this evolutionary background in mind, it becomes evident that the archetype of human creativity is the problem-solving ability that needs security for its unfolding. For creativity, attitude is regarded as essential. Both the creative person and his/her social environment need a great deal of openness to the process of generating ideas. Creativity needs a secure environment offering space for self-regulation and self-responsibility to support self-efficacy, whereas these as part of a competence promoting learning environment are well known to foster learning (Sadeh & Zion, 2009; Franklin, Xiang, Collett, Rhoads, & Osborn, 2015; Schmid & Bogner, 2015; Conradty & Bogner, 2016).

3.3.4 Digital competence

Digital competence for sure is another channel which needs consideration and inclusion. As "digital natives" (DN) are defined as people who were raised during the cyber age (Prensky 2001), Prensky suggests an upbringing with digital elements in everyday life shaped our current generation how to learn, work, communicate and interact with others. However, researchers like Støle (2018) point out that we are using digital methods in schools already, yet never assessed whether students are equipped with the necessary skills to use them properly. Florjančič und Wiechetek (2019) add that passively learning 21st century skills is insufficient to successfully reach skill levels necessary to compete in the international job market. When teaching methods only consider non-digital natives and their learning processes, it seems inevitable that DNs cannot fully use their full learning capabilities. Therefore, Bagur-Femenías et al. (2020) recommended acknowledging digital nativity when teaching education for . Brudermann et al. (2019) suggest that ESD is the basis for young, ambitious students to be successful on an increasingly international job market. By implication, teachers must assess digital skills before they implement digital teaching methods into their syllabus.

3.3.5 Social competence

Children learn active and responsible citizenship through opportunities to practise it – but this requires formal channels to incorporate children into school- and community-based programmes for evaluating, planning and caring for local environments (Louise Chawla 2002).

3.3.6 Drivers of change: challenges and opportunities for sustainability in Europe

The concept of sustainability citizenship is framed in the **context of current socio-cultural megatrends**. For each megatrend, the project will identify gaps that impede the transition to more sustainable societies. By making these explicit connections, we argue that SYNAPSES approach provides an effective and innovative framework for bridging the identified gaps and creates the conditions for the expected change.

The future of Europe's environment and sustainability is likely to be highly influenced by developments of societal, technological, economic, environmental and geopolitical natures, as well as changes in values and lifestyles. These **drivers of change** differ from each other concerning their origin, nature, likelihood, significance, geographical scale and timescale. Although some of them are well established and well known, some have just emerged, and their effects have not yet unfolded or are still unknown.

According to the EEA Report No 25/2019[7], building on the experience of both the EEA and Eionet, there are four categories of drivers of change are:

- **Global megatrends** are global, long-term trends that are slow to form but have a major impact once in place. They are the tremendous forces that are likely to affect our future in all areas throughout the world over the next 10 to 15 years. Furthermore, they are often strongly interconnected.
- **European trends** are mid to long term trends specific to Europe and, contrary to global megatrends, not all of them are likely to have major implications on a global scale. They are directly or indirectly interconnected between them and with global megatrends. Their direction of change can be aligned or contrasting to global megatrends (e.g., a stagnating European population in contrast to a growing global population, promoting the GreenComp Framework, Implementation of the NEB Initiative at scale in European Member States).
- **Emerging trends** represent emerging developments at a fast pace but are not yet fully established over mid to long term timescales. For this reason, their potential implications are not yet well understood. Depending on their evolution, they might lead to the establishment of new European trends or global megatrends.
- **Wild cards**, instead, are developments that may seem unlikely or very unlikely at present but could occur in the future, and, if they do, they are likely to bring about disruptive changes (major catastrophic events like wildfires and floods in the participating countries).

Megatrends in the environmental dimension subsume energy transitions (away from fossil fuels triggered by source or sink limitations), rising challenges to resource security and increasing climate change impacts. Societal megatrends include the continuation of the global demographic transition, the on-going shifts in the economic and political centres of gravity worldwide, and the growing use of information and communication technologies. These megatrends fundamentally reshape the global framework conditions for Europe.

3.3.7 Learning Ecologies: The context of implementation for the development of sustainability citizenship.

To understand and value the world we live in, we need to understand our natural environment, our responsibility for maintaining it by instilling an environmental awareness that leads to a shared sense of Sustainability Citizenship. Young people should early on understand the role and impact they have by participating in hands-on activities addressing an environmental challenge in their community. Even more, we need to connect the learning of basic competencies and skills with a deeper sense of responsible citizenship, coupled with and based upon scientific knowledge and an understanding that altogether provides meaning to information. Only this way, young people will learn to value data-based information, solve problems, make educated decisions, and take advantage of opportunities. Without the ability to critically evaluate information, scientific concepts can be misunderstood, and pseudo-scientific reasoning can mislead people – such as climate-change deniers. Therefore, we need to help young people develop the necessary dispositions and become informed citizens capable of using their competences in science and technology wisely to solve the numerous global problems humans now face. The most recent example of this is the misinformation about the COVID-19 pandemic that can be found in popular media as well as the overall attitude of citizens towards the efforts of the scientific community to reduce the spread of the infections.

Formal schooling is one way people can learn about the existential environmental challenges the world is facing, but also about the solutions that science and society can offer. It is organised and guided by formal curricula focusing on the acquisition of domain knowledge and scientific skills leading to a formal accreditation such as a diploma or certificate. As stated in the report on "Rethinking education. Towards a Common global goal?" (UNESCO, 2015) the changes in the world today – and in specific the challenges of sustainability and preserving the environment - are characterized by new levels of complexity and contradiction. These changes generate tensions for which education systems are

[7] https://www.eea.europa.eu/publications/drivers-of-change

expected to prepare individuals and communities by giving them the capability to adapt and respond. Overcoming the complex societal challenges of today will require all citizens to have a better understanding of science and technology if they are to participate actively and responsibly in science-informed decision-making and knowledge-based innovation as it is stated in the recent report to the European Commission "Science Education for responsible citizenship" (EC, 2015) produced in 2015.

While the central role of formal education is beyond doubt a significant part of competence development, skill acquisition and personal growth, one needs to acknowledge that a big part of learning takes place out-of-school. It results from daily activities related to family or leisure. In most cases, it is guided by curiosity or interest and leads to enjoyment. Particularly young people learn in diverse places as they grow up, for instance within their families, their communities, through the media, in after-school programmes, in the street. At the same time, they travel, and while they visit places like zoos, museums, and science centres. Sometimes – and ideally - , they are confronted with and learn about the same concepts and phenomena in different learning contexts.

As a result, a significant challenge arises: How can we integrate the same concepts and phenomena they learn in these different contexts in a connected ecosystem? While some research shows that people create links between different learning contexts[8, 9], most of the literature points to a severe lack of contact between formal and informal learning contexts introducing the same concepts and phenomena[10, 11]. As out-of-school learning experiences become more common in people's lives (considering the increased number of informal science learning initiatives available), it is crucial to facilitate stronger links and connections between the different learning settings and actors, that commonly are in the position to facilitate a "deeper learning" in environmental issues in formal education in combination with activities and partners outside the classroom.

There is a unique opportunity to bridge the gap between the two worlds by developing an appropriate catalyzing process: A **connected science learning ecosystem** where young people may encounter a wide range of learning experiences and be supported by adults, scientists and policy experts, as well as peers in ways that could lead to future opportunities in personal, academic, professional, and civic realms. This vision requires educators and organisations to think beyond the bounds of their institutions to consider how collective action at the level of networks can provide opportunities and address inequalities in a way that more isolated efforts cannot. When discussing how youth might thrive in such an ecosystem—and what sort of interventions we can develop to help all youth do so—the idea of pathways[12] has often come up as a useful metaphor that invites us to consider youths' "learning lives" over time and across the many contexts (e.g., home, school, community organisations, science centres and museums, web and social media) where learning may occur.

While there are many ways to productively conceptualize such pathways, we simply invoke pathways as a metaphor for thinking about ways to provide structure to youth experiences – **Learning Paths** –, how they might "connect to" or "build upon" one another and thus allow a young person to pursue goals that require extended engagement or persistence across multiple contexts and learning opportunities. Learning paths take many forms influenced by emerging research and discoveries, changes in society's needs and interests, and changes in personal interests or opportunities. Some

[8] Eshach, H. 2007. Bridging In-school and Out-of-school Learning: Formal, Non-Formal, and Informal Education. Journal of Science Education and Technology 16, 171–190.

[9] Fallik, O., Rosenfeld, S. and Eylon, B. (2013). School and Out-of-School Science: A Model for Bridging the Gap. Studies in Science Education, 49:1, 69-91.

[10] Kim, M. & Dopico, E. (2016). Science education through informal education. Cultural Studies of Science Education, 11, 439-445.

[11] Leonard, S. N., Fitzgerald, R. N., Kohlhagen, S., & Johnson, M. W. (2017). Design principles as a bridge between contexts: From innovation in the science museum to transformation in formal education. EDeR. Educational Design Research, 1(1). https://doi.org/10.15460/eder.1.1.1059

[12] Sotiriou, S., Bybee, R., & Bogner, F. X. (2017). PATHWAYS – A Case of Large-Scale Implementation of Evidence-Based Practice in Scientific Inquiry-Based Science Education. International Journal of Higher Education, 6(2), 8–17. https://doi.org/10.5430/ijhe.v6n2p8.

individuals describe their learning path as an upward trajectory, pointed towards a clear goal. Others describe their path as more irregular, resembling steps or, more often, an erratic bumpy line. Learning opportunities are made possible and shaped by the learning *ecology* that one inhabits.

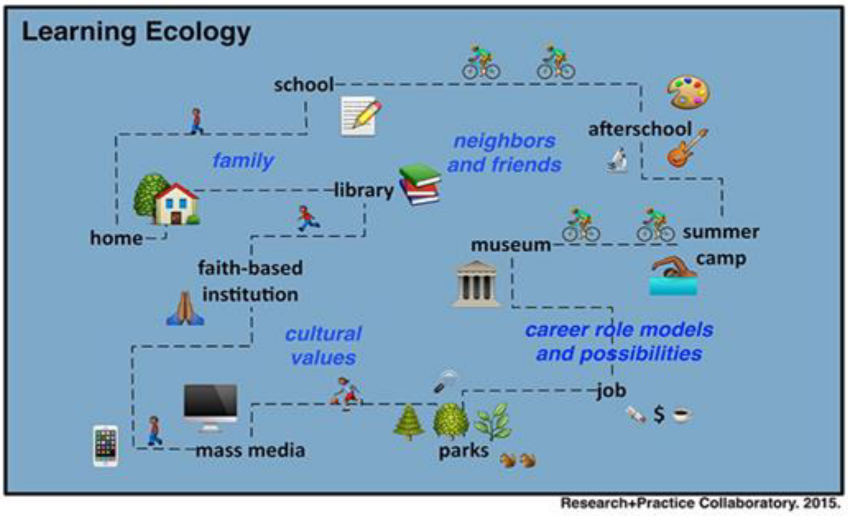

Figure 9: *A graphical representation of the Learning Ecology[13] that describes the learning paths of individuals in the framework of school and out-of-school learning activities. By introducing the concept of Learning Ecologies, NEB-Lab has the ambition to design and set-up a strong learning ecosystem based on the building renovation.*

A **Learning Ecology** is the physical, social, and cultural context in which learning takes place. Like natural ecosystems, learning ecologies (see Figure 4) have physical dimensions, which may or may not include easy access to nature, science museums, or advanced science programmes or internships. However, we are less used to thinking about the sociocultural dimensions of learning ecologies.

In the framework of NEB-lab, Learning ecologies are the contexts—the physical settings, social interactions, value systems and histories—in which teachers learn over time, both daily and during the lifespan. Like their natural counterparts, robust learning ecologies are characterised by diversity, redundancy, and local adaptations. This means that a robust learning ecology contains a wide variety of training programmes and opportunities, across a range of institutions and places, allowing teachers different and multiple ways to engage with environmental issues. Even more, this framework encourages individuals to take increasing levels of ownership over their own training as they gain more experience.

Nonetheless, such connected training ecosystem needs to be established and coordinated. It requires the cooperation and connection of collaborative partnerships, consisting of formal, non-formal and informal learning providers and stakeholders that can act as a key factor to optimise training opportunities across a range of institutions and organisations.

[13] https://www.nsta.org/connected-science-learning/connected-science-learning-march-2016/stem-learning-ecologies

4 Beyond the Educational Building: Developing a neighborhood living lab around a zero-energy school

4.1 Schools as drivers of Green Neighborhood Living Labs

NEB-LAB main ambition is to demonstrate that educational buildings (for formal and informal education) hold a great potential **to act as drivers in the Green Renovation Wave and to enhance the social acceptance of energy efficient solutions** by creating sustained and meaningful engagement of local communities. NEB-LAB describes the characteristics of the Open Schools, core social centers that can act as lighthouse projects for the local communities. Under the term **Open School,** we describe every educational environment that adopts a culture open to innovations and to external interactions. An educational environment that operates as an **innovative ecosystem**, acting as **shared site of science learning** for which leaders, teachers, pedagogues, students and the local community share responsibility, over which they share authority, and from which they all benefit through the increase of their communities' **science capital** and the development of **responsible citizenship**. NEB-LAB, to realize its ambition has selected **three construction and renovation school projects that are currently under development**, **one of the leading Universities in Europe that has already in place a plan towards a zero-energy university campus (in the framework of the** UN's **"Race to Zero" initiative)** and **an emblematic Science Center** in Lisbon that aims **to transform the building itself to an exhibit of the Green Renovation Wave.**

By deploying a systematic approach, NEB-LAB will enable the demonstration sites to open themselves safely and securely **up to the wider world** and communicate with external physical and digital infrastructure. It will support them to go even beyond that and to be integrated **into the wider climate ecosystem** so they can positively contribute to local infrastructure and flexible demand-side operations. The target of NEB-LAB is to deliver a suite of physical and digital technologies empowering building owners and operators to get more from their assets and people.

- Maximize space efficiency
- Enhance human wellbeing and productivity
- Improve climate resilience
- reduce operational carbon emissions and offset remaining emissions with renewable sources
- Reduce operation costs to a minimum
- Increase operational flexibility and resilience to Covid-19 and future pandemics

4.2 The Multiple Benefits of Educational Buildings Retrofits and Climate Action Plans

Energy retrofits of existing buildings are particularly relevant in cities that have already experienced high rates of urbanisation, population growth and economic development. According to (C40 Cities and McKinsey, 2017)[14] public building retrofits (e.g., schools) that result in savings on energy bills, create jobs and spur industrial activity, while improving conditions for residents and users, make a strong case for why every property owner, public or private, should follow suit. To demonstrate these benefits NEB-LAB will develop an evidence-based tool that enables the project team to quantify the multiple benefits of the building retrofit programmes put forward for each educational organization in the project. The tool can support a rapid scale up of the neighborhood climate action by providing an easy-to-use toolkit that allows local stakeholders to quantify the multiple benefits of building-retrofit projects. By using this toolkit, the local stakeholders can calculate the environmental, social and economic benefits of building energy-efficiency improvements and use this quantifiable evidence to

[14] C40 Cities and McKinsey Center for Business and Environment (2017). Focused acceleration: A strategic approach to climate action in cities to 2030. Available at: www.c40.org/researches/mck-insey-center-for-business-and-environment

make a strong case for climate action. Of course, it is important to remember that the total benefits are commensurate with the level of retrofit ambition. Retrofitting one building will not have a significant impact on the health or level of energy poverty across an entire city, for example. But many individual projects could add up over time, and so will the associated total benefits. Retrofitting schools could have a unique advantage as they represent a building that is present almost everywhere. Furthermore, in every location it consists of a core community center that could have a significant social value for the local community.

Figure 10. *Average ranges of 2030 emissions reduction potential for different cases. NEB-LAB will demonstrate how this can be achieved in different educational buildings focusing in all cases initially to the optimization of the energy use and then to more location-specific cases. (C40 Cities and McKinsey, 2017)*

The tool based on the long experience of the AS&E team will model different parameters related with the pilot sites operation. For example, GHG emissions are modelled to show the environmental benefits from mitigating climate change. Standard emissions factors are applied to energy savings to evaluate the potential emission reductions. Increased demand for energy efficiency services and technologies have proven to create many local jobs[15]. The indicator used to calculate job creation is based on full-time equivalent (FTE) jobs per million Euro spent. Employment creation is calculated across all building typologies. Expenditure is based on the capital cost of the retrofit programme and employment opportunities have been proportioned between direct, indirect, and induced job creation:

- Direct local jobs: created as a result of the intervention (e.g., working on the construction site);
- Indirect jobs: manufacturing jobs associated with the specified interventions (e.g., glazing or insulation production);
- Induced jobs: created in the neighborhood that surrounds the specified interventions (e.g., in a shop due to increased footfall and expenditure).

Net Present Value (NPV) and payback-time calculations will be used to appraise retrofit investments. It is assumed that a project with a positive NPV will be profitable as it indicates that the projected earnings generated by the building retrofits exceed the anticipated costs over a period of time. The discount rate is an indicator of the value of money over time. It is recommended that one of the scenarios tested consider a 3% discount rate (EU Regulations, 2012)[16]. When calculating NPV, maintenance cost savings have been estimated as a percentage reduction based on energy audits undertaken by each city. Maintenance costs include future intervention to replace the equipment over the building lifetime. Most of the maintenance costs fall to the building owner, but energy savings may affect both the owner and the occupant. Retrofit interventions may also affect productivity levels

[15] Burr, A. Majersik, C. Stelburg, S. and Garrett-Peltier, H. (2012). Analysis of job creation and energy cost savings: from building energy rating and disclousure policy. Available at: www.imt.org/wp-content/uploads/2018/02/Analysis_Job_Creation.pdf

[16] EU Regulations (2012). Available at:

https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=O-J:L:2012:081:0018:0036:EN:PDF within buildings, which informs the NPV. The financial value attributable to a productivity increase has been used as an indicator. This is based on average staff salary costs and the anticipated productivity increase in terms of reduced sick-leave and turnover. In addition, a calculation for payback time will be included in the analysis to allow cities to understand how long it will take for the original investment to be repaid. The tool will account for scenarios where building retrofit projects are being delivered in partnership with an Energy Service Company (ESCO); this makes it possible to identify the proportion of savings that will be passed on to the consumer, the owner and the ESCO.

Each building stakeholder involved in NEB-LAB proposal identified deep energy retrofit projects across its building stock that would allow their buildings energy efficiency and quantify the corresponding environmental, social and economic outcomes of the overall project. The NEB-LAB project introduces a variety of projects, from small-scale retrofit measures to be piloted to major renovation projects. These projects will be used to test the methodology and exemplify how building and local stakeholders can use the toolkit along with the NEB-LAB Approach to make the case for specific projects within a wider retrofit programme (in the framework of Green Deal or other related EU or national support frameworks). The exact benefits will differ between projects depending on a building's current standard in terms of energy-efficiency and operation. The environmental benefits of retrofits will be greater in an energy inefficient building than in a passive house where there is a limited opportunity for additional energy savings, while health improvements will be more significant in buildings where users are experiencing low temperatures and high degrees of mould.

4.3 Creating Green Jobs, upskilling Workers and Attracting New Talents

The design, installation and operation of circular and low-carbon solutions often require a high level of technical knowledge. Specific skills are also needed for the safe management of historical buildings and safeguarding their heritage value. The transformation towards a climate-neutral building stock will only be possible if existing jobs are transformed to include green and circular skills and if new job profiles emerge, such as specialists in deep building renovation, installers for advanced technological solutions, or Building Information Modelling managers. Only well-informed professionals can play their potentially key role in offering end-users latest available technical opportunities for resource and energy efficiency. Finally, professionals require training to improve accessibility in renovations. Already before the COVID-19 crisis, there was a shortage of qualified workers to carry out sustainable building renovation and modernisation. The potential for job retention and creation in this sector has been and remains large. Energy efficiency in buildings is the largest generator of jobs per million euros invested[17].

If Member States were to quickly implement measures to improve insulation, technical building systems and appliances, new employment opportunities would immediately present themselves. Policy should signal to the market that innovative and sustainable solutions are needed. For example, the bioeconomy can provide new low-carbon materials for deep renovations, increasing new specialist job opportunities. Increasing the presence and role of women in the construction sector can help improve the availability of skills and qualified professionals. Revising vocational and educational training strategies by involving industry, creating an inclusive and accessible working environment and overcoming prejudices is key. SMEs should be given better access to information about training and apprenticeship programmes. Social partners, including workers' and employers' representatives of the construction sector at national and European level, have solid expertise in upskilling workers, attracting new talent and promoting an inclusive working environment and should be involved in the design and implementation of measures to achieve these goals. In the framework of NEB-LAB partners will join forces with industrial partners, high-level research institutions and innovative consulting engineers to design and install advanced solutions to different types of buildings in different locations in Europe.

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[17] 12-18 local jobs per million euro invested, IEA, Sustainable Recovery, June 2020.

4.4 Scalable Design of Green, Positive Energy Neighborhoods

While changes in technology, policy, and culture are increasing the number of energy-efficient new buildings, the large existing urban building stock needs to be retrofitted to support real change. Buildings are our homes, schools, universities, and workspaces, where we spend 90% of our time. Improving indoor environments can significantly impact our health and well-being. Poor indoor air quality, cold temperatures, mold, and dampness affect our physical and mental well-being as well as economic productivity. And moreover, energy-inefficient buildings increase energy costs and household spending – which is particularly challenging for low-income residents. The pilot sites will develop synergies in their neighbourhoods committed to enriching modern living and improving sustainability through combatting climate change, growing the circular economy, and safeguarding citizens' wellbeing. *How many new jobs will a building retrofit project result in? How will an improved building standard affect urban residents' health, well-being, and productivity?* Knowing the impact of those climate actions on health and the economy is critical to making better policy choices, and for convincing a wide range of urban stakeholders that the high upfront cost of retrofitting buildings is worthwhile.

4.5 Capitalizing on the use of Advanced Technologies

Virtual Reality (VR) and Augmented Reality (AR) technologies have been rapidly recognized in architecture, business negotiations, and educational programs because they are believed to be effective in enhancing the quality and interacting with a created scene or a model. But VR & AR can be also helpful in landscape design. In modern landscape design, a scene plays an important role in presenting spatial relationships, structure, and node sequence. AR that blends the digital and real-world into one visual and audio experience in landscape design has certain advantages in comparison with other representation tools traditionally used (2D drawings, images or videos). That's why in NEB-LAB we offer a new way to plan and reveal the future design of the Green, Positive Energy Neighborhoods around the NEB-LAB Demonstration Sites. Based on AR solutions citizens will be given a brand-new view of their area, that is true to scale and ready to explore in real-time from any angle. Moreover, AR brings huge opportunities for cutting costs and delays in the development due to identifying design risks at an early stage of your project. There are a series of ways that AR can enhance the engagement of the different stakeholders in the Living Lab operation:

4.5.1 Emotional connection with the environment

One of the most important characteristics of AR is to create the immersive feeling of "being in the real world". Through the interaction between you and devices, you can truly experience the existence of the virtual environment. The application of AR technology in landscape scene construction makes up users' experience of uncompleted landscape design and creates a new way for a designer to explain the project. For example, constructing a landscape design scene, you can add textures, materials, and geolocated sunlight. Moreover, energy changes resulting from the number of users involved in the scene will trigger the sensor for new changes and form a different landscape. Also, the landscape model will be able to reflect the invisible forces in a visible way. This interaction between people and the environment can be achieved only through AR devices and helps users interact naturally with multidimensional virtual environments.

4.5.2 Compare different prototypes at no extra cost

Another benefit of AR in design visualization is that it enables the comparison of different concepts at the same time. For example, in the 3D interactive virtual environments, designers and citizens can explore and interact with several virtual spaces. They can also convert the data into a simulation and modify the objectives as they wish in this simulation. The usage of virtual worlds in the field of landscape design (and architecture too) can benefit you and your customers in terms of understanding the essence of a created style. Being able to look at the materials installed helps them make the right decisions. You can very clearly present that information to your client.

Figure 11. *BIM-enabled mobile mixed reality visualisation of heating and ventilation pipes in the Ellinogermaniki Agogi building (Source: Doerner et al, 2019*[18]*)*

4.5.3 Connect the public with landscapes

AR could well teach the public to connect with its surroundings better as technology facilitates the transmission of information. Some public authorities, like Lyon in France, already use this technology to communicate with locals about urban redevelopment. A similar case happened in Szczecin (Poland) where our team at Pixel Legend in collaboration with the Architizer A+ laureate Freedomes worked together on the interactive projection system called Hyperdome. Dome was active on an island for 3.5 months and was visited by over 5000 guests who saved 150 scenes in the cloud. While younger guests-built scenes for fun, adults argued how the industrial areas should blend with commerce, cultural and residential zones on the island.

4.5.4 Implement complex projects

In comparison with interior architecture where the created spaces and objects are static, landscape architecture deals with dynamic exterior spaces. The main challenge for each landscape architect is the realization of an architectural vision, which conceptually is based on architectural objects but also combined with living materials like trees, shrubs, herbs, and grasses (planting objects). AR is particularly great for showcasing hardscaping projects, namely outdoor living spaces, due to their complexity. The software can render large, complex designs such as parks and golf courses, as well as residential landscapes. Space can be filled with people to help determine how space works when crowded and it can be view in daytime and nighttime settings. AR would allow you to save time by superimposing the render over reality instead of building out the environment.

The Concept of a Smart Urban Metabolism (SUM): The aim of the SUM concept is to provide knowledge on energy and material flows as close as possible to reality by collecting and analyzing real-time user generated data sources. The SUM concept can be classified as a hybrid approach as it attempts to include both production and consumption perspectives. ICT infrastructure is used to collect data on energy and material flows from utilities, and sensors and smart meters installed in households, businesses, and public spaces. These data streams are collected in an information management system and analyzed by a real-time calculation engine which can provide feedback related to sustainability indicators set by the city, building owners, and citizens themselves. Accordingly, the SUM concept advances the conventional urban metabolism concept and uses ICT and smart-city technologies to derive a real-time dynamic understanding of urban energy and material flows. This may provide planners, organizations, and citizens with a better basis for decision-making through an increased awareness of their system consequences. Furthermore, it has the potential to enable the automation of relevant decisions and the optimization of the metabolism of a city.

[18] Dörner, R., Geiger, C., Oppermann, L., Paelke, V., Beckhaus, S., 2019. Interaktionen in Virtuellen Welten, in: Virtual Und Augmented Reality (VR / AR) - Grundlagen Und Methoden Der Virtuellen Und Augmentierten Realität. Springer Vieweg.

Figure 12. *Smart Urban Metabolism: Towards a Real-Time Understanding of the Energy and Material Flows of a City and Its Citizens*[19].

4.6 An integrated Approach for Neighborhoods and Municipalities

These mobile mixed reality interactions need to be co-designed with relevant stakeholders in the project and in the neighborhoods, appropriating and building on existing results from prior projects. The development-process needs to be iterative and aligned with the two phases of the project, schools as agents of change, and schools as drivers of change in the green neighborhoods; linking it with the NEB-LAB approach and the Social Value Framework (**WP5**) to address the key stakeholders and become scale up accelerators that take the message further and thus act as an agent of community well-being.

The NEB-LAB demonstration sites are inhabited by different educational institutions, ranging from schools, over a science center, to a university. The mobile demonstration interfaces and collaborative tasks supported by them thus need to be embedded into a larger pedagogical framework and appropriated for the age group to support non-formal learning through collective tasks and intergenerational activities. Citizens could engage with forestation activities and being energy detectives, for example, or deal with more complex and interdependent real estate, city planning, and social community relationship aspects.

[19] Hossein Shahrokni, David Lazarevic and Nils Brandt, Journal of Urban Technology, 2015 Vol. 22, No. 1, 65–86, http://dx.doi.org/10.1080/10630732.2014.954899

5 KPIs Definition and Monitoring

This Chapter describes the KPIs of the overall project and provides the guidelines that were offered to the pilot sites representatives during the work in WP2 to localize and define the KPIs (both technical but mainly pedagogical related to their pilot sites.

5.1 NEB-LAB overall KPIs

Table 2 gives a summary of the potential impact of the projects that will be implemented in the five demonstration sites.

Table 2: *Summary of NEB-LAB KPIs*

Potential impact at the Demonstration Sites and beyond	
Users	280,000 per year
Climate Action Plans	Detailed Climate Action Plans for the five pilot sites and their neighbourhoods
Citizens Interest and Motivation to act on sustainability, the environment, and the climate change	Significant increase in Sustainability Citizenship (assessed by the project instruments)
Users on Education for Climate Coalition platform	>10,000 new users in the framework of the project
Interventions and potential impact at the Demonstration Sites (based on the existing eco-renovation projects in place)	
New Buildings (2)	1,050m^2 (Students Residences and School Canteen)
Retrofitted Buildings (24)	39,607m^2 (School Buildings, Science Center Exhibition Area, Students Residences, School Canteen, Sports Halls)
Total Area to be covered by OPV and BIPV (Produced Energy)	6,000m^2 (2,33GWh per year)
Mini Wind Farm (Produced Energy from 5 Turbines)	50MWh per year
Current Total Energy Consumption	6,059 GWh/year
Energy Reduction by Improving Buildings' Efficiency	3,147GWh/year
Total Energy Reduction	5,482GWh/year
Average Energy Consumption Before and After Retrofitting	Before: 167kW/m^2 After: 80kW/m^2

The monitoring of the technical KPIs will be based on the **energy master plan**. Key features of an effective energy master plan include the following:

- Document and validate the current energy consumption of each building;
- Establish energy goals for each building;
- Coordinate with energy priorities of local regulatory and utility policies, including incentives and rebates;
- Balance energy conservation with renewable energy production and distributed generation;
- Develop a menu of appropriate energy conservation strategies for both modernization and new construction projects;
- Prioritize energy conservation projects in alignment with the strategy of the organisation;
- Specify an appropriate building energy management system to ensure long-term energy tracking and performance.

A successful energy master plan will maximize the return on investment, delivering the greatest long-term energy savings, and thus reducing the operating cost for the buildings.

The focus of the NEB-LAB project is to facilitate the development of practically feasible measures related to the proposed or already implemented renovation projects in the pilot sites. For example, in the case of the Green Canteen project in Ellinogermaniki Agogi determining where GHG savings could be made and developing measures that the school canteen could take is the reference point that will provide the baseline data. Potential savings in the recipes could be determined using ceteris paribus analyses. The values for the actual menus were calculated and then the calculations were carried out on selected variations in the composition of the dishes. To identify potential savings in the area of food processes, these processes could be modeled based on the energy measurements. Refrigeration, cooking, serving, dishwashing, lighting, heating and air conditioning, washing and drying, and hot water could all be modeled. In the case of the Ellinogermnaiki Agogi educational program, the models are based on average consumption and qualitative surveys of the school kitchen. Next, average potential GHG savings were determined, extrapolated to one year, and then translated into specific measures. This concept was tested in the five school canteens and kitchens over four weeks to identify any obstacles to implementation and to identify solutions that could be used to overcome these obstacles. The final step was the evaluation and optimization of the measures that had been tested.

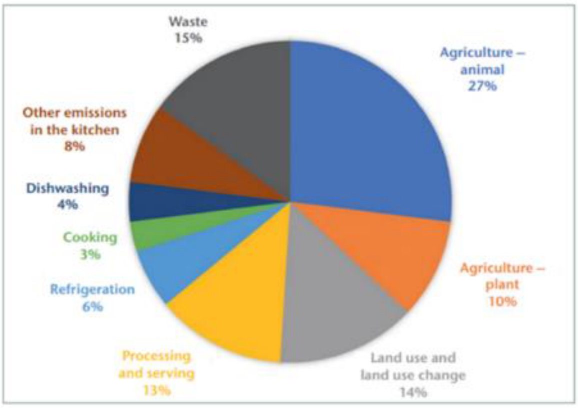


Figure 13. *Total GHG emissions per school menu broken down according to the stages of the value chain (Spec et al., 2020)[20].*

Mea-sure		Potential GHG emission savings[a]
MT-1	using efficient freezers	3.70%
MT-2	using efficient refrigerators	0.95%
MT-3	more refrigeration in place of freezing	1.40%
MT-4	efficient use of convection ovens and cooking appliances	0.75%
MT-5	upgrading to LED lighting	0.90%
MT-6	using efficient dishwashers	1.40%

Mea-sure		Potential GHG emission savings[a]
MF-1	climate-optimized menu plan through substitution and reduction of meat	10.30%
MF-2	weekly replacement of a meat dish with a plant-based dish	1.90%
MF-3	partial or total replacement of milk and dairy products	5.40%
MF-4	partial replacement of rice with spelt	2.10%
MF-5	using climate-friendly packaging	0.75%
MF-6	provision of tap water	2.50%
MF-7	using more organic foods	1.50%
MF-8	using seasonal and regional products	0.65%

Figure 14. *A combination of Technical and Behavioural KPIs for the School Canteen operation and use: Proposed measures in the area of action "Optimizing technology through investment" and in the area of action "Selection of foods".*

5.2 Guidance and Support for the Definition of the KPIs related to the users behaviour

This section describes the guidelines that were provided to the pilot sites for the definition of the KPIs. The focus is on the development of the Sustainability Citizenship Competence for the users of the

[20] Speck M, Wagner L, El Mourabit X et al.: The climate- and energy-efficient school kitchen. Making school meals climate friendly and child friendly. Ernahrungs Umschau 2021; 68(7): 128–33.e6–7. The English version of this article is available online: DOI: 10.4455/eu.2021.027

building, the openness of the organization and the social impact of the overall project to the local community. It must be noted that each renovation project has different scale while the proposed activities in their use cases and their initial Greek Action Plans vary significantly at different levels (curriculum integration, duration) so the expected impact and the related KPIs could vary significantly.

5.2.1 Monitoring the development of the Sustainability Citizenship Competence

KPIs targeted by the Sustainable Citizenship Model introduced for the impact assessment (see deliverable D5.1). This will cover all variables that can be assessed in the framework of the project with the use of the proposed instrument (see Figure 10).

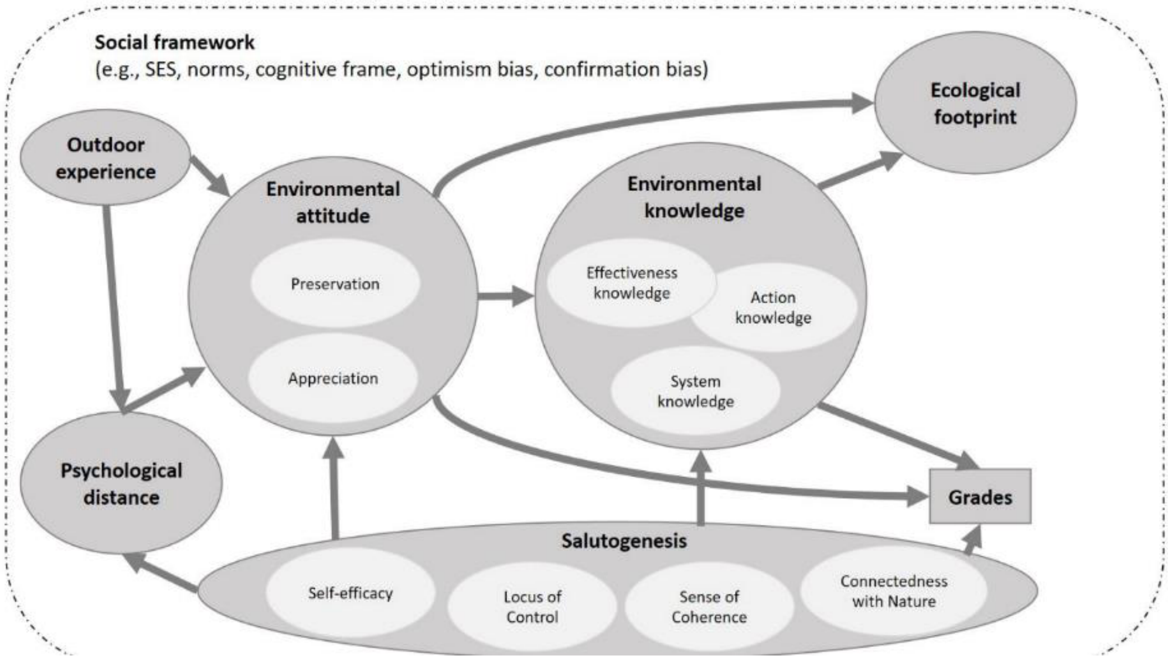


Figure 15. *The Sustainability Citizenship Competence partial abilities that will be assessed in the framework of the pilot activities (**WP5**). The potential change (small, medium, large effect) will form the related KPI for the local interventions in the pilot sites.*

There are typically large effects for knowledge increases, while other inherent variables such as attitudes or self-efficacy show typically small to medium improvements during intervantions that are realized for short time periods. Some examples:

- For a four-day residential outdoor program with one-month follow-up activities, e.g., we measured medium effects in environmental attitude improvements.
- For a one-day intervention, there were only small improvements in environmental attitudes.
- Attitudes are typically harder to change in older students. They are also fairly positive until age 12 and show a typical dip throughout adolescence.

Depending on user involvement (e.g., if there is extensive duration and involvement, we can even expect large effects on environmental attitude). These improvements are highly dependent on the **starting level** and on the **user involvement** (e.g., How do you engage students? Are they involved in problem-solving activities? Do they conduct experiments? Is the teacher rather a moderator, so students have a better chance to improve their self-efficacy? etc.)

Here are the variables (in **bold**) that can be assessed through the measurement tool, so those are the template KPIs:

- We expect *medium*-sized improvements in the study participants' **attitude** (attitude toward nature and environmental attitude) scores.
  - The study participants will improve their **attitude toward nature**. We expect a *medium* effect.
  - There will be positive changes in **environmental attitude**, presuming a *large* effect size.

- The study participants will change their **Psychological Distance** scores on a *small/ medium* level, as sustainability issues will be felt more relevant and closer to their lives.
  - The study participants will mostly improve on their **temporal/geographical/social/hypothetical Psychological Distance** scores.
  - Info: Psychological Distance shows to what extent people feel that sustainability issues target them. If you think, e.g., climate change hits only people far away in other countries (e.g., Africa), you are less likely to act pro-climate (= **geographical** distance). Likewise, if you think climate change issues will only hit people in the future (= **temporal**), or people that you are not involved with (= **social**), or if you doubt scientific facts about climate change and its consequences (= **hypothetical**), you are less likely to act environmentally friendly.
- The study participants will improve their overall **salutogenesis** scores by *small* effects.
  - The study participants will improve their **self-efficacy** scores *moderately*.
  - The study participants will strengthen their **connectedness to nature** by small *effect* sizes.
  - Through strong study participant engagement, they are expected to improve their **locus of control** scores by at least *small* effect sizes.
- The study participants will decrease their **ecological footprint** scores, proposing *small* effect sizes.
  - The ecological footprint scores will mostly improve in the food/ electricity/ other good consumption/ transportation domain.
- If knowledge is assessed: The study participants will increase their **environmental knowledge** scores. We expect *large* effect sizes.
  - The study participants will increase their **system knowledge** scores. We expect *large*- sized improvements.
  - The study participants will *moderately* gain **action knowledge** and **effectiveness knowledge**.
  - Info: system knowledge = facts, action knowledge = behavioral choices of individuals in daily life, effectiveness k. = environmental strategies often on political or larger scale levels (beyond individuals).

5.2.2 Monitoring the Organisation's Openness

Assessing the effectiveness of the NEB-LAB approach to the organisation needs an appropriate tool that is sensitive to monitor the key characteristics of these environments (Fullan, & Quinn, 2016, Fullan, 2018). Based on the related work in **WP5**, the Open Schools Self-Reflection Tool (OSOS-SRT) has been proposed to monitor the organisation development process and the overall organisational change during the implementation of the renovation project and the related activities. Its development is based on the recent methodologies for assessing the impact of RRI in education (van Atteveldt et al., 2019; Hobbiss et al., 2019), which is implemented as an integrated approach that includes the educational building community engagement in research and innovation, enabling easier access to scientific results for students, the take up of gender and ethics in the research and innovation content and process, and acting as a bridge of formal and informal science education, on the EU recommendations for the science education and on the development of responsible citizenship (EC, 2015) as well as on similar approaches that have been developed to monitor the development of educational organisations' e-maturity (Sotiriou et al, 2016; Kampylis et al., 2015; EC, 2019). By focusing on three identified areas of 'growth' – management, process and staff professional development– the specific instrument is offering the opportunity to the building community stakeholders to describe in detail the current situation in their school while at the same time they are able to translate the findings to specific recommendation for future actions and development. More specifically the tool aims to support the building owners and stakeholders to identify the status of their organisation in the following key areas (levels of openness):

- **Management:** The aim of the instrument is to assess the vision, the leadership of the building community key stakeholders towards the adoption of a change culture towards openness (Earley, & Greany, 2017; Hobbiss et al. 2019) and the overall innovation potential of the building community (George, & Desmidt, 2018) and to highlight the appearance (or not) of the key factors that can catalyze the cultural changes (e.g. coherence of local or national policies, development of a shared vision and understanding, development of motivation mechanisms and specific plans for staff competences, school and university autonomy). This section of the instrument includes a step-by-step approach for the building owners to define a root of development and to locate the current position of their organisation in the innovation journey.

- **Process:** The aim of this section is to identify which process are already in place in the building users community and which must be further developed. The instrument is sensitive in highlighting the processes and the mechanisms like a) the operation of collaborative environments and tools (for content co-creation and sharing), b) how many members of the building community are using them regularly, c) adjustments with the curriculum that allow for the implementation of open school activities, d) external stakeholders' involvement in the open school activities and e) procedures in place that are offering opportunities to reflect, monitor and debate, communication and feedback mechanisms).
- **Professional Development:** The aim of this section of the instrument is to assess to what extent the staff engaged in the open schooling approach, have a holistic view of science, scientific research and major scientific developments (Harris & Tassell, 2005; Authors, 2016). This section includes reflections on the integration of RRI principles into school and university curricula and teaching practices (van Atteveldt et al., 2019) as well as into exhibitions design for science centres. These reflections and evaluation of curricula and practices are supposed to reveal changes in awareness/knowledge aspects/behaviour in relation to the RRI principles – such as gender, ethics, open access, open science, public engagement, governance, socio-economic development and sustainability, social issues related to scientific developments. Supporting educators leadership may play an essential role to empower reaching this target (Muijs & Harris, 2003).

For each one of the above-mentioned levels, the tool reflects upon 8 task-specific statements (24 statements in total, see Table 3) that follow specific Open Schooling indicators. Task-specific statements function as "scoring directions" for the person who is grading the work. Because they detail the elements to look for in a participant's answer to a particular task, scoring participants' responses (in our case schools) with task-specific statements is lower-inference work than scoring participants' responses with general rubrics. For this reason, it is faster to train ratters to reach acceptable levels of scoring reliability using task-specific rubrics for large-scale assessment. Similarly, it is easier for example for school heads to apply task-specific rubrics consistently with a minimum of practice (Brookhart 2013). Rubrics has been tested for their validity as an assessment tool (self-assessment as well) for peer groups of participants (Hafner & Hafner, 2003). In Deliverable **D5.1**, the 24 task-specific statements are presented in detail.

Table 3: *The 8 items in each one of the 3 levels of openness, 24 items in total.*

	Management Level	Process Level	Teacher's Professional Development Level
1	Vision and Strategy	School Leaders and Teachers Shaping Learning Systems	Teacher Awareness and Participation
2	Coherence of Policies	Creating an inclusive environment	Setting Expectations
3	Shared Vision and Understanding	Collaborative environments and tools (co-creation, sharing)	Professional Culture
4	Education as a Learning System	Implementing Projects	Professional Competences, Capacity Building and Autonomy
5	Responsible Research, Reflective Practice and Inquiry	Parents and external stakeholders' involvement in organisation's activities/projects	Leadership Competence
6	Motivation Mechanisms	Reflect, Monitor, Debate	Collaborative learning (mobility actions)

7	Plans for Staff Competences	Learning Processes adaptation	Collaborative learning (ICT Competences)
8	Communication and Feedback Mechanism	Established collaboration with local, national institutions	Use and reuse of resources

For each statement in each level the building owner or the organisation representative can choose one statement that corresponds to the actual situation in the organisation at the specific time. Each statement corresponds to an organisation typology, according to its readiness to adapt an open schooling culture. The four organisation typologies that are presented in Table 4, are following the Open School characteristics that were presented in the previous section. Schools, according to their statements, will be characterized according to their openness status to four categories: Enabled, Consistent, Integrated or Advanced.

Table 4: *The four school typologies according to the Open School characteristics*

ENABLED	CONSISTENT	INTEGRATED	ADVANCED
Organisations that are at an initial stage of incorporating educational innovation in their settings and beyond	Organisations that have achieved a certain level of innovation and openness through specific measures, educational ICT tools, best practices, CPD, but they still consist isolated cases without a network of other educational organisations and external partners to facilitate the process	Organisations that have achieved a high degree of innovation and openness and they have already established cooperation with community stakeholders and other external partners	Organisations that are considered rather extreme cases that offer a glimpse to the open school of the future

After the completion of each one of the required sections of the self-reflection tool, the organisation representative gets a report that includes the answers in each one of the sections as well as the results of the reflection process. The status of the organisation could be Enabled (25% as the minimum of the selected scales – starting point for a school unit), Consistent (scores between 26-50%), Integrated (scores 51-75%) or Advanced (scores 76-100%).

Based on the work of Sotiriou et al, 2021[21], the overall growth in openness (result of the implementation of the open schooling approach and the related activities) can be modelled as follows (Table 5 presents the fit parameters):

$$Openness\ Level\ (Post) = 36{,}5 \times 1{,}011^{Openness\ Level\ (Pre)} - 0{,}06 \times Openness\ Level\ (Pre)$$

Table 5: *Fit Parameters*

N	500					
Mean of Y	4,179					
R^2	0,620					
R^2 adjusted	0,619					
RMSE	0,1764					
Parameter	**Estimate**	**95% CI**		**SE**	**t**	**p-value**
Constant	3,597	3,535	to 3,660	0,031630	113,73	<0,0001

[21] Sotiriou M, Sotiriou S and Bogner FX (2021) Developing a Self-Reflection Tool to Assess Schools' Openness. *Front. Educ.* 6:714227. doi: 10.3389/feduc.2021.714227

Openness Level (Pre)	0,01047	0,009386	to 0,01155	5,5119E-04	18,99	<0,0001

Formula (1) represents the expected openness level (post) of the organisation after one full year of interventions, in respect with its current openness level (pre) as it was measured with the OSOS-SRT instrument. The model provides an almost perfect match with the data from about 500 schools and science centers (RMSE value very close to 0 and the R^2 of the regression is relatively high) that were involved in the Open Schools for Open Societies (OSOS) initiative (Sotiriou et al, 2021). The corrective term in the model ($-0{,}06 \times Openness\ Level\ (Pre)$) is used to improve the prediction of the model for organisations that are scoring quite high at the first measurement.

NEB-LAB Pilot sites will use the reference Formula (1) to set their KPIs as far as the organizational change and more specifically openness is concerned.

5.3 Contribution to the development of standards towards the zero-energy and energy positive educational buildings.

Finally, the ambition of NEB-LAB is to contribute to the development of standards towards the zero-energy and energy positive educational buildings and to support the related work of EU and Member States towards this direction. NEB-LAB will assess current standards and regulatory aspects is Europe and in USA (e.g., EPBD, CHPS Criteria, 2019, https://chps.net/, International Energy Code Council (IECC) and ASHRAE) and will define specific targets and KPIs for the five demonstration sites (**WP2**, **T2.6**). The consortium will have the chance to present data from three schools, a university campus and a science centre and to perform comparisons and to make specific proposals.

As a large-scale project NEB-LAB has set ambitious aims and plans to make them reality. It is bringing together a multidisciplinary consortium (leadings consultants and engineers, leading industries in energy and lighting, energy network operators, constructors of bioclimatic buildings, technology experts, software developers, architects and topographers, technology transfer organisations, journalists and science communicators, educational experts and educational buildings stakeholders along with their communities) with significant expertise in their sectors to a) design and implement a methodological approach that aims to demonstrate the unique potential of educational buildings to act as catalysts of the social acceptance of energy efficient innovations, b) demonstrate the multiple benefits of Educational Buildings retrofits – through the realization of four retrofit projects varying from small scale interventions to full building reconstructions, c) to create green jobs, to upskill workers and to attracting new talents in the sector and d) to contribute to the New European Bauhaus through the creation of four innovation clusters in Greece, in France, in Sweden, in Portugal and in Ireland. In this section we are highlighting these key areas of the NEB-LAB project ambitions.

6 Pilot Sites Green Action Plans

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

6.1 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/	

STEP 1. Vision, Mission and Goals

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.

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 2023), 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 2023). 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.

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.

EA, through the implementation of the NEB-LAB project, 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.

STEP 1a. A first intention and Integrated Approach (commitment to start a Climate Neutral renovation project)

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

A **new school canteen building** of 50m^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 to is located 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.

A **modern hi-tech photovoltaic park** (adopting a nature-inspired architectural design) on the roof of the facility and 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.

STEP 1b. Key Focus Areas and opportunities for learning-action by experimentation

Referring to Eco² Schools as New European Bauhaus Labs 5 thematic focuses:

Focus 1- Solutions for retrofitting schools in series,

Focus 2- Multifunctional, open for the neighbourhood,

Focus 3- Other configurations for co-learning better,

Focus 4- A community engaged in the eco-transition,

Focus 5- Restore a cycle with nature-permaculture.

The aim of EA is to take advantage of the major renovation project that is under development to enrich the environmental education programme of the school by using the infrastructure as a place of experimentation and learning. EA will adopt the three-step approach: Design, Deliver and Diffuse of New European Bauhaus that is proposed by the project:

1. Diagnose and address energy inefficiencies at the school canteen building level by optimizing existing systems and adding new technology layers where required.
2. Once the school canteen running as efficiently as possible, EA will open to the wider world and will act as a demonstration building for other schools and for the local community.
3. Once the school canteen is open to the wider world, it will be integrated into the wider school energy ecosystem so it can positively contribute to local infrastructure and flexible demand-side operations.

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. The building embedded photovoltaics will generate enough renewable energy on-site to cover 100% of its energy needs on a net annual basis. A heat pump will be used to cover the refrigeration requirements and the heat demand. As the heat demand lasts for limited time during the day the heat waste of the refrigeration will be pumped to the swimming pool of the campus to reduce the costs of its operation. The aim of the school stakeholders is to transform the canteen to a learning hub for the students to test solutions for reducing energy, water use and for interacting with the food systems. Through making these efforts highly visible, this leadership inspires a larger movement that significantly accelerates the adoption of a sustainability lifestyle – first around energy, but also, around other critical areas like food, use of resources, and relationship to the natural world. EA is one of the nine FoodSHIFT Accelerator Labs (https://foodshift2030.eu/), established in partnership with engaged citizens, NGOs, SMEs, researchers, local administration and policy makers to incubate local food system innovations. Through events, tools, and resources, we'll share these innovations and inspire everyone to join food systems shift. The process will facilitate the transformation of the EA pilot site to **innovative ecosystem, acting as shared site of climate and sustainable food related behavioral change and science learning** (**Focus 3**) for which canteen staff, teachers, students share responsibility, over which they share authority, and from which they all benefit through the development of sustainability citizenship. In such a way this NEB-LAB demonstration site will present ways to increase the energy efficiency of the educational buildings and provide at the same time a unique opportunity to improve health and well-being.

- **Promote education and training for sustainability (Focus 3)**, helping all actors (school staff, students, families, citizens) to develop competences and positive behaviours for green practices. Educational materials and supporting activities will be developed and they will be integrated to the existing environmental education programme of the school at different levels (primary, lower and upper secondary).
- The notion of **school as a living lab** (**Focus 4**) promotes partnering of school with the local communities and stakeholders. It is introducing an ideation phase in the co-creative renovation project that progresses from setting the framework and sharing information to diverging and collecting ideas, converging to order and refine those ideas, discussing limitations, sharing feelings, and finally, voting for the final choice. This systematic approach ensures a comprehensive exploration of ideas while incorporating participants' perspectives, emotions, and collective decision-making.
- Develop **citizen awareness** raising activities (**Focus 2**) spreading the concept of energy and resource efficient building and renovating. Social innovation will be addressed through community engagement in 'Green' practices (in the school environment, community involves students, teachers, and other visitors). EA is actively involved in the **Pallini** Learning City initiative related to sustainable food systems. **UNESCO Learning Cities**[22] promote green and healthy environments, strive to achieve equity and inclusion, and support decent work and entrepreneurship. They are therefore key drivers of local-level sustainability in both urban and rural areas. 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.

[22] https://www.uil.unesco.org/en/learning-cities

- All the **innovative digital technology** that will be developed and used in this project has a strong market potential.
- **Promotion of district energy management** (**Focus 1**) through DR flexibility scheme. 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). Furthermore, the energy consumption at the school canteens and restaurants is a significant parameter for the overall performance of the school building. The canteen is considered the Energy Hot Spot of the facility as it can consume up to 5 times the energy of the whole school per m^2. So, achieving Zero-Energy in a Restaurant is considered a major challenge. A holistic energy solution must be implemented to reduce the energy consumption of the school kitchen operation. For this reason, one of the key demonstrations of the NEB-LAB project will be the design (Systems thinking and integrative design are paramount), the construction and the operation of the Zero-Energy EA School Canteen. It must be noted that improving the Efficiency before the use of renewable energy supply is most cost effective in the process. Based on the techniques and methods that will be designed and implemented by the Chamber of Quality, NEB-LAB will deliver a pilot demonstration Zero-Energy restaurant to act as a "learning lab" to test and validate new technologies. Then this model can be adopted from numerous schools as the implemented **solutions will be scalable** to other school buildings.

- The overall design of the project was done **with respect to the environment, preservation of the existing building and with particular interest in the landscaping of the exterior spaces** (**Focus 5**) with extensive planting, with the aim of better inclusion into the local community. The overall design is based on three key principles: Ecology - Use of natural materials both in the indoor and outdoor spaces, Aesthetics - a wide choice of textures, shapes and hues, and Sustainability – economical and long-lasting solutions. Numerous Eco-friendly materials used in the surrounding area: Robinia (pseudoacacia) square blocks paving in the courtyard of total surface area $420m^2$, which are particularly environmentally friendly and resistant and Stabilized Ceramic floor, from ecological and bioclimatic material, that is water permeable and in case of rain it could absorb the rainwater. The final surface is ceramic – earthen, "tied" but also relaxing for the pedestrian.

STEP 2. Set up a "Core Team", form and engage a "Community" in learning-action
Initial goals and allocated resources (+ first opportunities for learning-action to Sustainability Citizenship)

EA envisions the development of a learning ecology focusing on the energy efficient operation of the whole school. Such a vision requires from all stakeholders to think beyond the bounds of their institutions to consider how collective action at the level of networks can provide opportunities and address inequalities in a way that more isolated efforts cannot. In the framework of the EA pilots projects, Learning ecologies are the contexts—the physical settings, social interactions, value systems and histories—in which students, teachers, school staff and parents learn over time, both daily and during the lifespan. This means that a robust learning ecology contains a wide variety of educational activities and opportunities, across a range of places beyond classrooms, like the school canteen, allowing teachers different and multiple ways to engage students with environmental issues. Even more, this framework encourages individuals to take increasing levels of ownership over their own training as they gain more experience. Nonetheless, such connected learning ecosystem needs to be established and coordinated. It requires the cooperation and connection of collaborative partnerships, consisting of formal, non-formal and informal learning providers and stakeholders that can act as a key factor to optimise training opportunities across a range of institutions and organisations.

In this framework EA has established the following team to design and implement the two pilot projects for NEB-LAB:

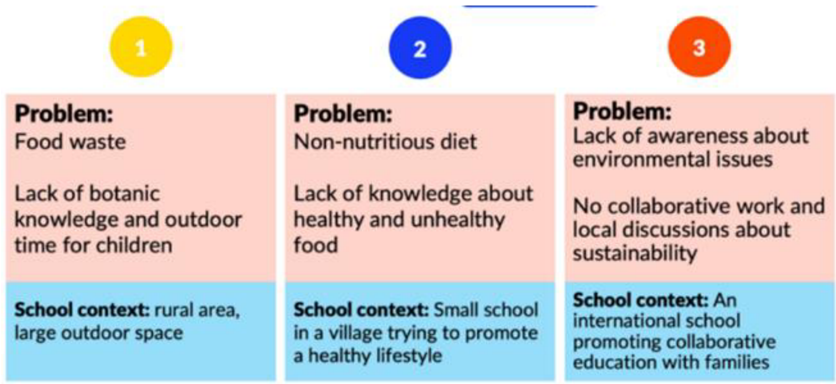
- **Nikolaos Zygouritsas**, Researcher (Coordinator of the NEB-LAB Pilots)
- **Olympia Befa**, School Vice-Head (Responsible for the integration of innovations in school curriculum)
- **Katerina Riviou**, Researcher (Responsible for the Green Canteen project and related initiatives)

- **Dr. Lukas Katikas**, Researcher (Responsible for the Nature Based Solutions initiative)
- **Thalia Tsaknia**, Researcher (Curriculum Developer and Instructional Designer, Responsible for Climademy (https://climademy.eu/), a teachers' training academy for environmental education).
- **Elena Kyriazi**, Architect Engineer, Responsible for the construction of our new school building and the Green Canteen
- **Lazaros Kelesidis**, Civil Engineer, Responsible for the operation and the maintenance of the school infrastructure. He is coordinating the solar farm installation.
- **Pavlos Koulouris**, Researcher (Responsible for the Schools as Living Labs Initiative (https://www.schoolsaslivinglabs.eu/), Expert in co-design processes and mechanisms)
- **Vassilis Liakopoulos**, Researcher (Coordinator of the Schools as Living Labs schools network)
- **Dr. Sofoklis A. Sotiriou**, Head of Research and Development Department and the EA Teachers Training Center, Expert in the school innovation and in instructional design.

STEP 3. Document and explore the initial situation (for start documentation, indicators of Current Performance, first observations)

With your Core Team think how you will engage/support your community in combining skills-experiences-talents towards a more environmentally friendly School Infrastructure.

To engage the user communities EA is using the Living Lab approach. A Living Lab is a collaboration between various actors from the public or private sectors, and users, that has a common aim to provide solution to a challenge or a problem. For instance, in the NEB-LAB Living Lab Green Canteen project, the partnership includes students, teachers, parents, the canteen staff, the school technical team, food systems experts and curriculum developers. To broaden the collaboration, Living Lab school projects may also involve other local actors like a company, policymakers, local restaurant owner, local farmer. This approach is aligned with the Open Schooling concept, which wants schools to become agents of community well-being by creating new partnerships in their local communities.



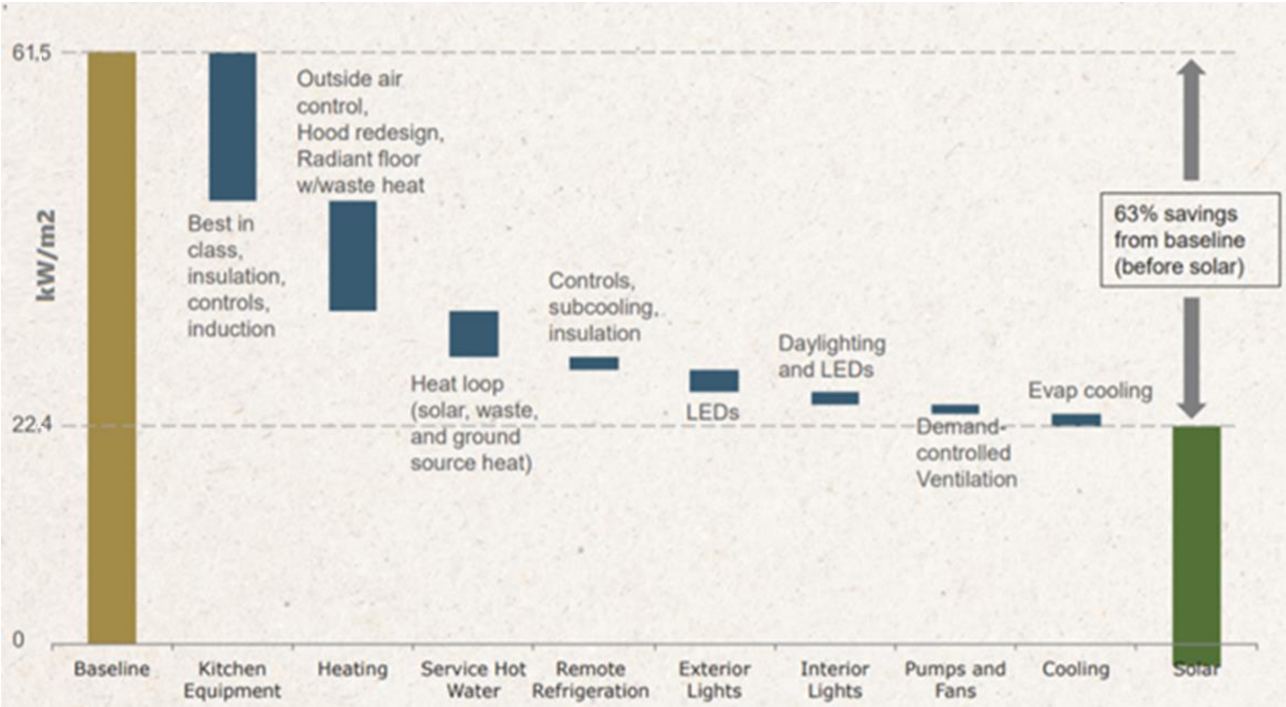
In EA school curriculum the development of healthier habits is a major priority. Students are involved in numerous projects and activities that are aiming to fight obesity and to help students realize the importance of the development sustainable food systems. The implementation of the activities is based on the Living Lab Methodology.

The Living Lab methodology uses design cycles to facilitate the engagement of all stakeholders: Creating ideas together after exploring the issue, building some elements of the solution, which can be done fast and economically (often referred to as 'prototyping'), testing the solution with users and getting feedback to improve it. To start a Living Lab school project, one needs to create the foundational elements that will shape the project's constraints, possibilities, and assets. These elements include: 1. Exploring the theme, 2. Building a partnership, 3. Trying concrete, even if temporary solutions 4. Setting up the assessment framework. This process is used at all levels of the project.

EA team plans to integrate the two pilot projects in the educational programme of the school. To do so, with the support of the Chamber of Quality, a series of testing activities will be designed and implemented (see Deliverable D3.1) to introduce the energy efficient operation of the school canteen and of the school building to the school curriculum.

STEP 4. Co-design a Climate Neutral renovation Green Action Plan (opportunities of the use case to achieve a more environmentally friendly School Infrastructure, by circular, self-sufficient energy step by step improvement)

As discussed before, the energy consumption at the school canteens and restaurants is a significant parameter for the overall performance of the building. The Canteen operates continuously for many hours, it is exposed to the weather conditions while there is a need for simultaneous operation of cooking, heating, freezing and dishwashing infrastructure. Achieving Zero-Energy in a canteen is considered a major challenge for the whole school community, and this considered as the starting point for the first EA pilot project. A holistic energy solution, combined with significant changes to the attitude of the users of the canteen, must be implemented to reduce the energy consumption and the of the school canteen operation. In this framework, the Green Canteen project in EA is **bringing all together:** To meet the challenge of a Zero-Energy School Canteen, EA employs **both technical solutions** (bioclimatic, architecture, Insulation, High Performance Windows and Controls, Heat loop, Airtightness, lighting based on LED and daylighting and advanced HVAC design) **and pedagogical approaches** based on inquiry learning, problem solving and critical thinking techniques and data analysis and reflection that will introduce a change culture in the school and will facilitate a significant increase on users interest and motivation towards environmental and climate change issues.

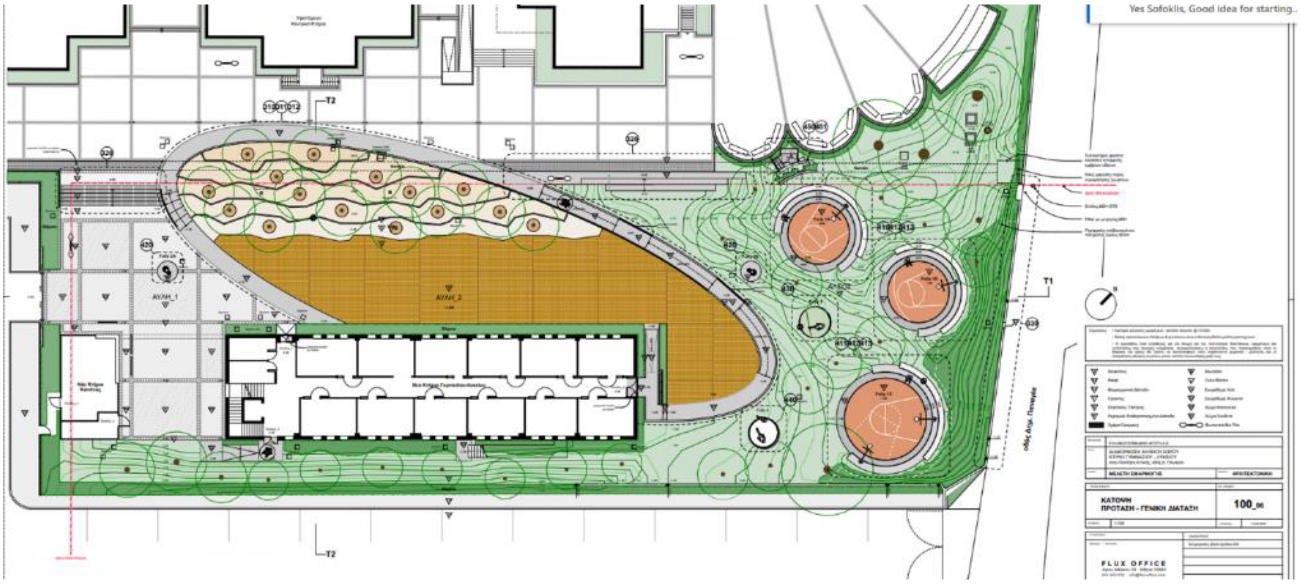


Refrigeration, cooking, serving, dishwashing, lighting, heating and air conditioning, washing and drying, and hot water could all be modelled. The models will be based on average consumption and qualitative surveys of the school canteen. Next, average potential GHG savings will be determined, extrapolated to one year, and then translated into specific measures. It is expected that these design options will reduce 63% the operational energy consumption of the canteen, while the remaining 37% **will be produced from the solar park**. The fact is thought is to set a challenge to the users by determining where further GHG savings could be made and developing measures that the school canteen could take, for example potential savings in the recipes could be determined using ceteris paribus analyses, using organic food, using local products, and adapting a climate-friendly menu. The values for the actual menus were calculated and then the calculations were carried out on selected variations in the composition of the dishes. To identify potential savings in food processes, these processes could be modelled based on the energy measurements. At this point the contribution of the Chamber of Quality is necessary for the development and use of innovative digital solutions for energy monitoring, analytics, and recommendations platform. Additionally**,** smart, Covid-compliant air purification systems for a safer environment, and upscaled BMS for energy management could be proposed and integrated to the overall design.

STEP 5. Make a first limited scale scalable proof of concept (opportunities of the use case to make a first demonstration and extend this to the surrounding space)

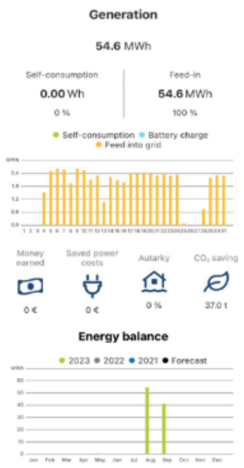
With your Core Team think how the chosen limited space will become a a local hub that will further transform the whole school in different dimensions, involving the school's community and the neighborhood at 3 generations, with support of decision makers, institutions and skills sponsors.

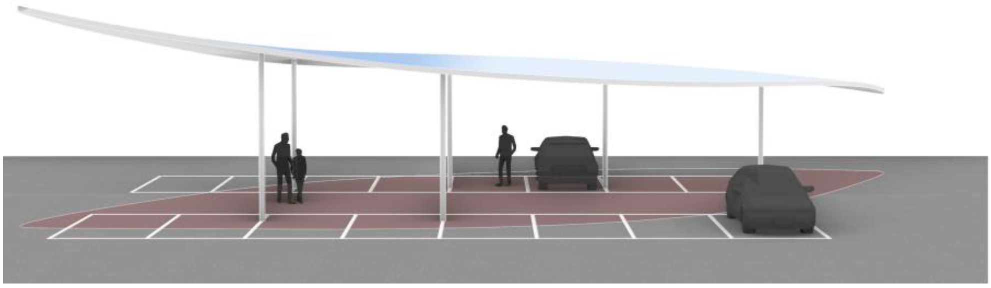
The new canteen building to is in the central school campus plaza which is bridged over to interconnect the primary and secondary school buildings. The bioclimatic canteen building is part of the school strategy towards the transformation of food systems that require low-carbon, circular and planted 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. An advanced food waste management system is also integrated to demonstrate the full food chain process.



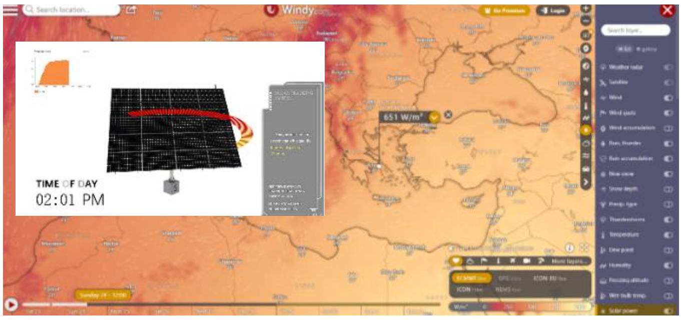
The new canteen building to is in the central school campus plaza which is bridged over to interconnect the primary and secondary school buildings. The canteen is used from the high school staff (about 150 people) and the high school students (about 600 people). The canteen is also open in the afternoon/evening and the weekends when there are specific events, info days, parents meetings and observation nights. 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. An advanced food waste management system is also integrated to demonstrate the full food chain process.

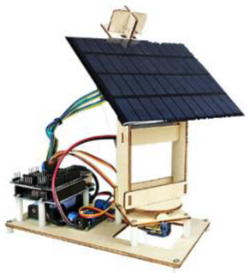
The concept of **solar parking lots** aims at coupling the development of clean solar electricity and electric mobility. Solar panels provide shade and generate electricity to charge parked electric vehicles. In a vehicle-to-grid approach, the vehicles may also feed the grid and support it with ancillary services. Large parking lots offer a chance to charge EV fleets in an optimized way. In the case of solar carports, this approach means that the charging is adjusted dynamically according to solar electricity production and the vehicles' needs. Additionally, it is possible to respond to price signals from the electricity spot market. The adjustment may be for the entire fleet or for each vehicle individually. Electric cars are parked most of the time during the day and, due to their batteries, they represent energy storage systems. Therefore, in a network that allows bidirectional energy fluxes, they can act as a new player providing services to the power grid.

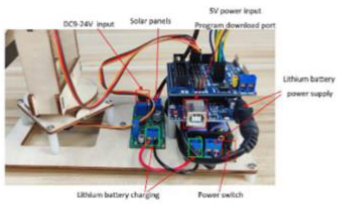




In this way **social innovation** will be addressed through community engagement in 'Green' practices (in the school environment, community involves students, teachers, and other visitors). Through the construction of the solar car park and the use of ICT energy management solutions it is anticipated to create a link to the **energy value chain for integrating with smart energy grids** by including electricity distribution network operator (HEDNO).

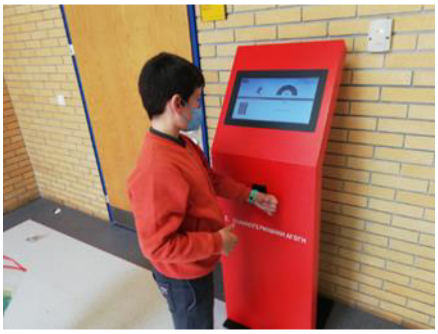






At the same time the operation of the solar park is offering unique opportunities for the **design of innovative educational activities**. For example, using interactive energy dashboards, students can experience the energy-efficient features and the varying conditions of season and weather. The dashboard gives students a synergistic view of how the pilot site operates as an integrated system of which they are an essential component. Another example could be the development of a portal to the inner workings of their school creates pride and a sense of collective responsibility for their environment. Furthermore, students can design systems that could increase the efficiency of the installation, for example moving panels that are programmed to follow the path of the sun on daily basis. After understanding the why and how of zero-energy, and the uniqueness of their school students are more likely to engage in other green initiatives.

Additional Focus Areas: Food Health and Wellbeing



Currently there are numerous activities that are focusing on the importance of the sustainable food systems and on the development of healthier food habits of the students. For example, numerous interactive screens are in the school building, offering students the chance to visualize the number of steps they are walking in a specific time period. Another example is the BigO (https://bigoprogram.eu) that is focusing on students (9 – 18 years). Students are becoming citizen scientists by collecting data on their behaviours and living environment using the myBigO app on a smartphone or smartwatch. In this way, students can experience what it is like to be a scientist and collect data, in an educational and fun way. Not only is it personally interesting, but with the information gathered, citizen scientists also help future generations of children by helping to find answers to the question of how living environments across Europe can be made healthier. Participating in BigO teaches children to observe their behaviour within the bigger picture of their environment, allowing them to become aware of different health behaviours, and the effect of their surroundings on these behaviours.

Additional Focus Areas: Waste Reduction and Circular Economy

EA encourages waste-free lunches by cutting down on food packaging, single-use and disposable items. For students that are bringing their own lunches it is recommended to bring them in reusable snack boxes and eliminate plastic bottles and cartons going in the bin with reusable water bottles. Students are encouraged to prevent using excessive packaging such as foil-wrapped sandwiches and cling film wrapped fruit, if possible, too. The school has also installed numerous water fountains to avoid pupils having to bring in plastic drink's bottles.

Apart from food waste related initiatives there are further actions in place in EA. Some examples include a) Minimize paper waste by make double-sided photocopies/printing where possible, b) print only when necessary, c) school administration keeps electronic copies of files instead of printing everything out and sends out email newsletters or notes to parents rather than printed ones.

School is giving every class its own set of waste and recycling bins can help encourage everyone to recycle more, making it easier by making it a simple task. Having clearly labelled bins throughout the school is a simple way to encourage children and adults to follow a whole school recycling program and dispose of their rubbish correctly.

Additional Focus Areas: Transportation to the Building

When it comes to sustainable practices, transportation to the school building is an area that demands attention. Integrating sustainable transport in school guidelines not only reduces carbon emissions but also fosters a sense of environmental responsibility among students. Sustainable transport encompasses a variety of methods that prioritize the environmental impact of transportation. By encouraging eco-friendly alternatives in the school environment, we can significantly reduce greenhouse gas emissions, improve air quality, and alleviate traffic congestion. In fact transportation is related with both EA proposed pilots (solar farm and green canteen) as a) EA plans in the near future to replace its current fleet with EVs (about 150 school busses) and b) the physical activity is encouraged. There are numerous benefits:

- **Reduced carbon footprint:** Sustainable transport reduces carbon emissions, contributing to global efforts to combat climate change.
- **Healthier environment:** By reducing pollution levels, we can improve air quality, ultimately leading to better health and quality of life for students, teachers, and the community.
- **Improved student well-being:** Promoting sustainable transport options encourages physical activity among students, enhancing their overall well-being.
- **Teaching environmental values:** By integrating sustainable transport in school guidelines, we provide students with valuable lessons on environmental conservation and responsibility.
- **Enhanced community engagement:** Implementing sustainable transport practices within schools fosters community involvement and engagement, as local authorities and organizations often support such initiatives.

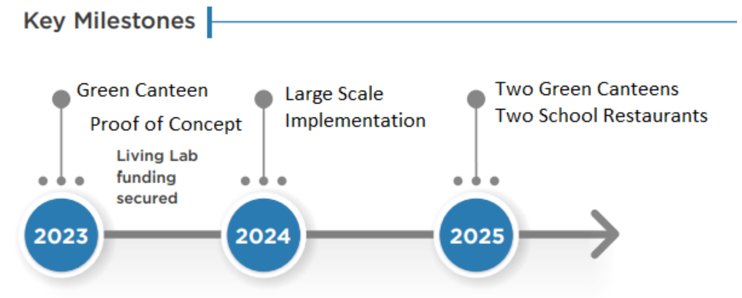
Key Strategies for Integrating Sustainable Transport

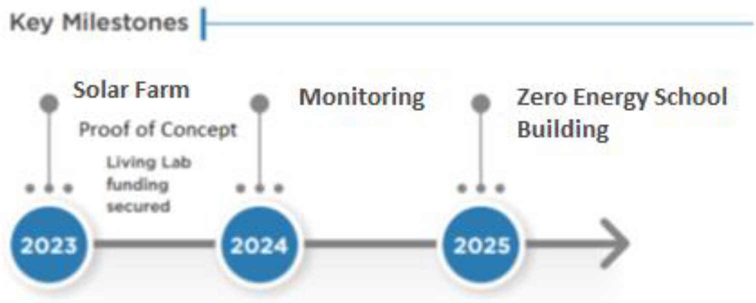
Integrating sustainable transport practices in school guidelines requires a well-thought-out approach. Here are some key strategies to effectively implement greener transportation methods:

- **Promote Active Modes of Transport:** Encourage students to utilize active modes of transport, such as walking or cycling, for daily commutes. By providing safe walking and cycling paths, schools can incentivize students to opt for these eco-friendly alternatives. Research shows that children who cycle or walk to school show improved concentration and physical fitness.
- **Develop Carpooling Initiatives:** Organize carpooling initiatives for students, where parents and guardians can come together to create shared transportation arrangements. Carpooling not only reduces traffic congestion around schools but contributes to lower fuel consumption and emissions, benefiting both the environment and families.
- **Integrate Public Transport Accessibility:** Collaborate with local transport authorities and ensure that schools are conveniently accessible by public transport. This encourages students and staff to utilize buses or trains instead of private vehicles, reducing carbon emissions and traffic congestion. By advocating for improved public transport connections, schools play a vital role in sustainable urban planning.
- **Implement Eco-Friendly School Bus Policies:** For schools that rely on bus transportation, implementing eco-friendly policies can play a significant role in reducing environmental impact. Consider investing in fuel-efficient buses, adopting renewable energy sources for bus fleets, or optimizing routes to minimize travel time and fuel consumption.

Expected Outcomes and Time Plan (Preparing STEP 6)

The time plan for the implementation of the two proposed interventions is presented graphically in the next Figures. In both cases it includes the design and implementation of a proof-of-concept experiment during the first pilot phase (in parallel with the Testing Activities proposed by the Chamber of Quality, WP3), monitoring and impact assessment with the tools provided by WP5 and based on the lessons learnt and the findings scaling up to further deployments.





Monitoring and Reporting – Action Plan KPIs (STEP 6)

Technical KPIs – Towards a Zero Energy School Campus

Site (surface)	Current Consumption (kWh/year)	Future Production (kWh/year)	Energy Reduction (kWh/year)	Average Energy Consumption After Retrofitting (kWh/m²year)	Directive 2010/31/EU for retrofitted / positive-energy level buildings for new constructions[23]
EA – Campus (15.807m²)	1.800.000		540.000 (Heat Pumps, IoT)	79	A+ (75-90kWh/m²year)
EA - Solar Park (5.000m²)		1.800.000		-113,87	Zero Energy
EA – School Canteen (New)	-	6.720	-	0 (New)	Zero Energy

Pedagogical KPIs – Teaching for Sustainability Citizenship

Here are the variables that can be assessed through the measurement tool:

- We expect **medium-sized** improvements in the students' **attitude** (attitude toward nature and environmental attitude) scores
  - The students will improve their **attitude toward nature**. We expect a medium effect.
  - There will be positive changes in **environmental attitude**, presuming a large effect size.

[23] https://ec.europa.eu/energy/topics/energy-efficiency/energy-efficient-buildings/nearly-zero-energy-buildings_en#national-plans

- Students will change their **Psychological Distance** scores on a medium level, as sustainability issues will be felt more relevant and closer to their lives.
    - Students will mostly improve on their **temporal/geographical/social/hypothetical Psychological Distance** scores.
    - Students will improve their overall **salutogenesis** scores by small effects.
    - Students will improve their **self-efficacy** scores moderately.
    - Students will strengthen their **connectedness to nature** by small effect sizes.
    - Through strong study participant engagement, they are expected to improve their **locus of control** scores by at least *small* effect sizes.
- The study participants will decrease their **ecological footprint** scores.
    - The ecological footprint scores will mostly improve in the food/ electricity/ other good consumption/ transportation domain.
- If knowledge is assessed: The study participants will increase their **environmental knowledge** scores. We expect large effect sizes.
    - The study participants will increase their **system knowledge** scores. We expect large-sized improvements.
    - The study participants will moderately gain **action knowledge** and **effectiveness knowledge**.

Organisation's Openness – Creating an Open Learning Environment

The following Table highlights the key areas where highest impact is expected. EA is performing the self-reflection assessment on an annual basis and as it is already considered and advanced open schooling environment a small increase could be expected in the specific key areas.

	Management Level	Process Level	Teacher's Professional Development Level
1	Vision and Strategy	School Leaders and Teachers Shaping Learning Systems	Teacher Awareness and Participation
2	Coherence of Policies	Creating an inclusive environment	Setting Expectations
3	Shared Vision and Understanding	Collaborative environments and tools (co-creation, sharing)	Professional Culture
4	Education as a Learning System	Implementing Projects	Professional Competences, Capacity Building and Autonomy
5	Responsible Research, Reflective Practice and Inquiry	Parents and external stakeholders' involvement in organisation's activities/projects	Leadership Competence
6	Motivation Mechanisms	Reflect, Monitor, Debate	Collaborative learning (mobility actions)
7	Plans for Staff Competences	Learning Processes adaptation	Collaborative learning (ICT Competences)
8	Communication and Feedback Mechanism	Established collaboration with local, national institutions	Use and reuse of resources

Organisations involved

EA: Building and infrastructure, Green School Living Lab, BURO HAPPOLD: Building Simulation and Participatory Design, Social Value; TEKEM: Consulting engineers, 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.

6.2 Microville 112 : Eco^2-Campus Microville Durable

<table>
<tr><td rowspan="5">
</td><td>Eco^2-Campus M112</td><td>Courcy (Greater Reims), France</td></tr>
<tr><td colspan="2">Sector: educational third place, 3 generations, worksite school</td></tr>
<tr><td colspan="2">District buildings portfolio: Educational third places</td></tr>
<tr><td colspan="2">Target groups: Neighbourhoods-villages, multi-stakeholders community involved by learning-action on Microville 112, supportive institutions</td></tr>
<tr><td colspan="2">Link: https://www.microville112.org</td></tr>
</table>

STEP 1. Vision, Mission and Goals

The "core team" of ECO^2-Campus Microville Durable® on Microville 112 (in Courcy, Greater Reims FR) is leading, with a multi stakeholders open community, the forward looking project to renovate the former military air base 112 into a Sustainable Microcity®, a climate-neutral half-hour territory of proximities.
Patiently prepared since 2018 with the village of Courcy (municipal team and collective of residents, local stakeholders, laboratory schools and a diversity of external support partners), the project has been operational since December 2021 via a dedicated land SCIC Microville 112 (cooperative society of collective interest). www.microville112.org .
This cooperative society with a mission aims to create a living space that generates value through continuous improvement at the scale of the project, the villages and the surrounding territory;
- eco-renovate buildings, infrastructures and natural spaces (~40 buildings, 55,000 m^2, 65 ha),
- install new activities, visitors-users, Climate Neutral infrastructures and services,
- co-produce sustainable quality in open cooperation via the Chamber of Quality, a "conversations" system, "challenges" and a Microville Durable® "living lab".
- The spaces are sold to lessees-investors in the form of a long-term lease, without transfer of land, the proceeds from sales are 100% reinvested in the renovation of the site, common equipment, and services (logic of autonomy, circularity and sharing of value in continuous improvement).
The project is being built more broadly across the entire former military air base 112, via a Free Union Association as a place of partnership with neighbouring municipalities and www.terrasolis.fr (bioeconomy innovation hub, cinematographic creation).
We are installing there in open co-production, a Sustainable City living lab (nourished by a "Quality Chamber", thematic conversations, challenges and tests-experiments) where everyone can co-learn to act within a community. An advisory board and a cooperative budget make it possible to support, consolidate and scale up in a network the best existing methods-tools-initiatives-solutions, in France and throughout Europe. At the heart of the urban project will be a New European Bauhaus cultural center and an ECO^2-Campus Microville Durable®, one of the 5 pilot sites of the project. https://eco2-schools.eu/eco%c2%b2campus-microville-durable-france/
It is a third educational place and worksite school (learning-action living lab) open to a network of neighbourhoods/villages in transition, which will extend to the whole former military airbase site BA112 and the surrounding villages, then the Greater Reims area of proximity 15-30 minutes away. This territorial scale is the main goal of the ECO^2-Campus as a climate-cultural cross border hub (learn, test, consolidate, upscale) for this systemic changemaking process within the New European Bauhaus, beautiful | sustainable | together.

STEP 1a. A first intention and Integrated Approach (commitment to start a Climate Neutral renovation project)

Motivating the School Community to Rise Up against Climate Change – Planning
The planned intervention on ECO^2-Campus Microville112 is a systemic Climate neutral renovation project that will be implemented in two phases:

Phase 1) Transitional Occupation: Build a multi stakeholders' commitment as a community (start to do thing together with 4 test-activities), codesign and learn by doing together a "for Climate Neutral renovation Green action plan".
Phase 2) Lighthouse demonstrative renovation project: a real-scale worksite-school, scalable proof of concept for renovation of a neighbourhood with ~40 buildings/65ha.

The past military educational building will be reactivated as an Eco²-Campus Microville Durable®, heart of the living lab Microville112 open to the Reims region, schools, neighbourhoods/villages in France and in the European Union (EU).
This will involve and train educators, students (a diversity of schools), inhabitants (association Collectif Citoyen Agora M112), craftsmen (apprentices that will become young professionals), experienced professionals (facilitators-designers, skills sponsors), experts and researchers (challenging the combination of best existing initiatives-solutions), public-private supports (public authorities, foundations, sponsors).

- **The project is advised with a local "Chamber of Quality" for Microville112** (advisory board to be started in February 2024, with ~10 complementary skills independent experts), that will provide common learning-action and will support the co-design and challenge the implementation of the project, advise continue improvement with a clear forward-looking concept. +50 persons coming from different institutions will be associated for following the common learnings and experimentation being part of the ECO²-Campus founding association.
- **Local and national institutions are invited to participate in a cooperative budget for co-owning and co-developing the ECO²-Campus** experimental program, common infrastructures and services (15-30' territory of proximity living lab, cross border hub for Climate neutral renovation learning-action).

STEP 1b. Key Focus Areas and opportunities for learning-action by experimentation
Referring to Eco² Schools as New European Bauhaus Labs 5 thematic focuses:
Focus 1- Solutions for retrofitting schools in series,
Focus 2- Multifunctional, open for the neighbourhood,
Focus 3- Other configurations for co-learning better,
Focus 4- A community engaged in the eco-transition,
Focus 5- Restore a cycle with nature-permaculture.

Estimating the ecological footprint of the building and of the overall operation
The ECO²-Campus project is willing to start with a committed community a dedicated space for empowering common learning-action, at the scale of Microville 112 (5 minutes neighbourhood), the former military airbase site BA112 and surrounding villages (15 minutes city), the Greater Reims area (30 minutes territory). This will be also step by step opened to a community of researchers (R&D departments, University Chairs) as visiting associations, families, schools and institutions (Climate neutral renovation immersion worksite school, training, partnerships with other territories / schools, neighbourhoods, villages, networks).
This is meaning that the 2 existing to be renovated buildings ("T2" and "Maître Ouvrier") will need to be augmented, by adding a newbuild extension (a 2 storeys multifunctional bamboo greenhouse, that will link together the 2 existing buildings and offer an extended roof capacity for renewables in self consumption). This will perspective is offering from the beginning the opportunity of a "worksite school" that will involve citizens, students, trainees, young professionals being actively involved in building the learning-action infrastructure and services. This worksite school process will be further implemented in the wider area of Microville 112 neighbourhood renovation project, with different places offering a wide panel of opportunities for learning-action.

From the beginning, the transitional occupation of the T2 building is part of the implementation of the 5 focuse areas of NEB-LAB.

Focus 1- Solutions for retrofitting schools in series:

The Core Team is bringing a first circle community (citizens from AGORA M112, trainees and educators from AFPA, ...) in documenting and exploring the potential to reactivate the existing buildings (T2 + Maître Ouvrier) with a reduced energy consumption approach and with renewables energy in self-consumption.

Main opportunity is to replace by the autumn 2024 the outdated oil heating by a solar hybrid thermal and photovoltaic energy system:

- reuse of the existing heat distribution network with low temperature water,
- installation of daylight hybrid heat/electricity solar panels on the roof (https://honeworld.com/eng/product/) and direct plug in PV on façades (https://sunology.eu , https://www.sunity.fr/), that will produce energy for self consumption in the 2 buildings,
- possibly installation of a light weight removable wind turbine (https://kitex.tech/ , https://uneole.fr/),
- storage of heat/cold energy day/night (using the inertial capacity of the network itself, heat tanks in the cellars near the exchanger/circulator system) and week/month, inter-seasons storage of heat (using a high capacity watertank, possibly a recycled concrete mass heat battery, ex. https://jenni.ch/swiss-solartank-fr.html , https://polarnightenergy.fi/sand-battery) and cold (using an insulated iced water mass storage),
- combination of different equipment that will store the electricity day/night, using plug in recharge for electric vehicles and possibly an innovative decentralized high speed rotating concrete cylinder battery (https://www.energiestro.fr/ , https://www.stornetic.com/),
- reuse of fatal heat from a micro data center for local purposes in Microville112 (https://www.immersion4.com/). This equipment can be used in particular to increase the solar panels temperature (in winter), allow the production of cold with high temperature (https://www.soundenergy.nl/our-technology/) and excess heat storage in a mass storage (in summer).
- Installation of a network of sensor that will offer a capacity to track the performance real time as on daily/weekly/monthly/yearly base. The sensors will offer opportunity to teach how the installation works and be part of the learning-action environment.
- The community could be step by step associated to the installation, understanding of the operation and basic maintenance of the installation, as develop communication materials on the ECO²-Campus and Microville112 (signalisation, explanation panels, digital content that will be published on the permanent documentation portal and website).
- In the Summer 2024, intention is to extend the worksite school with AFPA on “Maître Ouvrier building” (MO), including replacement of the very old windows (single glass, not wind proof) and external insulation (with hempcrete projection). Depending of the need, this biosourced insulation could also be used under the roof (before solar energy will be installed).

Focus 2- Multifunctional, open for the neighbourhood:

First occupation of the T2 and MO two buildings opens many perspectives for common co-design and testing of multifunctional uses, in a central location wide open for the neighbourhood (visitors, users, educative community, citizens, companies, researchers, local associations, institutions...).

The ECO²-Campus will include from the beginning a “Work Room”, a “permanent documentation space of the project”, “classrooms-workshops”, a common “multi-purposes exhibition room”, a “common courtyard and garden” for outdoor class and test activities (including sciences, biodiversity and food, proximity cultural placemaking, art).

Focus 3- Other configurations for co-learning better:

Three complementary spaces will offer a direct opportunity for testing other configurations.

- The “permanent documentation space of the project" will be equipped with on 1 wall a “Fresk Renaissance Ecologique, 15-30 minutes territory of proximities”, where groups of visitors will be invited to share their ideas and opportunities for common initiatives with completing personas, shared resources and stakeholders mapping (this living material will be saved in digital format and reused in different tools and co-design workshops).
- The opposite wall will give a view of the past history, present activities and projects under development for the future.

- The third wall will be used for video-projection of an introductory film, presentations, a living guide-plan of the project that will bring together all ongoing initiatives and transformations.
- In the centre of the room, a 3d model of Microville 112, with an interactive projection of different information, as lifestyles and consumptions in different time of uses and seasons.
- A digital portal will offer access to this permanent documentation to all users and visitors, even when not present in the place.

Focus 4- A community engaged:

The ECO²-Campus is the start point for building a multi-stakeholders community, with citizens (AGORA M112), the municipality, SCIC Microville 112, educators, students-trainees-apprentices, families, users-occupants, researchers, supportive professionals, public and private institutions.

- The process is being driven with co-design workshops (4 co-design workshops in 2023) and thematic work sessions, that organize on the ground learning-action that brings the stakeholders to become active contributors of the project (commitment through test-activities), live common conversations and challenging experimentations.
- The aim is to welcome students and educators as active ambassadors linking with follower schools in the Greater Reims/Champagne-Ardenne region (test-involvement with ~8 duos teacher + eco-delegate student). This will become possible begin 2024 with active involvement of the Rectorate of the Academy/ LAB 17bis Reims.
- A partnership is agreed with FEE Eco-Schools relating to the Green Schools program of the UN (Sustainable Development Goals). The ECO²-Campus is willing to implement with visiting schools the FEE Eco-Campus process (Green Flag).
- As with Renaissance Ecologique (www.renaissanceecologique.org) and Chaire ETI La Sorbone in order to implement a for Schools adapted version of the Fresk "24 transformation projects of the ecological renaissance", "15-30 minutes territory of proximities" (space for permanent cooperative documentation of the School renovation project).
- The "Chamber of Quality" of the program Microville Durable® will also associate a circle of ~100 persons from institutions of the Greater Reims region in following the Living Lab Microville112. The ECO²-Campus association will be the central place for common meetings, learning and initiatives, with a common program and cooperative budget.

Focus 5- Restore a cycle with nature-permaculture:

The ECO²-Campus is located in direct contact with Nature that has regained its place the past 8 years after the Military Airbase closure. The community is willing to use the central courtyard and surrounding green area for making a systemic demonstration of a Climate neutral adaptation plantations and biodiversity restoration strategy.

- Renovation as a Green Schoolyard for outdoor learning-action.
- Saving of the young trees and hedges plants with a temporary preservation nursery for the plantations on Microville 112.
- Starting a permaculture training facility, with a demonstrator of food agro forestry and a conservation vegetable/medicine plants garden. This permaculture garden will be a start point for healthy-tasty food cooking, with using the energy of the sun and green waste biogas.
- Test of a bamboo plantation that will have a triple role (bio-climatization of the sun exposed façades, purification of gray waters + air quality, CO^2 capture + local carbon neutral bio sourced material).
- The community is willing to build in the summer 2024 a demonstrator of bamboo solar canopy, for learning-action on the carbon neutral adapted renovation strategy. This test activity will be consolidated for replication by follower schools. Idea also is to build in 2025 a first demo section of the Bamboo Greenhouse extension, as a students/young professionals challenge summer "worksite school".

STEP 2. Set up a "Core Team", form and engage a "Community" in learning-action

Initial goals and allocated resources (+ first opportunities for learning-action to Sustainability Citizenship)

Focus on the key competencies related with the Sustainability Citizenship

From December 2023 until April 2024, the Transitional Occupation is started with the Citizens association AGORA M112 and Municipal Council (Martine JOLLY, Mayor of Courcy and Jean-Pierre BARRE, first deputy mayor). **A first worksite school partnership is started with AFPA** (National Agency for Adult Vocational

Training); that will start a first 3-month training with 12 adults on the renovation Maître Ouvrier building (MO), which will be reactivated as a New European Bauhaus Cultural Center.
This "Core Team" with support of 2 persons of Alliance Sens & Economie, will start involvement of the local community in documenting-exploring the 2 buildings initial situation (T2- ECO²-Campus and MO- NEB Cultural Center). **A "Project Room", "Meeting and advisory Room", "Exhibition Space" and rooms for "Class-workshops" will be set up and occupied with first learning-action activities.**
Targets to be completed for this start are:

- **With the association AGORA M112, start the Core Team supportive management of the project**, organize a weekly base presence for using the ECO²-Campus (T2 building), manage first visible initiatives that will be invitation for a larger involvement in the starting community (by learning-action), build a continue reportage by involving citizens, families, schools and professionals.
- **With 2 co-design workshops, build a common commitment of multi-stakeholders local community** (in the T2 ECO²-Campus building, document-explore the initial situation, identify first needed repairs, as change-making opportunities for Climate Neutral reactivation of the energy infrastructure (heat, cold, electricity, ventilation). As also first possible learning-action activities in relation with the building and surrounding green spaces (educational-cultural garden courtyard connecting the T2 and MO buildings).

STEP 3. Document and explore the initial situation (for start documentation, indicators of Current Performance, first observations)
With your Core Team think how you will engage/support your community in combining skills-experiences-talents towards a more environmentally friendly School Infrastructure.

The Core Team of ECO²-Campus Microville 112 is willing to start the Multistakeholders Community with the "Document and explore the initial situation" in the 2 buildings T2 and MO.

- With the Citizens association AGORA M112, the T2 building will be cleaned up and a documentation of each room equipment and needed reparations will be set up.
- 2 co-design workshops will be organised by the Core Team with support of CY Design School (Stéphanie HEMON, Test activity "Community building"), with as focus to map the for start activities, the needs, accessible resources, opportunities.
- Will is to start the first occupancy of the T2 building, with setting up the "Offsite school living base" (with showers, wc), the "Project Room (space for permanent documentation of the project), a "Meeting and advisory Room" (local Chamber of Quality), an "Exhibition Space" (that will be inaugurated with presentation of the EUROPAN17 and CY Design School students proposals for Microville112) and 4 first "Class-workshops" (for hosting the community activities, trainings, welcome of external visiting schools/educators-students).

STEP 4. Co-design a Climate Neutral renovation Green action plan (opportunities of your use case to achieve a more environmentally friendly School Infrastructure, by circular, self sufficient energy step by step improvement)

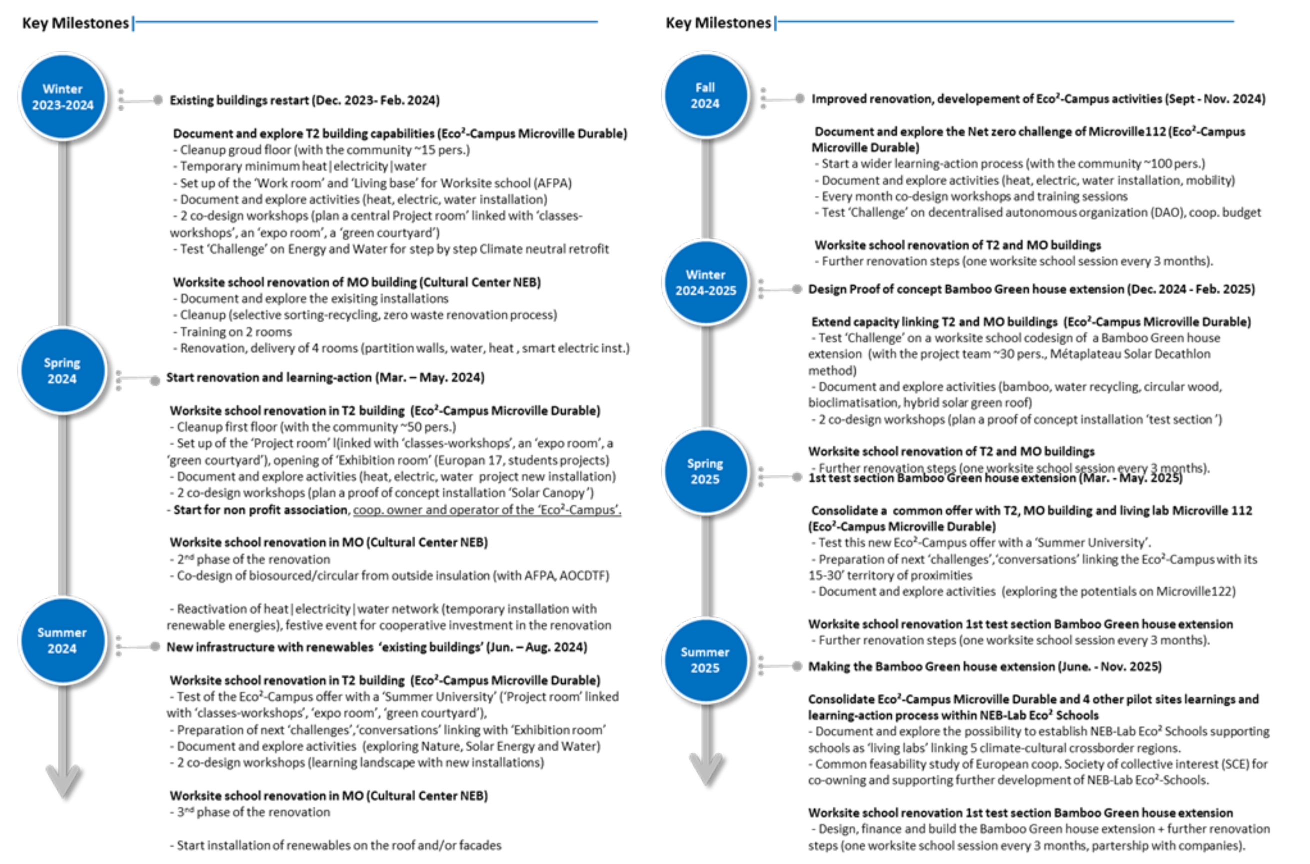
The Core Team of ECO²-Campus M112 is willing to drive with a demonstrative implementation on 2 first buildings T2 and MO, that will be a lighthouse signal for the start of the Climate neutral renovation process of Microville112 (as a neighbourhood, in connection with the surrounding villages that are part of the process). The will is also to associate to this co-design external "Follower schools" and institutional stakeholder concerned by the Climate neutral renovation of educational buildings (Schools).

- A series of co-design workshops,
- immersive activities and enlightening conversations, test activities (learning-action),
- a cooperative Challenge on "Energy and Water" innovative solutions that can be combined on this forward looking with a best sustainable value scalable approach,
- a "Worksite school" strategy for real/scalable implementation of the Climate neutral renovation action plan with students, young professionals.

This will be initiated with a common brief that will frame very clearly:

- what we want to do,
- where we want to go,
- how we want to achieve this goal,
- where are opportunities,

• changemaking bricks we want to combine and test in a positive sidestep posture, beautiful-sustainable-together.
STEP 5. Make a first limited scale scalable proof of concept (opportunities of your use case to make a first demonstration and extend this to the surrounding space) ***With your Core Team think how the chosen limited space will become a a local hub that will further transform the whole school in different dimensions, involving the schools community and the neighbourhood at 3 generations, with support of decision makers, institutions and skills sponsors.***
Intention of the Core Team is to make in 2025 a first demo section of a newbuild carbon neutral bamboo greenhouse newbuild extension that will consolidate the ECO²-Campus services and autonomy with renewable energy/water in circular use. The 2 existing buildings will be possibly interconnected with a large scale a Bamboo Extension 4 seasons Greenhouse. This to codesign newbuild carbon neutral construction will be full part of the "worksite school" process. This will offer possibilities to welcome a larger public with a totem building of the beautiful-sustainable-together renovation process, combining best efficiency bio sourced and smart circular technologies as: • Light construction that is raising the sustainable quality of the existing buildings, with renewables, negative carbon bio sourced, and circular upcycled materials (locally cultivated bamboo for structure) • Green roof with integrated natural ventilation and rainwater harvesting (with in the basement rainwater storage, grey water treatment with a bamboo filtering and a aquaponic basin), • Parietodynamic recycled window glass façade (low energy optimized facility, with sun protection using high efficiency daylight solar collectors producing heat/cold), • Coloured thin film solar PV envelope (lowest environmental footprint technology, with easy access maintenance, permeable to wind and rain, coloured patterns inspired by nature as by the cathedral of Reims). The co-design process will create numerous opportunities for collaboration with students, apprentices, teachers/trainers, experienced craftsmen and creative artists.
Additional Focus Areas: Health and Wellbeing
To be developped, following the co-design process (this will be filled in when the community is started in Jan. 2024). In partnership with: SCIC Santé bien-être (project on M112), La Fabrique Spinoza (Territoires Heureux), Société Française d'Ethnopharmacologie *https://www.fabriquespinoza.org/actus/territoires-heureux/ ;* *http://www.ethnopharmacologia.org/lassociation/les-objectifs-et-activites/*
Additional Focus Areas: Waste Reduction and Circular Economy
Sustainable Water Management, Comprehensive Solid Waste Management Intention, to be developped following the co-design process (this will be filled in when the community is started in Jan. 2024). In partnership with : CU du Grand Reims, Adopta. *https://www.adopta.fr/; https://www.grandreims.fr/services-aux-habitants/gestion-des-dechets; https://syvalom.fr/missions/*
Additional Focus Areas: Food, Landscape Heritage and Natural Resources
Intention, to be developped following the co-design process (this will be filled in when the community is started in Jan. 2024). In partnership with : Terrasolis, Parc naturel de la Montagne de Reims (Projet Alimentaire Territorial - PAT) and Office National des Forêts (ONF), Résilience Alimentaire (Les Greniers d'Abondance, RMT Alimentation Locale). *https://www.terrasolis.fr/terrasolis-farm ; https://www.parc-montagnedereims.fr/nos-actions/agriculture-et-alimentation/ ; https://www.onf.fr/ ; https://resiliencealimentaire.org/*
Additional Focus Areas: Transportation to the Building
Intention, to be developped following the co-design process (this will be filled in when the community is started in Jan. 2024). In partnership with : Fabrique des Mobilités (FAMOB Xtreme défi), Chaire ETI (Territoire des proximités 15-30'). *https://wiki.lafabriquedesmobilites.fr/wiki/Accueil ; https://xd.ademe.fr/approche-integrale ; https://chaire-eti.org/portes-de-paris/*
Expected Outcomes and Time Plan(Preparing STEP 5)



Monitoring and Reporting – Action Plan KPIs (preparing STEP 6)

Energy Savings, Efficient Use, and Alternative Technologies

ES-KPI 1. Measured waste = xxxx kg/m², % sorted and recycled

ES-KPI 2. Measured energy need Electricity = xxx kWh/m², % in self-consumption (target is to reach 100% with renewable installed)

ES-KPI 3. Measured energy need Heat = xxx kWh/m², % in self-consumption (target is to reach 100% with renewable installed)

ES-KPI 4. Measured energy need Cold = xxx kWh/m², % in self-consumption (target is to reach 100% with renewable installed)

ES-KPI 5. Measured water need = xxx m³/m², % in self-consumption (recycled water, reused rain water)

ES-KPI 6. Measured Renewables energy Electricity = xxx kWh/m², Electricity stored = xxx kWh per day summer and winter

ES-KPI 7. Measured Renewables energy Heat = xxx kWh/m², Heat stored = xxx kWh per day summer / winter

ES-KPI 8. Measured Renewables energy Cold = xxx kWh/m², Cold stored = xxx kWh per day summer / winter

Green Competence Framework

GC-KPI 1. Participation to the community (meetings, co-design workshops, conversations, challenges, events) = number of persons, % participants.

GC-KPI 2. Commitment in community learning-action (by taking responsibilities, active involvement) = number of persons, % participants.

GC-KPI 3. Transmission in the community (maintain, transmit and improve knowledge, skills, competences) = number of beneficiary persons.

GC-KPI 4. Gained knowledge, skills (with open badges peer to peer recognition) = number of open badges gained within the community (active members).

GC-KPI 5. Gained attitudes (assessment by the educative team using activities evaluation grid/ A1- Embodying sustainability values, A2- Embracing complexity in sustainability, A3- Envisioning sustainable futures, A4- Acting for sustainability) = total score gained within the community (active members).

> Work in progress (the first indicators, templates for monitoring and reporting will be set up (common approbation) with the start of the community's documentation and exploration of the existing building, January-March 2024).

Organisations involved
PARTNERS: AS&E, SCIC Microville112, a multi-stakeholders partnership that will be defined by the community's set up (December 2023-March 2024), with engagement of first contributors and sponsors (target is a public communication for April 2023, with a side-event involving the 5 pilot-sites during the NEB Festival). Intention of the Core Team is that the ECO^2-Campus will be at this moment supported with the creation of a for non-profit association, with a common cooperative budget (necessary to start the operation, develop common resources and initiatives, secure fundings for the "Worksite School" strategy and demonstrative cooperative Climate neutral renovation).

6.3 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/

STEP 1. Vision, Mission and Goals

Ciência Viva is the Portuguese National Agency for Scientific and Technological Culture. It was created to support basic scientific education with experimental science teaching, and to promote scientific culture in Portuguese society. Since the beginning, Ciência Viva promotes alliances between different sectors of Portuguese society, from universities to primary schools, from companies to research laboratories, from local authorities to private associations and professional organizations. Over more than two decades of existence, established a successful strategy of training the main agents of scientific education and promoted an active involvement of the public in science and dialogue between science and society, being internationally recognized in its areas of intervention.

Ciência Viva values social progress based on curiosity, in creativity, critical thinking and the involvement of citizens. Therefore, science centers should reflect the concerns and interests of society, and sustainability is today a primary issue with a worldwide scale and spread in all sectors of human life. The Pavilion of Knowledge positions itself as a reference in the debate on science and technology at the service of sustainable development and as an example of sustainable practices. To the Pavilion of Knowledge, sustainability means placing knowledge and cooperation without any barriers in the service of the well-being of people, communities, and the planet.

Recently, at the 2017 Science Centre World Summit, which took place in Tokyo, the partners agreed for the importance of the involvement of centres and science museums in implementing the Sustainable Development Goals. The Pavilion of Knowledge contributed to these documents, subscribing to them, and implemented the principles in the Strategic Plan of Ciência Viva.

Ciência Viva has a long history of disseminating and encouraging a range of good sustainability practices that, internally, have already led to the implementation of measures to reduce consumption of energy, water, paper, plastic, volume of waste, and the change into some alternative mobility habits, more environmentally friendly (green mobility).

STEP 1a. A first intention and Integrated Approach (commitment to start a Climate Neutral renovation project)

Building a more sustainable future depends on the involvement of most varied stakeholders, as citizens, companies, and governments. The challenge of contributing to sustainability is triggered by a change in the paradigm of society, assuming the need to incorporate structural changes in human societies. Being sustainable therefore involves rethinking behaviours, often rooted, rethinking economic growth and development, analyse the costs and consequences of our actions for the planet based in informed and conscious options.

The global average temperature in 2020 was 1.1 ºC above the pre-industrial period. To prevent an increase of more than 1.5 ºC, as agreed in the Paris Agreement, and significantly reduce the risks and impacts of climate change, we need to reduce emissions by 7.6% every year, until 2030.

In 2019 more than 11000 scientists across the world – including members of the Ciência Viva team –declared a climate emergency. In this mutual agreement in Ripple et al. (2020): World Scientists' Warning of a Climate Emergency, it was reported that after so many meetings and agreements, there is still a lot to do. Emissions of greenhouse gases continue to increase – alarmingly – at a rapid rate, with devasted consequences for the planet. Just a concerted global response, but with local actions, can tackle global warming.

STEP 1b. Key Focus Areas and opportunities for learning-action by experimentation

Referring to Eco² Schools as New European Bauhaus Labs 5 thematic focuses:
Focus 1- Solutions for retrofitting schools in series,
Focus 2- Multifunctional, open for the neighbourhood,
Focus 3- Other configurations for co-learning better,
Focus 4- A community engaged in the eco-transition,
Focus 5- Restore a cycle with nature-permaculture.

There has been growing concern regarding environmental issues in the Pavilion of Knowledge. Therefore, in the last decade, it was implemented a wide range of measures which aim not only to optimize energy resources, but also to improve production management and waste disposal. Such changes also provide a more pleasant experience for visitors of the science centre, such as:

- the implementation of recycling bins.
- development of the DÒING (workshop room), dedicated to the reuse of materials.
- optimization of the Pavilion's air conditioning processes.
- replacement of obsolete equipment with more efficient equipment's.
- replacing regular lightbulbs with LED lights.
- implementation of flow restrictors on taps.
- reuse of material from events (such as, posters) for wrapping and packaging orders in the store of the Pavilion of knowledge.
- donate materials and equipment to collection centres or for social solidarity institutions.

Aware that there is still a lot to improve, Ciência Viva and the Pavilion of Knowledge implemented in 2020 a sustainability plan based on a structured strategy that includes environmental, social and economic dimensions, spread over seven distinct thematic axes:

- green energy;
- saving resources;
- resources sustainability;
- waste management;
- mobility;
- well-being and sustainability of human resources;
- awareness and internal/external action.

In 2019, the carbon footprint of Ciência Viva/Pavilion of Knowledge was 472.4 tons of CO_2. Since the annual carbon footprint/per inhabitant in Portugal in 2018 is 5 tons of CO_2, the overall contribution Ciência Viva/Pavilion of Knowledge is equivalent to around 95 inhabitants.

The largest portion of the Ciência Viva/Pavilion of Knowledge carbon footprint come from electricity consumption (45%), a total of 682 029 kWh which translates into around 213 tons of CO_2/year. This is followed by home-to-work trips (26%) and work trips (23%) which include both trips by team members to national representations and international events. The smallest contributions to the carbon footprint Ciência Viva/Pavilion of Knowledge include national trips with the Ciência Viva fleet (4%), consumption of paper (1.4%), water (1%) and waste production (0.1%).

STEP 2. Set up a "Core Team", form and engage a "Community" in learning-action

Initial goals and allocated resources (+ first opportunities for learning-action to Sustainability Citizenship)

The Core Team combines a group of people who play a crucial role in the sustainable development of a project. In fact, this team is a driving force behind a Community of Practice (CoP) where different people with similar interests are responsible for developing better communities for the planet. The members of the core team must present complementary skills and should be experts and passionate by the subject.

In the Pavilion of Knowledge, the engagement of visitors, students and overall school communities as social change agents is essential for achieving sustainable development from local to larger contexts. This sustainability citizenship is a participatory work-in-progress where visitors and schools in the Pavilion of Knowledge can rethink climate change, habitat destruction, biodiversity loss and other environmental issues. Furthermore, sustainable citizenship has the potential to challenge and optimize the structure and function of the Pavilion of Knowledge with constructed discussions engaging the core team, the team of Ciência Viva, visitors, school communities and other stakeholders.

STEP 3. Document and explore the initial situation (for start documentation, indicators of Current Performance, first observations)

With your Core Team think how you will engage/support your community in combining skills-experiences-talents towards a more environmentally friendly School Infrastructure.

1. Green Energy

An important step in fighting climate change and reducing greenhouse gas emissions (GHG) is through the reduction of fossil fuels consumption, namely for energy production. The Pavilion of Knowledge annual energy consumption, in 2019 (pre-COVID-19 pandemic), was estimated at 1341 kWh, resulting in 235 tons of CO_2. Therefore, aware of the finitude of fossil fuels and the importance of increasing the use of energy from sources renewable sources, Ciência Viva/Pavilion of Knowledge intends to obtain part of the building energy from renewable sources, both for interior spaces and to outdoor spaces, thus triggering an energy revolution in building.

2. Saving Resources

From energy to water, paper and plastic, it is urgent to reduce resource consumption. In 2019, the use of printer paper was estimated at 1662 kg, corresponding to 24.2% of total paper consumption. A contribution even greater is allocated to book production, accounting for 37% of paper consumption (2536 kg). In relation to water consumption, in 2019 it was estimated at 4633 m^3. Nevertheless, it is important to note that this consumption is highly dependent of the number of visitors.

It is important to find methodologies that ensure reducing resource consumption, while maintaining quality. The commitment to the protection and conscious use of resources combined with measures that can be implemented to increase savings and optimization of resources, and the simplification of processes and methodologies, offers better guarantees for saving resources.

3. Resources sustainability

Ciência Viva/Pavilion of Knowledge is becoming more aware about the use and disposal of resources and goods. That is why the Pavilion of Knowledge is promoting an end to the use of disposable materials and reinforcing the need to invest in reusable and durable material. It is also making changes from the design of exhibitions to the logistics of internal events. The fight against food waste is equally important and the purchase of food products from local suppliers has been encouraged.

4. Waste management

The total production of urban waste (UW) in Portugal was, in 2019, approximately 5.28 million tons, a value greater than 1% compared to 2018. This production corresponds to an annual capitation of 513 kg/(inhabitant year), meaning a daily production of UW of 1.4 kg per inhabitant. Also in 2019, around 58% of UW was landfilled and only 13% went to recycling. Ciência Viva/Pavilion of Knowledge contributes to the inversion of these numbers by enhancing the separation of waste sent for recycling and reducing landfill disposal. In this section it is also important to highlight the intention to promote the circularity of resources, achieved through the collection of organic waste that becomes raw material for composting, contributing at a later stage to the cultivation of products that are, in turn, used in the activities of Ciência Viva/Pavilion of Knowledge.

5. Mobility

In order to reverse the environmental impact caused by human action on the planet and to reduce GHG emissions, there is a need to change the way people move and their mobility patterns. These changes involve rethink transportation, but also reviewing the number of trips made and the time, to avoid rush hour. If one-fifth of the distance travelled individually by car per Ciência Viva/Pavilion of Knowledge elements were carried out using public transportation, emissions associated with commuting from home to work would reduce by 9%, a total of 11t less CO_2/year. In this sense, the Ciência Viva/Pavilion of Knowledge aims to contribute to the use of public transport and soft mobility means, while favours flexible working hours.

6. Well-being and sustainability of human resources

Alongside with the concerted effort to reduce the environmental impact of Ciência Viva/Pavilion of Knowledge on the planet it is also necessary to improve work conditions. Ciência Viva/Pavilion of Knowledge not only wants to contribute to a more sustainable planet, but also for a team that is more satisfied with their job/workplace. A healthy balance and better management of the personal-professional relationship are fundamental for the well-being of employees, who are also, consequently, more productive. Pavilion of

Knowledge thus promotes well-being and the sustainability of human resources through the decentralization of decision-making regarding individual departmental management and, at the same time, seeks to improve the conditions of physical spaces.

7. Awareness and internal/external action

Rasing awareness and the call to action are visible in many changes that are implemented individually and triggers other changes as a cascade effect. Recognizing that the lack of knowledge in some areas or themes is often the reason for absence of actions that are more respectful of the natural world, Ciência Viva/Pavilion of Knowledge have promoted a set of measures that challenge employees, partners and visitors to adopt practices that contribute to a healthier and more sustainable planet. Simple actions like (i) turning off all computers before leaving the office, (ii) suspend computers and manually turning off the screen during short periods of inactivity, allow an annual energy reduction of 400 kWhA and 1360 kWh, respectively, and (iii) the develop of activities that motivate visitors to change behaviours. At work, or at home, adopting simple gestures makes all the difference.

STEP 4. Co-design a Climate Neutral renovation Green action plan (opportunities of your use case to achieve a more environmentally friendly School Infrastructure, by circular, self-sufficient energy step by step improvement)

1. **Green Energy**

- Install solar panels for energy production for internal consumption (obtain energy from renewable sources).

2. **Saving resources**

#energy

- Reconcile cleaning schedules with schedules for lighting the Pavilion of Knowledge, avoiding periods of unnecessary lighting;
- Introduce a purchasing policy that opts for more ecological equipment, namely with sustainability certification;
- Introduce motion or presence sensors where is possible and reassess the timing of current motion sensors;
- Replace all existing lights into LEDs.

#paper

- Transition from paper to digital format orders and processes for: purchases, days off, vacations, absences, payslips, budgets, applications for projects, publications, posters, agendas, birthday parties permits and “Holidays with Science”, project presentations, documents for training courses, tickets and invoices for visitors;
- Optimize the number of publications, posters sent to schools, Christmas cards and individual invitations to Ciência Viva actions;
- Introduce electric hand dryers;
- Reuse of posters, and other materials from events and exhibitions, for wrapping and packaging at the Pavilion of Knowledge store.

#plastic

- Allow adherence to the “Living Science Circuits” with digital option, avoiding the use of a physical card;
- Transition from printing and laminating protocols in the activities of “The Kitchen is a Laboratory” and of “The Laboratory” for projection;
- Introduce paper-gift ribbons instead of plastic ribbons;
- Remove plastic-bottle vending machines inside the building.

#water

- Introduce automatic faucets (with sensors) in all bathrooms;
- Introduce faucet flow restrictors;
- Verify the water fountain and continuously monitor its operation and any leaks.

3. **Resources sustainability**

- General: eliminate individual and/or single-use consumables in the different departments and promote the use of reusable materials;

- Exhibition area: reuse materials, modules and equipment produced during the exhibitions in the Pavilion of Knowledge;
- Escola Ciência Viva and DÒING: reduce waste of materials used by students and visitors in the course of activities developed in the Pavilion of Knowledge;
- Events: use electronic devices for communication actions, as an alternative to communication in paper form;
- Events: implement waste reduction measures, including team training and change of logistical protocols;
- Internal events: assess the need for acquisition of reusable materials in order to avoid the use of single-use consumables;
- Internal events: implement policy return of lanyards at events such as conferences and/or lectures;
- Internal events: opt for compostable identification badges/cards;
- Internal events: change to suppliers and local producers for contracting goods and food services; opt for organic products and in bulk whenever possible.

4. Waste management

- Expand the Escola Ciência Viva vegetable garden, including the introduction of a composter;
- Continuously expand reuse area in DOING;
- Evaluate the implementation of waste collection containers.

5. Mobility

- Promote flexible schedules, favouring the use of public transport during non-peak hours;
- Bicycle available for commuting near the Pavilion of Knowledge;
- Provide charging stations for electric cars in the garage;
- Whenever possible and appropriate, promote virtual meetings as an alternative to physical meetings that involve additional travel.

6. Well-being and sustainability of human resources

- Enable remote work;
- Allow department heads to manage the flexibility of working hours and teleworking of their team members.

7. Awareness and internal/external action

- Introduce guidelines on the use of reusable materials and waste production policy to (i) partners of internal events and (ii) catering companies;
- Inform internally and externally about sustainable practices, motivating visitors to adopt more environmentally friendly practices;
- Produce and/or present actions, events and exhibitions on the themes of sustainability and environment;
- Raise awareness and train employees in practices more sustainable related to everyday work (waste of energy and resources, separation of waste, reduce carbon footprint, alternatives to disposable, means of transport, sustainable shopping, reuse of materials, philosophy zero waste);
- Promote sessions of good practices and/or workshops on topics related to sustainability;
- Expand the range of sustainable products and materials in the store;
- Promote, develop and collaborate on national and international projects related to ocean literacy, environment, sustainability, biodiversity.

STEP 5. Make a first limited scale scalable proof of concept (opportunities of your use case to make a first demonstration and extend this to the surrounding space)

With your Core Team think how the chosen limited space will become a ***a local hub that will further transform the whole school in different dimensions, involving the schools community and the neighborhood at 3 generations, with support of decision makers, institutions and skills sponsors.***

The Pavilion of Knowledge is a science centre engaged on environmental sustainability. Therefore, has a social responsibility to show how educational buildings can create more sustainable, inclusive, and beautiful spaces. In fact, it is an ideal model to demonstrate how to involve citizens in the green transition from local to national level. Recently, the Pavilion of Knowledge has been working to increase the number and range of activities related to sustainability and environmental protection. These activities engage thousands of visitors and students throughout its educational programs and the network of Ciência Viva schools at national level. On

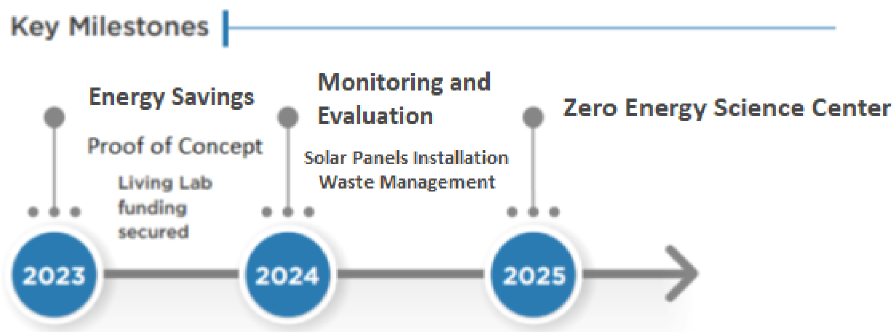
the other hand, the physical spaces of the Pavilion of Knowledge facilitate new experiences to visitors, such as DÒING (workshop room), that is dedicated to the reuse of materials, where there are frequently new dynamics and adaptations that follow recent scientific discovers. In a short-time, there will be also space to demonstrate innovative solutions, based on nature-based solutions, for transitioning to sustainability and change the way people live, driving the transformation that society needs.
Additional Focus Areas: Food Health and Wellbeing
Food plays a huge part in human health and wellbeing. In Portugal around 32% of Portuguese children are overweight and part of them (13.5%) are in fact obese (COSI Portugal 2022). Therefore, food literacy education is essential for acquiring knowledge, attitudes, and skills about food. This includes understand the connections between diet and wellbeing (including mental health) and learn how to make healthier food choices for healthy diets. Ciência Viva/Pavilion of Knowledge has been engaging its public in the dissemination and improvement of nutrition- and health-related literacy, always based on scientific facts: • In the Pavilion of Knowledge there is a room called "Cozinha é um laboratório" ("Kitchen is a lab"), where visitors and students undertake cooking workshops to develop skills and knowledge to explore nutritional impacts and to choose healthy recipes. • Ciência Viva/Pavilion of Knowledge is also engaged in European and national projects that main to promote a sustainable change in food systems, through behavioural changes relating to individual preferences, consumption habits and lifestyles. • There is a variety of activities and exhibitions related to food health in the annual educational offer.
Additional Focus Areas: Waste Reduction and Circular Economy
Circular economy is a reorganized economic model focused on coordinating production and consumption systems in closed circuits. It involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. These principles assume waste reduction, particularly in the European Union where more than 2.2 billion tons of waste are produced each year (European Parliament, 2023). The activities and actions developed in the Pavilion of Knowledge are in line with the commitments of the European Circular Economy Action Plan, adopted by the Commission on 11 March 2020. In this case, the building main goal is to stimulate the transition towards a circular economy to reduce the consumption footprint, increase its circular material use rate, and contribute to economic decarbonization. Besides ongoing related activities, Ciência Viva/Pavilion of Knowledge also develops exhibitions focus on sustainability. For example, "WATER - an unfiltered exhibition" gives voice to the basic right to safe drinking water with the help of science, technology, and the commitment of all and to remind the unsustainable consumption patterns of a substantial part of the world.
Additional Focus Areas: Transportation to the Building
Worldwide, new attitudes after COVID-19 pandemic seems to be taking shape, particularly on mobility and lifestyle. In short-term, after the COVID-19 outbreaks, virtual mobility dramatically increased (e.g., teleworking) with implications for both personal lifestyle and the environment (improvement of air quality, etc.). In relation to the Pavilion of Knowledge, this science centre is located in eastern Lisbon, with an accessible public transport network that facilitates visitors and employee's movement. Additionally, there is also space to adapt the garage of the Pavilion of Knowledge for electric vehicles and bicycles.
Expected Outcomes and Time Plan (Preparing STEP 5)
The implementation of the measures proposed in this Green Action Plan by 2025 allows that Ciência Viva/Pavilion of Knowledge will achieve significant resource savings, accompanied by several other benefits for the institution, for the employees, for visitors and for the planet in general. All the calculations and estimates made were based on the consumption of the year 2019 (pre-COVID-19 pandemic) so any potential savings always refers to this same period. Interconnected with the potential for resources saving, is the financial savings, that can be substantial. The implementation of all measures will enable electricity savings of around 91,000 kWh per year, a reduction of approximately 15% of the annual consumption of the Pavilion of Knowledge. The measures that contribute most to this saving are (a) the acquisition – when necessary – of more ecological and efficient equipment, (b) reduction of electricity consumption with the installation of a photovoltaic solar system, and (c) introduction of movement/presence sensors preventing certain areas are permanently and unnecessarily illuminated.

Measures relating to paper consumption will allow savings of 1500 kg/year, a value corresponding to 23% of the annual paper consumption in the Pavilion of Knowledge in 2019. As paper is a resource used by all departments, reducing their consumption implies the participation of the entire team, on different fronts. Also is fundamental the reduction of paper consumption by optimization the number of publications and promotional/communication material. A simple 10% reduction in the number of book copies, flyers and brochures associated with a 5% reduction in the number of copies "Circuitos Ciência Viva" will avoid the use of 430 kg of paper. The installation of electric hand dryers in the Pavilion of Knowledge bathrooms represents a potential paper saving of approximately 500 kg/year. Equally important is the transition from paper to digital format in various processes inherent to human resources management, such as authorizations and requests for days off, vacations, justification of absences, among others; This measure will also allow a reduction of approximately 100 kg of paper/year.

In relation to the potential savings associated with water consumption, it is expected a reduction of 450 m^3 of water per year, and savings of around 10% compared to the consumption of the year 2019. The measure that allows a major saving in this sector is the introduction of faucet flow restrictors.

It is also possible to reduce the production of plastic waste by around 180 kg/year. By eliminating the water bottle vending machine, we avoid using around 70 kg of plastic/year. Already a change in the logistics associated with weekly purchases, with the inclusion of reusable boxes will avoid the use of 250 to 520 plastic bags per year.

Alongside the concerted effort to improve the environmental performance of Ciência Viva/Pavilion of Knowledge it is expected a positive impact on the interest and motivation of surrounding community and staff about the green building. The number of activities and people engaged in environmental sustainability activities are expected to increase 5%, highlighting Ciência Viva/Pavilion of Knowledge as a reference of good practices for the public. Regarding the Ciência Viva teachers training centre it is expected an increase of 25% on professional development initiatives by 2025.



As this plan is dynamic, other technical, pedagogical, and organizational measures can be evaluated during the next years to increase the transition to green energy. Nevertheless, it is expected that most of the measures suggested will be implemented until mid-2024.

Monitoring and Reporting – Action Plan KPIs (preparing STEP 6)

The following KPIs (Key Performance Indicators) were selected to evaluate the success of the Pavilion's Green Action Plan:

#Technical KPIs

These KPIs will be evaluated by comparing data from 2019 (pre-intervention) with data from 2025 (after-intervention):

- Electric energy consumption (kWh/year).
- Renewable energy consumption (kWh/year).
- Carbon footprint from electricity (t CO_2).
- Paper consumption (kg/year).
- Water consumption (m^3 of water/year).

#Pedagogical KPIs

These KPIs will be evaluated by comparing information from 2023 with 2024 and 2025:

- Increased visitors interest and attitude towards environmental issues
- Number of teachers' professional development initiatives.

• Teachers and students’ interest and motivation to renovate their schools into green buildings. • Number of schools with green action plans following teachers’ professional development initiatives. **#Organizational KPIs** These KPIs will be evaluated by comparing information from 2023 with 2024 and 2025: • Increased Organisation’s Openness • Number of activities related to environmental sustainability. • Number of people engaged in environmental sustainability activities.
Organisations involved
JA Solar: Solar Park Construction; Mauser: LED bulbs. Alfa Energia: energy providing company.

6.4 University College Cork, Ireland: Green University Campus

	**UCC North Mall Campus**	**Cork, Co. Cork, Ireland**
	Sector: Tertiary Education and Research	
	District buildings portfolio: University building compromising teaching, laboratory and canteen area	
	Target groups: Staff and students, Other public sector bodies and Cork City Council, Local community (i.e. school visitors)	
	Link: https://www.ucc.ie/en/build/projects/current/deepretrofitoftheenterprisecentrenorthmallcampus/	

STEP 1. Vision, Mission and Goals

To be an exemplar community of practice in material sustainability impact, within the UCC ecosystem. Driving the agenda towards net zero through world leading research at the BEES and Applied Psychology Schools, demonstration of best practice at the Pilot Site, and education of current and future leaders and decision makers.

STEP 1a. A first intention and Integrated Approach (commitment to start a Climate Neutral renovation project)

UCC was the first university to achieve a green flag over ten years ago. Since that achievement, UCC reports on a variety of sustainability metrics such as STARS, Times Higher Education Impact, ISO50001 and SEAI's monitoring and reporting system. UCC has been recognized, both nationally and internationally, for its efforts in addressing its environmental impact. And became the first Irish university to achieve observer status observer status to the UNFCCC in 2015, thereafter sending annual delegations of academics and students to the *Conferences of the Parties*.

More recently, UCC published its Sustainability and Climate Action Plan (2023-2028) where a high-level commitment to achieve net zero emissions (across all 3 scopes) by 2040 was made. The retrofit project at the UCC pilot site is but one component of the university's project portfolio to achieve a 51% reduction (against a 2016-2018 baseline) in scope 1 and 2 emissions by 2030. This is a reduction in absolute emissions irrespective of UCC's planned growth in buildings (e.g., more student accommodation, new city centre campus for the business school).

UCC has top-down buy-in to the renovation project from the collective University Leadership Team (ULT) to the management of the two UCC schools based at the pilot site. And as a pathfinder project, there is extensive external interest throughout the Irish public sector. From this initial situation, UCC has strong commitment to pursuing the completion of this renovation project.

STEP 1b. Key Focus Areas and opportunities for learning-action by experimentation

Referring to Eco² Schools as New European Bauhaus Labs 5 thematic focuses:

Focus 1- Solutions for retrofitting schools in series,

Focus 2- Multifunctional, open for the neighbourhood,

Focus 3- Other configurations for co-learning better,

Focus 4- A community engaged in the eco-transition,

Focus 5- Restore a cycle with nature-permaculture.

Initially, the Green Action Plan will incorporate 3 focus areas of NEB-LAB.

Focus 2 – the UCC's campuses and buildings are predominantly open to the public, which is the case at the Enterprise Centre. An example of collaboration at the pilot site with the external Cork community are the past outdoor classroom sessions with children from local primary schools. The schools have very little access to green space on their schoolgrounds and can continue benefitting from the ample green space at this campus site.

The Mercy Hospital is also in close proximity to the North Mall Campus/Pilot Site. We will work to engage hospital staff/management about the available green space in vicinity to them. Green spaces have been documented by international psychology literature, to provide important co-benefits to people such as improving physical and mental wellbeing. By engaging the Mercy Hospital community we may also be able to better approximate who visits the campus, for what purpose and how frequently.

Focus 4 – From its inception, UCC Green Campus has being *student-led, research informed and practice focused*. Without the consistent student demand over the past two decades, UCC would not have become the world regarded leader in sustainability practice it is today.

To engage the Pilot Site community in localised objectives of this Green Action Plan, several actions are proposed. Firstly, to run an environmental literacy survey in cooperation with colleagues from the University of Bayreuth annually during and after the renovation to track any changes in attitudes from exposure to a more sustainable building. Secondly, to conduct the pilot activities with a variety of community members. Thirdly, to update university-wide for a such the Green Campus Committee of project progress to encourage input from across the UCC community.

Focus 5 – As mentioned previously, the pilot site is fortunate to have ample green space in it local environs. Projects to date, at the pilot site, complimenting nature and biodiversity include: an urban farm utilizing green tower technology; an apiary managed by a local beekeeper and the green space is subject to UCC's Biodiversity Action Plan and no-mow policy.

The green spaces near the pilot site will be highlighted on social media networks and the community will work to pilot a Green Campus Tour of the North Mall campus, building on the momentum built on main campus.

STEP 2. Set up a "Core Team", form and engage a "Community" in learning-action

Initial goals and allocated resources (+ first opportunities for learning-action to Sustainability Citizenship)

A Core Team was established in Autumn 2023 for the purposes of the NEB-LAB project. They comprise the following:

Green Action Plan Core Team

- UCC School of BEES
  - Dr Astrid Wingler (Head of School)
- UCC School of Applied Psychology
  - Dr Chris McCusker (Head of School)
  - Dr Annalisa Setti
- UCC Office of Sustainability and Climate Action
  - Dr Maria Kirrane
  - Irene Ní Shuilleabháin
  - Daniel Carr
- UCC Buildings and Estates
  - Pat Mehigan
- UCC Centre for the Integration of Research, Teaching and Learning (CIRTL), UCC
  - Ruth Nally

The Core Team is aware of the existing university-level Sustainability and Climate Action Plan especially regarding that plan's objectives "2. Learning & Teaching" and "4. Sustainability Citizenship" (see Deliverable D3.1). And existing university-level programmes ongoing such as carbon literacy training and Green Campus Living Laboratory programme. The Core Team has oversight of the implementation of the Green Action Plan's goals, monitoring and updates. They will also work as 'champions of sustainability' in their bespoke circles (research labs, student societies etc).

STEP 3. Document and explore the initial situation (for start documentation, indicators of Current Performance, first observations)

With your Core Team think how you will engage/support your community in combining skills-experiences-talents towards a more environmentally friendly School Infrastructure.

A pathfinder deep retrofit of the pilot site began prior to the development of this Green Action Plan. Incorporating a 'fabric-first approach', changing the windows and wall insulation was a key priority in the project's design before technological solutions such as the Ground Source Heat Pump were mooted. The pilot site's baseline GHG emissions, prior to the deep retrofit, was 93,757 tons of CO_2e. The campus is connected to the main campus by a river walkway/amenity that is suitable for pedestrians, cycling, scooting, wheeling (many forms of active travel). Bicycle facilities at the pilot site include bike racks and a bike repair station (minor repairs). Some building users (predominantly staff and school management) have been previously engaged in workshops, entitled *super saves*, arising from ISO50001. The pilot site is a significant energy user

(SEU) and thus has been a frequent target of energy efficiency measures and audits (i.e., moving desks blocking radiators etc.). From a biodiversity perspective there is amble greenspace, hedging and tree cover throughout the North Mall campus. There is a site long-treated for a Japanese knotweed infestation that is nearing the stage of remediation. Additionally, there is an urban farm and bee apiary in close vicinity to the pilot site.

STEP 4. Co-design a Climate Neutral renovation Green action plan (opportunities of your use case to achieve a more environmentally friendly School Infrastructure, by circular, self-sufficient energy step by step improvement)

The pathfinder project was developed by UCC Buildings and Estates in 2020/21 before presenting to the HEA to win the available funding. The project has been split into 2 main phases of work to accommodate the needs and wishes of the building's end users. Spread out across two summers to not interfere with the education, lab work and research ongoing during the university's semesters.

When UCC seeks recertification for ISO50001 in three years time, it needs to show continuous step-by-step improvement in energy efficiency performance. The finished retrofit at the pilot site will be a critical component of showcasing this progress.

From our initial documentation of the pilot site, there is some cycling infrastructure available. We will work with the UCC Commuting Office to build upon what is already existing and advocate for 'quality of life' improvements. There is further pre-planning for a new building on the North Mall Campus, that will be connected to the Tyndal campus by a new bridge. We will work to ensure that the pilot site's end users have an opportunity to input into its design and implementation. Also, to ensure that any potential loss in green space is minimized.

STEP 5. Make a first limited scale scalable proof of concept (opportunities of your use case to make a first demonstration and extend this to the surrounding space)

With your Core Team think how the chosen limited space will become a ***a local hub that will further transform the whole school in different dimensions, involving the schools community and the neighbourhood at 3 generations, with support of decision makers, institutions and skills sponsors.***

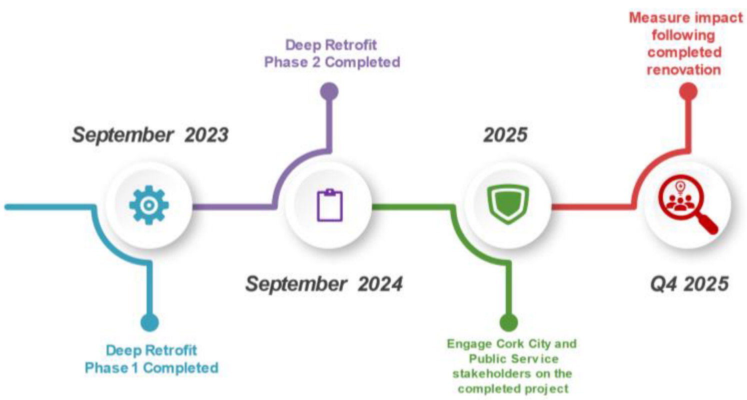
The Office of Sustainability and Climate Action has engaged the UCC School of Architecture to incorporate test activity 4 into their curriculum in semester 2 (Q1&2 2024) that compliments the existing green space at the pilot site or elsewhere in UCC's grounds.

Expected Outcomes and Time Plan (Preparing STEP 5)

Goal 1: Achieve a 50% reduction in GHG emissions (scope 1 and 2) at the pilot site following the deep retrofit project.

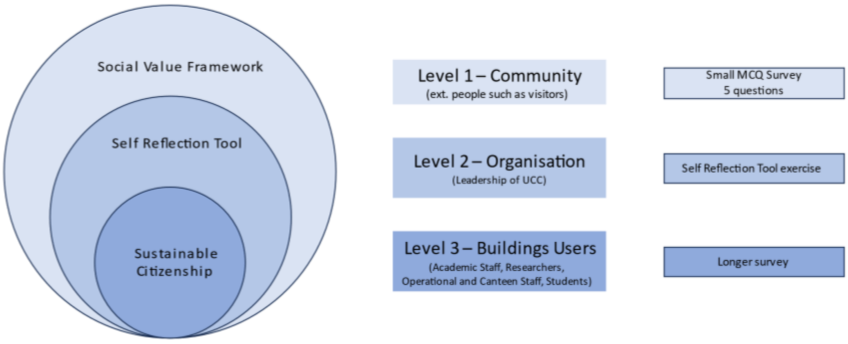
Phase 1 of the Pilot Site's deep retrofit was completed as of Autumn 2023. The renovation was split into stages over consecutive summers following consultation with the building's users. This ensures that the Enterprise Centre can still operate lectures, seminars and labs as normal during the academic year.

As per the UCC Use-Case Document (D 2.1), it is expected that the completed retrofit will result in at least a 50% reduction in the building's GHG emissions. In addition to a significant impact on the indoor air quality and thermal comfort for building users. Following the retrofit's completion, *UCC's Buildings and Estates* team will have considerable engagement, regarding the retrofit approach and outcomes, with analogous colleagues in the Irish Higher Education sector and Irish public service.

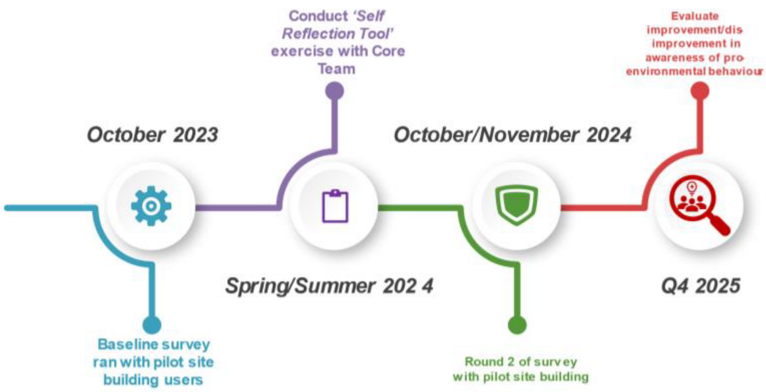


Goal 2: Enhanced awareness of staff, students and the surrounding community of sustainability and pro-environmental behaviour.

As stated previously, the global reputation of UCC as a sustainability leader would not have been possible without the consistent enthusiastic engagement of students and staff over many years. From its inception, UCC Green Campus has been *student led*, *research informed* and *practice focused*. The NEB-LAB project defines 3 levels of the community; building users, organization-scale and surrounding community.



At UCC's pilot site, a baseline survey of building users' awareness and attitudes to sustainability and pro-environmental behaviour was conducted in Autumn 2023. This survey will be repeated in 2024 and 2025 to monitor changes amongst participants during the lifetime of this *Green Action Plan*. The Core Team will also undertake the SRT exercise during 2024. The need to repeat the exercise overtime will be determined by the NEB-LAB consortium. At the community level (i.e., pilot site visitors), the smaller survey will be conducted during events with significant public footfall such as the annual Cork City Culture Night. When possible, this exercise will be repeated during the lifetime of this Green Action Plan.

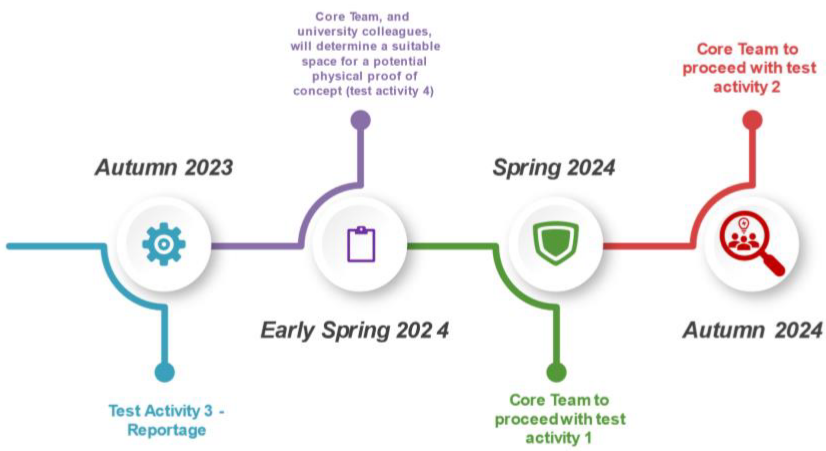


Goal 3: Greater awareness of the biodiversity and green-blue spaces adjacent to the pilot site (Learning Action and Sustainability Citizenship).

UCC has a highly regarded green campus with many actions conducted to date to enhance the biodiversity integrity of UCC's estate. Wildflower meadows have increased across campus. Use of powerful chemicals has been reduced to serious cases of invasive species such as Japanese Knotweed. The pilot site is situated within a riparian zone along the north channel of the River Lee. For many years, UCC has offered Green Tours of its campus both guided and self-guided by an app. During the lifetime of this Green Action Plan, we will offer dedicated tours of green spaces on the North Mall campus where the pilot site is based. Coinciding with existing initiatives that attract footfall such as UCC Green Week and UCC Climate Week. Additionally, there is a brown site that has being treated for a Japanese knotweed infestation for several years. It is now approaching a time for deciding what the future of that land is. An action to co-create a vision with the UCC community on its future is proposed. Whether the focus should be rewilding, a managed wildflower meadow or an integrated amenity for people and nature.

Goal 4: Develop a limited scale proof of concept at or near the pilot site incorporating circularity of materials and low impact on the existing green space and conduct the other NEB-LAB test activities (Learning Action).

To date, UCC has fostered several scalable and replicable proof of concepts throughout its campuses that are inadvertently of interest to the New European Bauhaus. Some examples include the UCC community garden, UCC sensory garden and urban farm. The urban farm is located adjacent to our pilot site where there are natural synergies as identified in step 3 (document the initial situation). UCC has incorporated test activity 3 (see Deliverable D3.1) into its current reporting and engagement activities. Utilizing existing structures such as the Green Campus Committee, Green Forum and newsletters. The UCC Office of Sustainability and Climate Action has engaged lecturers across the university community about incorporating test activity 4 (see Deliverable D3.1) into part of their curriculums. Interest has been indicated by both the School of Architecture and School of Applied Psychology. Each approaching the activity from quite different perspectives. The Core Team will promote and conduct the test activities 1 and 2 (stakeholder mapping and observation, see Deliverable D3.1) during 2024.



Monitoring and Reporting – Action Plan KPIs (preparing STEP 6)

KPI/Metric	Units	Definition	Monitoring	Timeframe
Goal 1: Achieve a 50% reduction in GHG emissions (scope 1 and 2) at the pilot site following the deep retrofit project.				
Completion of Retrofit Project Phase 1	n/a	Completion of the first phase of the HEA pathfinder project at the pilot site	UCC Buildings & Estates	2023
Completion of Retrofit Project Phase 2	n/a	Completion of the second phase of the HEA pathfinder project at the pilot site.	UCC Buildings & Estates	September 2024

Reduction in Thermal and Electrical Final Energy at Pilot Site	kWh	Final amount of energy consumed by the building per annum.	UCC Buildings & Estates	December 2024 and 2025
	kWh/ m^2	Final amount of energy consumed by the building per annum averaged across the site's total floor area	UCC Buildings & Estates	
Reduction in GHG emissions (scope 1 and 2) at Pilot Site	t CO_2e	GHG emissions derived from applying an emission factor to final energy consumed.	UCC Buildings & Estates	December 2024 and 2025
	t CO_2e/m^2	GHG emissions derived from applying an emission factor to final energy consumed per m^2.	UCC Buildings & Estates	
Engagement with other universities and public sector bodies following the retrofit's completion.	n/a	As a pathfinder project, the retrofitted Enterprise Centre is of national interest to the higher education sector and public service in Ireland. Conduct small MCQ survey before, after and further after this type of engagement activity if feasible.	Qualitative Notes by UCC Buildings and Estates Small MCQ survey data	December 2025
Goal 2: Enhanced awareness of staff, students and the surrounding community of sustainability and pro-environmental behaviour. Actioning the delivery of Sustainability Citizenship as a core ethos of UCC.				
Engagement with UCC Carbon Literacy course	#	Staff and students at the site will be encouraged to undertake the course	Online VLE	December 2025
Green Shoots ambassadors onsite	#	Aiming to have at least one Green Shoots Ambassador across the Pilot site each year	Green Shoots Programme Coordinator	December 2025
Climate/biodiversity public engagement events at the site	#	Aim to have at least one public engagement event focused on climate action and biodiversity annually	UCC Office of Sustainability and Climate Action School of BEES School of Applied Pyschology	September 2024/ September 2025
Concurrent to the direct intervention activities listed, track any improvement in study participants' attitude towards nature.	Survey score (1-5)	Survey score 1-5 scale. At least a 'medium' sized improvement expected.	UCC Office of Sustainability and Climate Action	December 2024 & 2025
Concurrent to the direct intervention activities listed, track any improvement in study participants' *psychological distance* scores across any variable: temporal, geographical, social or hypothetical.	Survey score (1-5)	Survey score 1-5. At least a 'small' sized improvement expected in each variable.	UCC Office of Sustainability and Climate Action	December 2024 & 2025

Core Team will conduct the self-reflection tool (SRT) exercise during 2024.	n/a	Completion of exercise.	UCC Office of Sustainability and Climate Action.	December 2024
Goal 3: Greater awareness of the biodiversity and green-blue spaces adjacent to the pilot site.				
Green Spaces "Living Lab" projects at the site	#	Aim to have a least one UCC Green Campus Living Laboratory project focused on green space management at the site	OSCA	December 2025
Engagement with new green tours for the North Mall campus.	#	Aim to have several North Mall green campus tours operating during 2024, especially to coincide with Green Week and Climate Action Week.	Green Shoots Coordinator UCC Arboretum	December 2024
Concurrent to the direct intervention activities listed, track any improvement in study participants' *psychological distance* scores across any variable: temporal, geographical, social or hypothetical.	Survey score (1-5)	Survey score 1-5. At least a 'small' sized improvement expected in each variable.	UCC Office of Sustainability and Climate Action	December 2024 & 2025
Goal 4: Develop a *limited scale proof of concept* at or near the pilot site incorporating circularity of materials and low impact on the existing green space and conduct the other NEB-LAB test activities.				
Progress of Pilot Activity 4 – Innovative Solutions. Developing the limited scale proof of concept. Measured by any improvement in their connectedness to nature scores (salutogenesis).	n/a	Exploring several options currently for a test activity. Potentially integrated as part of UCC Architecture's or Psychology's end of year project. The proof of concept may be a structure or the remediation of a green area on the site that was previously contaminated with Japanese knotweed. Study participants' connectedness to nature scores improve/dis-improve following test activity.	UCC College of Engineering and Architecture, Pysch. Remediated site	Spring Semester 2024 - Autumn Semester 2024
Pilot Activity 1 – Stakeholder Mapping	n/a	Completion of several versions of the community mapping template before coming to a consensus-meeting final version.	UCC Office of Sustainability and Climate Action	Spring 2024, Autumn 2024, Spring 2025
Pilot Activity 2 – Discover and Observe	n/a	Core Team, in cooperation with the project Chamber of Quality, to determine what observation activity at the Pilot Site will occur. Follow up more specific monitoring during drafting of Implementation Plan	UCC Office of Sustainability and Climate Action	Spring 2024
Pilot Activity 3 - Reportage	n/a	Ensuring a rapport between the university-wide sustainability actions (e.g., Green Campus Committee, UCC Arboretum) and community (Clubs and	UCC Office of Sustainability and Climate Action	

		Socs), local sustainability actions (UCC Urban Farm)		

Organisations involved
Retrofit Project Team • **UCC** ○ Tim Cronin (Capital Projects Officer) ○ Finbarr Wall (Deputy Capital Projects Officer) ○ Pat Mehigan (Energy and Utilities Manager) • **Design Team** ○ Butler Cammoranesi (Architect) ○ Cantwell Keogh & Associates (Fire Safety) ○ Powertherm (Mech and Elect) ○ AECOM (Quantity Surveyor)

6.5 Sigtunaskolan Humanistiska läroverket SSHL

SSHL School Campus	**Sigtuna, Sweden**
Sector: Secondary Education	
District buildings portfolio: School buildings	
Target groups: Building owner and users (students, administrative & teaching staff), municipality	

STEP 1a. Vision, Mission, and Goals

Sigtunaskolan Humanistiska Läroverket, commonly known as SSHL, is a distinguished boarding school nestled in the historic municipality of Sigtuna, Sweden's oldest town. Established in 1980, SSHL was born from the merger of two illustrious Swedish boarding schools with rich histories: Sigtunastiftelsens Humanistiska Läroverk, founded in 1925, and Sigtunaskolan, founded in 1927. Over the years, SSHL has emerged as a leading institution for boarding education in Sweden. As SSHL approaches its centenary milestone, we stand at the threshold of a new era. Our school has produced a roster of distinguished alumni, including Prime Minister Olaf Palme, the reigning King of Sweden, Carl XVI Gustaf, prominent members of the Wallenberg family, Nobel Peace Prize laureate Hans Levander, accomplished scientists, prolific writers, and many others. **As we embark on our journey towards our 100th anniversary, SSHL is committed to leading the way in addressing contemporary challenges that have surfaced in recent years.** Issues such as reverence for the natural environment, prudent energy and resource management, and responsible recycling have become imperative elements in resolving pressing environmental concerns that resonate with the global community. Our school is dedicated to championing sustainability and, within this framework, strives to evolve into a zero-energy consumption complex. We aim to not only inspire similar actions but also engage and educate the local Sigtuna community, where SSHL stands as a prominent landmark. With heritage buildings overlooking Lake Mälaren, SSHL seeks to integrate participative sustainable renovation initiatives that transcend the boundaries of traditional education. At the intersection of two smaller towns undergoing urban expansion, our integrated approach is centered on adopting the NEB-LAB concept.

Our vision for making the school more energy-efficient with several separate interventions proposed, is focused on:

- Achieving high energy performance and energy savings
- Use of innovative and sustainable energy solutions for improved indoor environmental quality for the users
- Optimal dynamic matching between on-site renewable energy generation and building/ neighborhood consumption
- Creation of innovation clusters that will apply new technologies and methodologies that can be used as references in future similar projects

This green action plan outlines our comprehensive strategy to transform SSHL into a sustainable, environmentally conscious institution, setting an example for future generations and fostering a greener, more sustainable world.

STEP 1b. Developing an Integrated Approach

Inspired by a shared commitment to combat climate change and contribute to a sustainable future, Sigtunaskolan Humanistiska Läroverket (SSHL) has embarked on a journey to motivate our school community to rise against climate change through meticulous planning. Our vision extends far beyond the confines of our campus, aiming to empower our students, staff, and local community to take proactive steps in this collective effort. To foster motivation, SSHL has actively involved students in various formally established clubs (student organizations like the “Design and Technology Group” (DTG) and “Life Link”) that focus on environment and sustainability, serving as change agents within our school. Additionally, our boarding home students play a pivotal role in nurturing environmentally conscious behavior among residents, nurturing a sense of responsibility. We have designed extracurricular activities that allow students to participate hands-on in our sustainability project, cultivating a sense of ownership and commitment. Furthermore, educational departments are embedding these projects into the curriculum, ensuring that the students gain an understanding of the significance of climate action. Our active collaborations with schools from other countries and the Municipality of Sigtuna have created synergies that can further enrich our grid and circular economy plans. Through these interconnected efforts, we envision motivating our school community to rise against climate change, with our campus serving as a beacon of inspiration for other educational institutions, communities, and the local society.

STEP 2. Structures and Key Focus Areas – Assess Current Performance

In this pivotal phase of our green action plan, we embark on a comprehensive assessment of our school's current environmental impact, encompassing both building infrastructure and overall operations. Our goal is to gain a holistic understanding of our ecological footprint, paving the way for a more sustainable future. The assessment process extends beyond energy consumption, delving into waste generation, carbon emissions estimation, and ecological footprint calculations.

Energy Consumption Assessment: A central element of our assessment focuses on electric energy consumption for lighting. This analysis involves a review of historical data, utility bills, and mostly on-site monitoring. We aim to identify areas where energy conservation measures can be implemented to reduce our carbon footprint significantly. This assessment not only serves as a valuable source for our project but also provides practical learning opportunities for our students in the field of energy efficiency.

Carbon Emissions Estimation: A pivotal aspect of our assessment centers around the endeavor to reduce and estimate carbon emissions. This involves a comprehensive evaluation of greenhouse gas emissions associated with our energy consumption and transportation. As we embark on this journey, we are actively exploring various methodologies to achieve accurate estimations. The aim is to search for standardized approaches that will allow us to calculate our carbon footprint, thereby establishing a baseline for the development of effective emissions reduction strategies. This data, once obtained, will become an indispensable component of our project, providing students with invaluable insights into the environmental impact of carbon emissions and underscoring the significance of reduction strategies.

Ecological Footprint Calculations: Recognized ecological footprint calculation methods are applied to quantify the environmental impact of our operations. These calculations offer a comprehensive overview of our current sustainability performance, creating a basis for our sustainability strategies. Moreover, these calculations provide educational opportunities for students to understand the broader implications of ecological footprints on the environment and society.

Through this extensive assessment, we aim to identify key focus areas where our school can make significant strides toward a greener and more sustainable future. This data-driven approach serves not only as a foundation for our sustainability initiatives but also as a valuable educational resource, empowering our students to engage with real-world environmental challenges and encouraging a deeper understanding of the importance of sustainability.

STEP 3. Set Goals: Learning and Teaching for Sustainability Citizenship

In this step of our green action plan, we shift our focus to establishing clear and ambitious goals that center on learning and teaching for Sustainability Citizenship. The foundation of these goals is to empower our school community with the knowledge, skills, and values necessary to become active agents of positive change in the realm of sustainability. This involves honing key competencies that will guide us towards a more environmentally conscious and socially responsible future.

1. **Environmental Education:** Our first goal is to foster environmental education among our students, staff, and the wider community. We will achieve this by integrating sustainability into our curriculum and extracurricular activities. This entails not only understanding environmental issues but also being equipped to critically analyze and address them.
2. **Critical Thinking and Problem Solving:** To be effective Sustainability Citizens, critical thinking and problem-solving skills are paramount. Our goal is to encourage innovative thinking and analytical skills that enable our community to identify sustainability challenges and develop practical solutions.
3. **Systems Thinking:** Understanding the interconnectedness of environmental, social, and economic systems is essential for Sustainability Citizenship. We aim to instill a system thinking approach that helps our community make informed decisions with a holistic perspective.
4. **Social Responsibility and Ethical Decision-Making:** Our school community will be guided by a commitment to social responsibility and ethical decision-making. By emphasizing the importance of ethical values and social awareness, we aim to nurture individuals who are conscious of the consequences of their actions.

5. **Effective Communication and Advocacy:** To effect change, effective communication and advocacy skills are critical. We will set goals to ensure that our students and staff can proficiently communicate sustainability issues and advocate for sustainable practices, both within and beyond our campus.
6. **Collaboration and Teamwork:** Sustainability challenges are often complex and require collaborative efforts. Our goals include fostering collaboration and teamwork skills to work collectively on sustainability initiatives and forging partnerships within our community and beyond.
7. **Leadership and Initiative:** We aspire to develop future leaders who take initiative in driving sustainability efforts. Our goals focus on cultivating leadership skills that inspire individuals to take ownership and lead by example.
8. **Cultural and Global Awareness:** In an increasingly interconnected world, cultural and global awareness is essential. Our goals include expanding our community's knowledge of global sustainability issues and cultural diversity to foster a sense of global citizenship.
9. **Adaptability and Resilience:** Sustainability progress may face challenges and setbacks. We will set goals to nurture adaptability and resilience in the face of adversity, ensuring that our community persists in its sustainability journey.

By setting these goals related to key competencies for Sustainability Citizenship, we envision our school community becoming informed, engaged, and empowered agents of positive change. These competencies will not only benefit our school but will also prepare individuals to address broader global sustainability challenges and contribute to a brighter, more sustainable future for all.

STEP 4. Towards a more environmentally friendly School Infrastructure

In this crucial step, our primary focus is on enhancing the environmental sustainability of our school infrastructure by reducing energy consumption. A critical component of this initiative involves the evaluation and transformation of our lighting system to gauge its impact on energy efficiency. Recognizing the pivotal role lighting plays in our ecological footprint, we strategically address this aspect to advance our commitment to sustainability.

Utilizing Eco-friendly Materials: Our journey towards a more sustainable school infrastructure commences with the conscious selection and utilization of eco-friendly materials. We meticulously examine the materials employed in our buildings, ensuring compliance with stringent sustainability criteria and adhering to regulatory limitations. Given that most of our campus structures are traditional buildings, the emphasis is on choosing materials with a diminished environmental impact, such as those featuring recycled content or possessing energy-efficient attributes. This approach aims to curtail the ecological footprint associated with our construction and renovation endeavors.

Integration of Bioclimatic Principles in Educational Buildings: At the core of our strategy is the incorporation of bioclimatic architecture principles. This design philosophy considers the local climate, topography, and natural surroundings to optimize energy performance and enhance occupant comfort. Embracing bioclimatic architecture, we aspire to design and retrofit our educational buildings, leveraging natural elements like sunlight and ventilation to diminish energy consumption for heating, cooling, and lighting.

Pilot Project for Lighting System Transformation: Our initial focus in this stage revolves around a pilot project aimed at transforming our lighting system. We embark on this venture to replace a portion of our conventional lighting system with innovative, energy-efficient alternatives. The primary objective is to assess the actual impact on energy consumption and ascertain potential cost savings. Through this pilot project, we aim to accumulate valuable data and insights that will inform the broader upgrade of our lighting system, ultimately leading to substantial reductions in both energy consumption and carbon emissions. By strategically advancing towards a sustainable school infrastructure, we envision a future where our buildings not only provide an optimal learning environment but also actively contribute to our overarching sustainability goals. As we navigate through this step, our endeavors will progressively extend to address other facets of our infrastructure, harmonizing our campus with the vision of a greener, more sustainable future.

Additional Focus Areas: Conversion to Geothermal Heating/Cooling System

Our commitment to sustainability extends to our heating and cooling systems. We are determined to transition from traditional energy sources, including electricity, oil, and pellets, to a more environmentally friendly alternative: geothermal heating and cooling. Geothermal energy taps into the Earth's natural heat, providing a consistent and renewable source for regulating indoor temperatures. This conversion significantly reduces our carbon footprint and offers long-term cost savings. By adopting geothermal technology, we are

taking a significant step towards a greener and more sustainable campus, ensuring a comfortable and eco-friendly environment for our students and staff.
Additional Focus Areas: Energy Efficiency Upgrade through Frames and Insulation Improvements
Our commitment to sustainability encompasses a comprehensive approach to improving the energy efficiency of our buildings. A key focus area involves the replacement of frames (doors and windows) and the enhancement of insulation. Our goal is to minimize heat loss during the winter and reduce heat gain during the summer. Energy-efficient window frames, coupled with high-quality insulation, will create a more comfortable indoor environment while reducing energy consumption. By investing in these upgrades, we aim to achieve substantial energy savings, reduce our environmental impact, and enhance the overall quality of our campus facilities.
Additional Focus Areas: PV installation and Smart batteries for energy production, and energy saving.
As part of our commitment to sustainability, we are taking bold steps to increase our energy production. A pivotal transformation in this endeavor involves the installation of a 500-kilowatt photovoltaic (PV) system, complemented by state-of-the-art smart battery technology. This innovative system harnesses the power of the sun to generate clean, renewable energy for our campus. The smart battery system stores excess energy, enabling us to use it when needed, reducing our reliance on the grid, and lowering our carbon emissions. This comprehensive approach aligns with our commitment to energy efficiency and contributes to a more sustainable energy model for our school and the wider community. By generating our electricity sustainably, we take a significant step towards a greener future and set an example for responsible energy management.
Additional Focus Areas: Transforming the Administration Building into a Net-Zero House
In addition to our green action plan, a pivotal initiative involves the total renovation of the administration building located at the entrance of our school campus. The objective is to convert it into a net-zero house, showcasing the sustainable technologies and practices described in our comprehensive green action plan. This transformation aims to turn the building into a "showroom" that vividly demonstrates the practical implementation of our school's commitment to environmental responsibility and energy efficiency. **Key Features of the Net-Zero House Transformation** Smart Lighting System: Implementing an innovative smart lighting system that significantly reduces energy consumption for lighting purposes. This mirrors the success of our pilot project, contributing to the overall energy efficiency of the net-zero house. Eco-friendly Materials: Meticulously selecting and utilizing eco-friendly materials to align with stringent sustainability criteria and regulatory limitations. This ensures that construction and renovation endeavors have a diminished environmental impact. Bioclimatic Architecture: Embracing bioclimatic architecture principles to optimize energy performance and enhance occupant comfort. The design incorporates natural elements like sunlight and ventilation, minimizing energy consumption for heating, cooling, and lighting. Renewable Energy Sources: Transitioning to renewable energy sources, such as a photovoltaic (PV) system coupled with state-of-the-art smart battery technology. This system harnesses clean, renewable energy, contributing to the building's energy self-sufficiency. Geothermal Heating/Cooling System: Adopting a geothermal heating and cooling system to replace traditional energy sources. This eco-friendly alternative taps into the Earth's natural heat, reducing the building's carbon footprint and ensuring long-term cost savings. Energy Efficiency Upgrades: Enhancing energy efficiency through the replacement of frames (doors and windows) and insulation improvements. This approach minimizes heat loss during winter and reduces heat gain during summer, contributing to overall energy savings. **Educational Hub and Community Inspiration** The renovated administration building, transformed into a net-zero house, will serve as an educational hub for our school community and beyond. By showcasing the practical implementation of sustainability measures, we aim to inspire and educate visitors, students, and the local community about the significance of green technologies and responsible resource management. This strategic initiative reflects our school's commitment to leading by example, fostering a culture of sustainability, and actively contributing to a greener, more sustainable world. The administration building, once renovated, will stand as a testament to the transformative potential of sustainable practices in the realm of education and beyond.

Expected Outcomes and Time Plan (Preparing STEP 5)

In this focused step, we outline the expected outcomes and time plan specifically within the project's life cycle from 2023 to 2025. Our primary objective during this period is to reduce electric energy consumption for lighting purposes through the implementation of an innovative smart lighting system.

Reducing Electric Energy Consumption for Lighting (2023-2025)

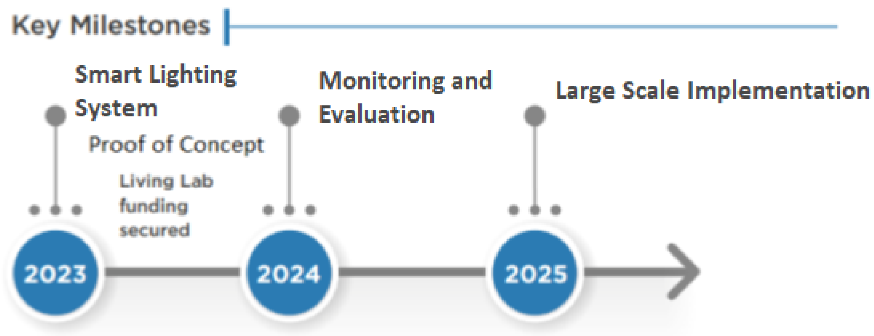
Our immediate goal is to achieve a significant reduction in electric energy consumption for lighting within the specified time frame. By introducing the innovative smart lighting system, we aim to realize a substantial reduction in energy use. We anticipate that this initiative will result in a minimum reduction of 60% and potentially reach a maximum reduction of 85% in electric energy consumption for lighting during 2023-2025. This period serves as a focused testing ground for the smart lighting system's performance and its impact on energy efficiency.

Time Plan (2023-2025)

2023: The implementation of the smart lighting system begins in four classrooms by the end of the year. We will start monitoring the energy consumption and performance of these classrooms compared to those still using the traditional lighting system.

2024: The second year of the project focuses on continuous monitoring and evaluation. By the end of 2024, we expect to have a clear understanding of the smart lighting system's effectiveness in reducing electric energy consumption for lighting within the specified time frame.

2025: In the third year, based on the results of the measurements demonstrating a significant reduction in energy consumption translating into corresponding cost savings and after calculating the estimated payback time of the investment (approximately three years), we plan to proceed with replacing the lighting system for a larger part of the school complex. This strategic expansion aligns with our commitment to long-term sustainability and energy efficiency.



Teacher and students' engagement

This transformative initiative is carefully crafted to yield significant benefits for both our students and teachers. For our students, it goes beyond reducing energy consumption—it's an opportunity to immerse themselves in a culture of sustainability. Actively participating in the learning process, students will not only contribute to a greener, more sustainable world but will also gain invaluable hands-on experience in real-world problem-solving. Through their engagement with the smart lighting system and its integration into the curriculum, students will develop a profound understanding of energy efficiency, environmental responsibility, and the pivotal role of technology in shaping a sustainable future. This project aims to empower students with the knowledge and skills needed to become conscious global citizens, well-versed in the principles of sustainability. Simultaneously, our dedicated teachers play a crucial role as guides and mentors, ensuring the success of this initiative. As supervisors, they facilitate a learning environment where students can thrive, fostering a collaborative spirit and a sense of ownership over our sustainability initiatives. The expected outcome is not only a more energy-efficient campus but also a community of students and teachers well-prepared to champion sustainability and make a positive impact on the world around them.

Local community

As a part of our broader vision to inspire and motivate the local society of Sigtuna, our school is committed to making meaningful contributions to a greener, more sustainable world. Through meticulously planned events, such as 'open house events' organized by the school, we aim to engage and educate the local community on the importance of sustainable practices. Furthermore, as a symbolic showcase of our commitment, we plan to renovate the administration building "Alhem" into a net-zero house, utilizing cutting-edge green technologies outlined in our green action plan. This transformation not only serves as a practical example for the community but also empowers this project, we anticipate a notable increase in awareness and participation from the local society in Sigtuna. The residents with insights into converting their own homes to more sustainable living spaces. By the conclusion of tangible transformation of 'Alhem' into a net-zero house, coupled with engagement initiatives like 'open house events,' is poised to inspire the community to adopt greener practices in their daily lives. We envision a future where our efforts not only benefit the school environment but also contribute significantly to a broader shift toward sustainability in the local community of Sigtuna.

This focused time frame not only solidifies our commitment to achieving immediate objectives but also underscores our dedication to sustainability. The anticipated outcomes and time plan seamlessly align with the project's 2023-2025 life cycle, demonstrating our resolute stance on reducing energy consumption through the adoption of innovative technology. Through meticulous monitoring and evaluation, we aspire to achieve more than just energy savings. Our initiative aims to cultivate a culture of sustainability within our student body, offering them hands-on experience in real-world problem-solving and fostering a deep understanding of energy efficiency, environmental responsibility, and the pivotal role of technology in shaping a sustainable future.

Furthermore, as our students actively engage in the learning process, contributing to a greener and more sustainable world, we also anticipate a ripple effect within our local community of Sigtuna. By organizing events like "open house events" and potentially converting the administration building “Alhem” into a net-zero house, we aim to inspire and motivate the local society to embrace greener practices. The expected outcome includes a heightened awareness and contribution from the local community towards creating a more sustainable world. In essence, our project extends beyond the immediate benefits of energy efficiency, reaching into the realms of education, community engagement, and a collective commitment to a greener, more sustainable future.

Monitoring and Reporting – Action Plan KPIs (preparing STEP 6)

In the final stage of our green action plan, we emphasize the critical aspect of monitoring and reporting our progress. This step is vital to ensure that our sustainability initiatives yield the desired results and lead to a more energy-efficient and environmentally responsible campus. Our Key Performance Indicators (KPIs) revolve around energy savings, efficient use of resources, and the adoption of alternative technologies.

Energy Savings: Our first KPI focuses on measuring the energy savings achieved through the implementation of our smart lighting system. By continuously monitoring energy consumption in the classrooms where this technology is in use, we can accurately assess the reduction in electric energy consumption for lighting. The data collected during 2023-2025 will serve as a benchmark for evaluating the impact of the smart lighting system in achieving our immediate objectives. By tracking energy savings, we aim to quantify the success of this initiative and ensure that it aligns with our sustainability goals.

Efficient Use of Resources: Efficient resource management is another integral aspect of our green action plan. We monitor the efficient use of resources, particularly in the context of energy consumption, across our campus. By analyzing data on energy usage and patterns, we can identify areas where further improvements may be necessary. The goal is to optimize resource utilization and minimize our environmental footprint. This KPI ensures that we continue to make informed decisions that support our commitment to sustainability.

Monitoring and Reporting with Student and Teacher Integration: Throughout the project's life cycle from 2023 to 2025, our commitment to monitoring and reporting extends to our students and teachers, who play an integral role in this process. As a part of the project's integration into the teaching process, students actively participate in the data collection and reporting. They utilize the project's measurements as valuable sources and databases for their assignments, allowing them to engage with real-world sustainability data.

Our dedicated teachers take on the role of supervisors, ensuring the reliability of the results produced by the students. Their guidance and expertise support the accuracy and integrity of the data. This collaborative approach not only empowers our students to connect their education with real-world challenges but also fosters a sense of ownership and responsibility for our sustainability initiatives. It aligns with our commitment to inspire and educate the next generation about the importance of responsible resource management and a greener future.

In addition, the integration into the learning process allows teachers and students not only to measure energy consumption but also to learn and compare new and old technologies. Students gain insights into various fields of natural science, exploring differences between LED lamps, fluorescents, and traditional bulbs. They delve into the workings of each technology, understanding concepts such as energy efficiency, power, and the principles behind smart systems and controllers (lighting control systems). This comprehensive approach broadens their knowledge and awareness, contributing to a well-rounded education that goes beyond energy conservation, touching upon the intricacies of modern lighting systems and their impact on sustainability.

Community Inspiration: The Community Engagement and Inspiration Index measures the level of involvement, interest, and inspiration of the local community in response to the implementation of the smart lighting system in our school. This index involves tracking community attendance and participation in events, workshops, and open houses, gathering feedback through surveys, and monitoring media coverage and social media metrics.

KPI /KPIs Definition	Test Activity / Monitoring	Metric
Energy Savings Measure the reduction in energy consumption achieved by implementing the smart lighting system	Conduct a side-by-side comparison of energy consumption in classrooms with the new smart lighting system and those with the traditional system. Use energy meters to measure and record consumption regularly over an extended period. Calculate the percentage reduction to determine the effectiveness of the smart lighting system.	Percentage reduction in energy consumption. We expected about 60% reduction in energy consumption after the change of the lamps with LED and up to 83% with the use of a smart lighting system
Cost Savings Assess the financial savings resulting from the reduced energy consumption	Compare the cost of electricity before and after the implementation of the smart lighting system. Monitor and record the energy-related costs associated with lighting over time.	Percentage reduction in energy-related costs. We expect a similar reduction in energy costs.
Smart Technology Adoption Assess the successful adoption and utilization of the smart lighting system	Implement user surveys and feedback sessions to assess the satisfaction and utilization of the smart lighting system. Monitor system uptime and collect data on user experiences. Calculate the percentage of classrooms successfully using and benefiting from the smart lighting system.	Percentage of classrooms successfully using and benefiting from the smart lighting system. We are expecting a medium to large-scale effect.
Environmental Impact and Ecological Footprint Reduction Evaluate the reduction in the school's environmental footprint resulting from the decreased energy consumption	Measure the reduction in carbon emissions associated with lighting. Collect data on energy consumption and convert it into carbon emissions. Compare the emissions from classrooms with the new system against those with the traditional system. Calculate the percentage reduction in carbon emissions.	Percentage reduction in carbon emissions. As the carbon emissions are proportional to energy consumption, we expect a large decrease in ecological footprint scores related to energy consumption for lighting, but this is a small percentage of the total footprint of the school.
Student Engagement Evaluate the level of student engagement with the project, including their use of measurement results in homework, exercises, and projects	Monitor the participation of students in utilizing energy consumption data for academic purposes. Conduct surveys to gather feedback on the integration of the project into coursework. Calculate the percentage of students actively incorporating project data in their homework, exercises, and projects.	Percentage of students actively incorporating project data in their coursework.

Environmental Attitude Improvement	Administer surveys before and after the implementation, asking students and teachers about their environmental attitudes and perceptions of the new lighting system. Compare the results.	Percentage increase in positive environmental attitudes. We expect a large effect.
Educational Integration Evaluate the integration of project data and concepts into the school's educational curriculum	Assess the inclusion of smart lighting system data in various subjects and projects. Review curriculum materials and projects to identify the integration of energy consumption data. Calculate the number of subjects/projects incorporating energy consumption data.	The number of subjects/projects incorporating energy consumption data. We expect a medium effect.
Knowledge Enhancement	Implement pre- and post-assessments to measure the increase in participants' knowledge about energy-efficient lighting systems and sustainable practices.	Percentage increase in knowledge. We expect a large-size effect.
System Knowledge Improvement	Integrate educational sessions focused on the larger-scale impact of sustainable lighting systems on the environment and society. Assess participants' understanding before and after the sessions.	Positive impact score on understanding the larger-scale impact. We expect a large-size effect
Action Knowledge and Effectiveness Knowledge	Measure participants' understanding of how their behavioral choices (action knowledge) and larger-scale environmental strategies (effectiveness knowledge) contribute to sustainability through assessments before and after relevant sessions.	Positive impact score on understanding the contribution to sustainability. We expect a large-size effect
Psychological Distance Reduction	Conduct interviews or surveys before and after the implementation to assess participants' perceived closeness to environmental issues. Analyze the data to measure the reduction in psychological distance	Percentage decrease in perceived psychological distance. We expect a small change.
Salutogenesis Improvement	Gather feedback through surveys, interviews, or observations on the well-being, health, and productivity of participants within the classroom environment after the implementation.	Positive impact score on well-being, health, and productivity. We expect a small change.
Self-Efficacy Enhancement	Conduct workshops or educational sessions and assess participants' self-efficacy in managing and utilizing the new lighting system effectively before and after the sessions.	Percentage increase in self-efficacy. We expect a medium size effect.
Community Inspiration Measures the project's impact in inspiring the local society, especially during events like "open houses".	Evaluate community attendance and engagement during events like "open houses." Conduct surveys to gather feedback on the impact of the project on the local society. Calculate the percentage increase in community engagement compared to pre-project events.	Percentage increase in community engagement compared to pre-project events. Our goal is to score a large-size effect, but a medium-size effect is more realistic.

Organizations involved

Our green action plan is a testament to the power of collaboration and the contributions of various organizations and stakeholders. This project is a collective team effort that involves the commitment and expertise of several key entities:

School Administration: The school administration serves as the backbone of this project. Their unwavering support and vision have set the stage for our sustainability initiatives. Their dedication to creating a greener and more energy-efficient campus has been the driving force behind this project, and their leadership continues to guide our actions and decisions.

Teachers and Students: Our teaching staff and students are at the heart of our green action plan. Teachers play a pivotal role in integrating the project into the teaching process, supervising students' activities, and ensuring the accuracy and reliability of data collected. Students, on the other hand, actively engage with the project, using it as a practical platform to apply their knowledge and connect classroom learning with real-world sustainability challenges. Their enthusiasm and active involvement are driving forces in our journey toward a more sustainable campus.

Student Organizations like the Design and Technology Group (DTG): The Design and Technology Group (DTG) has been an invaluable partner from the project's inception. It has played a crucial role in shaping the project's vision and implementation. DTG members have been actively involved in various phases of the project, providing insights, solutions, and hands-on contributions. Their continuous support and dedication demonstrate the power of student-led initiatives in driving change.

Corporate Partners - Signify: One of our most significant external partners is Signify, a global leader in smart lighting systems and indoor environment control. Signify's involvement in our project is a testament to their commitment to sustainability and innovation. They not only provide the equipment essential for our smart lighting system but also share their invaluable experience and knowledge. Signify views our school as a live laboratory (live lab) for sustainable lighting solutions, turning our campus into a real-world case study. This partnership is a win-win process that benefits both our school and Signify, further underscoring the importance of collaboration between education and industry.

Together, these organizations and stakeholders constitute the driving force behind our green action plan. Their commitment, expertise, and shared vision for a more sustainable and environmentally responsible future have propelled our project forward. Through this collaborative effort, we aim to inspire and educate our school community about the significance of sustainability, while actively contributing to a greener, more energy-efficient campus. This collective endeavor showcases the transformative potential of teamwork, where multiple organizations unite to create a positive impact and a brighter, more sustainable future.

7 Contribution of the Action Plans to the project

7.1 Environmental Impact of Retrofitted Educational Buildings

The 5 Educational Buildings participating in the project 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 their Green Action Plans described their concrete actions for the next two years to engage their communities to their renovation projects that are in place. Retrofitting these buildings, offers a viable solution to mitigate their environmental impact. By incorporating advanced technologies and systems that will be proposed by the Champer of Quality, the energy consumption of these buildings is reduced drastically. The Pilot Sites have decided to proceed to various infrastructure Interventions such as construction of green canteen, integration of 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 decarbonization of the energy sector.

The Green Action Plans present 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. At the same time demonstrate how these major investments could be used to promote the sustainability citizenship while at the same time – through the opening of the organization – could have significant social impact to the local communities. Moreover, it highlights the substantial environmental impact of retrofitting educational buildings and the pivotal role of the pilot sites Green Action Plans within the project, showing how they contribute to energy reduction, decarbonization of the energy sector, and the promotion of open schooling.

7.2 Expected contribution to the project

The development of the Green Action Plans 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 Green Action Plans, it was shown that key aspects such as Energy Storage and Energy Management have been thoroughly discussed leading to the proposal of tailored solutions and educational activities 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 the implementation of the Green Action Plans that will show the road for testing in real conditions the 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 Green Action Plans 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 (Section 5.1 and Chapter 6) has been 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.

8 Summary

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. At the same time the Deliverable, and more specifically Chapter 6 is the outcome of an extended exercise that the pilot sites representatives have realized to describe how the selected buildings that are going through the proposed renovations will act at the same time as innovative learning spaces, green living labs where pedagogy and technology are coming together to propose new learning environments that facilitate the green transition. Through the Green Action Plans in 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, the critical role of stakeholders in shaping these solutions and driving the data collection and analysis processes that inform strategic decision-making is highlighted. Devoted core teams are coming together with experts in the field to co-design the proposed interventions in a two-year long time-plan. Specific and detailed KPIs have been developed under the guidance of the technical and the evaluation team. A key parameter for the successful delivery of the Green Action Plans 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 preparation of the Green Action Plans 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 Green Action Plans will act as reference for 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 Green Action Plans 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 implementation of the Green Action Plans (WP4), through the continuous support of the Technical Team (WP3) and the systematic assessment of their impact to the local communities (WP5).

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