



Synergizing Buildings Renovation and Regenerative Urban Furniture to Co-create PED Ecosystem

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Statement of originality

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About the project

SET-PED aims to integrate buildings envelope renovation and urban furniture design to co-create a new PED ecosystem across different climates zones. This project offers low-carbon, circular economy-based solutions for public space transformation and energy resilience, utilizing local resources for co designing and co-implementing smart urban furniture, integrated within the social landscape (as a valued place by the residents), and integrated within sustainable development initiatives: PED and LEC. The project has four objectives:

- model and assess envelope renovation designs using circular bio-based systems by considering cross-impacts towards both reduction of environmental impacts and increase building energy performances.
- identify potential recycled materials for urban furniture to redesign production processes.
- develop an urban furniture prototype in each participating country, using recycled building material and incorporating a solar PV, recycled battery storage, and micro-grid energy hubs (nodes) for the optimized energy flow in a PED or LEC context.
- collaborate with different stakeholders to co-create a potential roadmap for smart urban furniture as the new standard in the case of integrated circular-economy-based renovation projects able to perceive the solution not just as a stand-alone element, but as a valuable intervention fostering PED and LEC diffusion and having the role of social coagulant.

Therefore, SET-PED combines expertise in building renovation, renewable energy, digital fabrication, design-based research, and urban planning to develop a sustainable and circular co-creation process. SET-PED will test pilots in Mascalucia (Italy), Eskilstuna (Sweden), and Bucharest Sector 6 (Romania) with the aim to enable the development, testing, and communication of circular co-design on an EU level. The design of prototypes in the pilots will be co-developed with stakeholders depending on local context, which will be further tested from aspects of energy generation, storage, distribution, and local demand through predictive modelling and advanced coordinated control strategy for optimized energy flows.

1. The project at a glance

SET-PED (Synergizing Buildings Renovation and Regenerative Urban Furniture to Co-create PED Ecosystem) is a three-year research and innovation project funded under the Driving Urban Transitions (DUT) Partnership, Call 2023, and developed across three pilot cities: Eskilstuna in Sweden, the Sector 6 district of Bucharest in Romania, and Mascalucia in Italy. The project addresses the energy, architectural design, environmental and social dimensions of the urban transition in an integrated manner, by combining the deep renovation of the existing building stock, the circular reuse of construction materials, and the co-creation of regenerative, solar-powered urban furniture conceived as a shared centre for local energy generation and social aggregation.

Within the DUT framework, SET-PED contributes primarily to the Positive Energy District (PED) Transition Pathway, and specifically to PED Topic 2 on urban regeneration and refurbishment, while also responding to the Circular Urban Economies (CUE) Pathway through its emphasis on the built environment as a resource base and on regenerative urban design. The project is coordinated by the University of Catania (UNICT) and brings together universities, municipalities, small enterprises and civil-society organisations from Italy, Sweden and Romania, with the University of Palermo (UNIPA) acting as DUT PED Knowledge Hub designated Expert.

During the first year of activity, the project finalised the design of its regenerative urban-furniture prototype, including the modular energy integration hub; completed a first inventory of circular climate-adapted renovation solutions supported by a systematic literature review; characterised the pilot districts; and consolidated its presence within the DUT PED Knowledge Hub. This document summarises, for a broad public audience, the main research activities and results obtained during the first reporting period. Activities that remained in progress at the end of Year 1, such as the physical realisation of the prototypes and the prototype-level life-cycle assessment, are identified as such and will be reported, once consolidated, in the next annual summary.

2. The regenerative smart urban furniture: prototype design

ITERATIVE PROTOTYPING AND ENERGY INTEGRATION (DESIGN PHASE) · WORK PACKAGES 3 AND 4

The technical core of SET-PED is a modular, solar-powered urban-furniture system, designed to generate and supply renewable energy locally while offering a regenerated public space for social use. During the first year the work concentrated on the design of this system rather than on its physical realisation, which is scheduled for the next phase. The design integrates three elements within a single object: a timber structure providing seating and a sheltering canopy, a set of circular and reused materials, and an energy system that converts the furniture into a small, local generator of renewable electricity. The integration of the energy hub into the furniture is led by Dalarna University and was finalised and tested during autumn 2025. The hub includes the photovoltaic modules, supplied by the project cooperation partner Midsummer, a battery, and auxiliary technical equipment. It was conceived as a mountable, modular kit so that it can be replicated across the three pilots despite their differing contexts; it delivers low-voltage electrical power, at 12 V, to the functions of the urban furniture, which are themselves being defined through the co-creation process. The architecture was sized to be replicated across the three pilots, providing the basis for the energy simulation and performance optimisation planned for the next reporting period, once the prototypes are physically installed.

The prototype design was governed by an explicit set of design criteria, developed jointly by the design and research partners. The technical requirements of public furniture (load-bearing capacity, weather and corrosion resistance, safety and accessibility, maintainability and adaptability) have been developed by Imottesjo and Dalarna University, circular-economy principles (design for disassembly, modularity, documented reuse and recyclability) have been studied by University of Palermo, the community co-creation activities (perception, needs and wishes, site context and landscape) have been carried out by Urbasofia, IntreVecini and Shared City. The selection of materials was framed by a dedicated set of criteria in which the absence of hazardous substances is treated as a non-negotiable requirement, alongside structural performance, durability under outdoor conditions, modularity for disassembly, documented previous use and local origin. On this basis, a circular material set was defined for the prototype, summarised in Table 1.

Table 1. Circular material set defined for the SET-PED urban-furniture prototype

Material	Source and origin	Circular rationale	Role in the prototype
Thinned timber (aspen, oak)	Locally thinned, Urban salvaged timber, forest timber, Eskilstuna	Renewable, low embodied carbon, biogenic carbon storage	Structural frame, canopy and seating
Recovered granite	Reclaimed mineral material	Reuse of a durable, high-strength material	Base and foundation elements
Reclaimed galvanised steel	Recovered from a decommissioned local kindergarten, and an elderly home	Reuse of corrosion-protected structural metal	Structural supports and fixings
Reclaimed stainless steel	Recovered from the elderly home building (kitchen)	Corrosion-resistant reuse, long service life	Surfaces and connections
Photovoltaic module + energy hub	New components (PV supplied by Midsummer)	Local renewable generation at 12 V	Energy supply to the urban-furniture functions

This material strategy is consistent with the evidence collected in the project's state-of-the-art review, which identified circular urban furniture as a still-emerging field in which environmental performance is dominated by the choice of materials and by design decisions, and in which design for disassembly, local reuse and eco-design are the most promising strategies. SET-PED contributes to this field by treating urban furniture not as an accessory design layer, but as an interface between public space, locally sourced material flows and community-oriented regeneration

3. Circular, climate-adapted renovation solutions

CLIMATE-ADAPTED CIRCULAR RENOVATION · WORK PACKAGE 2

This research line addresses the renovation of the existing building stock through a life-cycle and circular-economy perspective, on the premise that the preservation and selective upgrading of existing buildings generally yield greater environmental benefits than demolition and replacement, once the embodied impacts of construction are taken into account. During the first year, a database of circular, climate-adapted deep-renovation design solutions was completed, organising envelope-renovation strategies together with their associated bio-based and recycled material options and their expected energy and environmental performance.

This database was underpinned by a systematic state-of-the-art assessment carried out as a PRISMA-based literature review. The review screened 114 records, 59 from Scopus and 55 from Web of Science, covering the period 2010–2025; after the removal of 42 duplicates, 72 records were screened, 47 were assessed in full text and a final sample of 26 studies was retained. The analysis was structured around three intervention domains, namely building retrofit and energy renovation, the management and valorisation of construction and demolition waste (CDW), and urban regeneration based on circular materials and green infrastructure, and it drew on methodological approaches including Life Cycle Assessment (LCA), Building Information Modelling coupled with LCA, building-stock and spatiotemporal models, Geographic Information Systems (GIS) and urban-mining and logistics models.

Three results are of direct relevance to the pilot cities. First, preserving and selectively upgrading the existing stock shows lower life-cycle environmental impacts than demolition and replacement once upfront embodied impacts are considered, so that circular renovation is more robustly assessed through component-specific approaches than through generalised frameworks. Second, no universal material hierarchy emerges: the environmental value of recycled, reused and bio-based materials depends on the component considered, the scenario assumptions, the selected indicators and the service-life and replacement cycles adopted. Third, the recovery potential of CDW at the territorial scale is conditioned not only by material availability but by transport organisation, sorting quality and the capacity of local recovery and reuse chains. The principal circular material strategies identified for the building envelope are summarised in Table 2.

Table 2 Circular and bio-based material strategies for building renovation (synthesis of the SET-PED state-of-the-art review)

Material family / strategy	Building application	Circular rationale	Key constraints
Bio-based insulation materials	Wall, roof and internal insulation in renovation	Lower embodied burdens and biogenic carbon storage	Moisture behaviour, durability, fire requirements, service-life assumptions
Agro-industrial residue-based products	Non-structural masonry units, bricks, envelope components	Valorisation of residual biomass; reduced virgin-material demand	Feedstock quality, manufacturing routes, local availability
Prefabricated circular envelope systems	Façade retrofit and added insulation elements	Design for disassembly combined with energy upgrading	Upfront impacts, logistics, assembly and component service life
Secondary and recovered materials in refurbishment	Selective replacement of envelope and finishing components	Reuse/recycling of existing flows; fewer virgin inputs	No universal hierarchy; outcomes vary with scenario, indicators and replacement cycles
Recovered construction and demolition material streams	Secondary supply for district-scale renovation products	Urban mining and recovery of demolition-flow stocks	Strongly conditioned by local infrastructure, market conditions and traceability

In parallel, a district-scale characterisation of the pilot areas was initiated, combining building-archetype definition with energy modelling in order to frame renovation interventions at the neighbourhood level, with an additional Italian reference district considered alongside the three pilots. At the prototype scale, a cradle-to-grave LCA of the regenerative urban furniture was initiated, with the functional unit defined as one prototype providing public seating and local energy generation through the integrated photovoltaic-energy hub; data collection covered material quantities, origin and suppliers, transport and energy use, and the analysis will deliver a contribution analysis, the identification of environmental hotspots and the definition of eco-design strategies. This prototype-level assessment remains in progress at the close of Year 1.

4. Co-creation and the reading of public space

ITERATIVE PROTOTYPING AND COMMUNITY CO-CREATION · WORK PACKAGES 3 AND 5

A defining feature of SET-PED is that the renovation of buildings and the design of urban furniture are approached as co-creation processes rather than as purely technical exercises. During the first year, the Her City methodology, facilitated by Shared City Foundation (and UN-Habitat) was adopted as the shared co-creation strategy across the three pilots, providing a structured and inclusive sequence of tools through which residents and local actors contribute to the analysis of public space and to the definition of design priorities.

Qualitative public-space assessments were carried out with the Her City Toolbox together with target groups and local stakeholders in Eskilstuna and in the Sector 6 district of Bucharest, combining on-site spatial analysis, the mapping of accessibility, perceived safety and patterns of everyday use, and structured co-design sessions. In Eskilstuna the assessment culminated in a two-day co-creation workshop on 27–28 August 2025 and produced a state-of-the-art analysis identifying the optimal locations for the prototypes (Figure 1). The same methodology and associated training were transferred to the Italian and Romanian teams in order to prepare the equivalent activities in Mascalucia, scheduled for the following reporting period. The co-creation activities for the city of Mascalucia will take place in the Monte Ceraulo park, the case study of the project, in March 2026. The work delivered a deeper, place-specific understanding of community needs and of the opportunities offered by each site, and it established a common analytical language across pilots that differ markedly in climate, urban form and institutional context.



Figure 1 Participatory assessment of public space in Eskilstuna using the Her City methodology: an on-site walk to read accessibility, perceived safety and everyday use of the area

The Eskilstuna workshop functioned as an experimental Urban Living Lab: the technical principles of the energy hub were explained in accessible terms and were demonstrably taken up by participants in their design proposals. The participatory reading of public space also clarified, for many participants, the concept of smart urban furniture as a component of local energy and social infrastructure, a notion that was initially unfamiliar and that acquired concrete meaning through dialogue and direct engagement. The priorities and recommendations produced in these sessions fed directly into the prototype design described above.

5. Empowering communities

CO-DESIGNED URBAN FURNITURE AND INCLUSIVE ENGAGEMENT · WORK PACKAGE 5

SET-PED treats community empowerment not as an outreach activity but as a condition for the technical and social viability of its solutions. During the first year, multi-actor networks were identified and mobilised in the pilot areas through a comprehensive stakeholder mapping and multi-level stakeholder activation. Engagement was particularly structured in the Sector 6 district of Bucharest, where the municipality, school communities, local residents and civil-society organisations were brought together around the project, and it was deliberately targeted towards groups that are often under-represented in urban planning: adolescent girls in Eskilstuna; students, youth and young mothers in Bucharest; and children and families in Mascalucia, for whom preparatory activities were organised ahead of the workshops planned for the next period.

The engagement produced concrete participation. In the Drumul Taberei area of Bucharest, the project was introduced to residents during the West Side Flower Fest, where 26 residents responded to a structured questionnaire on the everyday use, comfort and safety of public space. In October 2025 a co-design workshop with 17 students from the Ion Mincu University of Architecture and Urban Planning carried out site visits and structured co-creation exercises on accessibility, comfort, lighting, safety and the potential functions of smart urban furniture (Figure 2). In Eskilstuna, adolescent girls were the main target group, engaged through the August 2025 workshop. Working closely with local partners proved decisive in securing the commitment of these groups, and the participatory process introduced new practices of collaboration between municipal actors and residents into the early planning of public space, an outcome that constitutes a social and process innovation in its own right. The co-creation activities translated everyday experiences into concrete spatial proposals, several of which were expressed as community-generated visions for regenerated, inclusive and safe public spaces equipped with smart urban furniture. Beyond their design value, these activities revealed the gap between institutional planning perspectives and the lived realities of young residents, and they demonstrated how inclusive participation can generate solutions that are at once more context-sensitive, more socially sustainable and more technically feasible



Figure 2 A student vision from the co-creation workshop: a modular urban furniture concept designed to adapt to community needs and different user groups, supporting rest, social interaction, greenery and flexible use in public space.

6. Sharing results and connecting to the DUT Knowledge Hub

KNOWLEDGE HUB SUPPORT · WORK PACKAGE 7

Within Work Package 7, SET-PED contributed to the activities of the DUT PED Knowledge Hub, including the Knowledge Hub session held on 14 November 2025 and the Topical Kick-off on 10 December 2025. The discussions focused on the main challenges and opportunities for the development and replication of Positive Energy Districts (PEDs), with particular attention to urban regeneration, the built environment, energy integration and the involvement of local communities. SET-PED also participated in the DUT Projects' Event in Milan (September–October 2025), which provided an opportunity to exchange with other DUT projects and contribute to the broader PED discussion.

Within these activities, SET-PED brought a specific interest in the integration of energy strategies with urban regeneration and co-creation processes. In particular, the project presented the potential of smart urban furniture as a multifunctional urban infrastructure, capable of combining renewable energy generation with social interaction and community engagement. This perspective contributed to the discussion on how PED approaches can extend beyond building-level energy performance and address the wider spatial, social and regenerative dimensions of neighbourhoods.

SET-PED also contributed to the definition of the DUT PED Roadmap, understood as a shared strategic framework for identifying priorities, Key Areas of Action and pathways for the development and replication of PEDs. The project contributed by bringing into the Roadmap discussion its specific focus on urban regeneration, co-creation and innovative energy-generating urban infrastructures, and by relating these aspects to the broader objectives identified by the DUT PED community.

The opportunities identified through the Roadmap provide a framework for further developing and positioning SET-PED results within the PED agenda. In particular, the project's approach can contribute to the areas of urban regeneration and refurbishment, the built environment as a resource base, and regenerative urban design. These connections can support the uptake and transferability of SET-PED solutions and methodologies in other urban contexts, while strengthening their contribution to future PED strategies.

7. Key takeaways from Year 1

The first year of SET-PED can be summarised through five findings that cut across the technical and social dimensions of the project:

1. Renovation over replacement. Preserving and selectively upgrading the existing building stock generally outperforms demolition and replacement once embodied impacts are considered, and circularity is most reliably assessed component by component rather than through universal material hierarchies.
2. Circular sourcing is local. The recovery and reuse of construction materials depends strongly on local logistics, infrastructure and market conditions; this was confirmed both in the literature and in the pilot contexts, where materials recovered from a decommissioned building were redirected to the prototype.
3. Co-creation adds technical value. Participatory methods did not merely legitimise the design but improved it, surfacing place-specific needs and constraints that would not have emerged within a single discipline.
4. A new object requires a new conversation. The notion of smart urban furniture as energy and social infrastructure was initially unfamiliar to many stakeholders, and early, face-to-face engagement proved essential for building shared understanding, trust and ownership.
5. Integration is the innovation. The distinctive value of the project lies in combining local renewable energy generation, circular material reuse and inclusive design within a single, replicable object and process.

8. Looking ahead

The second year will consolidate the results initiated during the first reporting period: the inventory of circular renovation solutions will be completed and extended towards prototype-level life-cycle assessment and eco-design; the co-creation activities will be implemented in Mascalucia; the physical prototypes will be built from the design described here and progressively validated together with the local communities, and the engagement with the DUT PED Knowledge Hub will deepen towards the harmonisation of results with sister projects. Practical examples of these synergies include the exchange of knowledge and results with sister initiatives within the DUT PED framework, the alignment of approaches and methodologies, and the contribution of SET-PED perspectives to joint discussions and roadmap development. These developments will be reported in the next annual public results summary.

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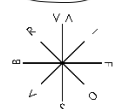


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