„PNRR: Fonduri pentru România modernă și reformată!”

National Competence Centre and solutions for the development of Climate Neutral and Smart Cities

Deliverables - Project 2

„PNRR. Finanțat de Uniunea Europeană – UrmătoareaGenerațieUE”

https://mfe.gov.ro/pnrr/ https://www.facebook.com/PNRROficial

Deliverables - Project 2

P2.D1.1. Study concerning energy transition approach and goals
Within this study, the project documents the reference approach and goals for local energy transition towards climate-neutral cities. Our analysis connects municipal energy use, greenhouse gas inventories and the transition logic required for short-, medium- and long-term decarbonisation. It specifically reports the baseline categories of consumption, energy carriers, decarbonisation priorities and the expected contribution of accessible smart technologies, renewable energy and energy efficiency measures. The main competencies obtained are urban energy diagnosis, GHG baseline assessment, transition-roadmap framing and alignment of technical measures with local climate-neutrality objectives. The result is the strategic foundation for the methodologies, digital replications, pilots and training activities developed in the following work packages.
P2.D1.2. Methodology for the Smart and Carbon neutral Cities
The methodology for analysing and supporting smart and carbon-neutral cities translates the climate-neutrality objective into an operational workflow: data collection, energy and emissions inventory, multi-benefit assessment, prioritisation of actions, monitoring indicators and replication principles. The report specifically connects energy systems, buildings, renewable resources, smart grids, environmental data and stakeholder participation in one decision-support logic. The competencies developed and presented in this report include climate-neutrality methodology design, indicator definition, multi-sector diagnosis and evidence-based planning for lighthouse and follower cities. The result is a replicable methodological framework that enables municipalities to prepare roadmaps and compare interventions across the energy, environment and digitalisation dimensions.
P2.D1.3. Smart energy grids
The Deliverable reports on the role of smart energy grids in the transition to carbon-neutral cities. The content addresses the connection between distributed

generation, prosumers, monitoring, demand response, grid flexibility and digital data exchange. It specifically reports how smart grids support renewable integration, efficient operation and coordination between producers, consumers and local energy-management platforms. Competencies developed include smart-grid concept analysis, grid-flexibility assessment, prosumer integration, data-driven monitoring and alignment of electricity infrastructure with climate-neutrality objectives. The result is a technical and conceptual basis for later work on smart contracts, demand response, PV networks and AI-assisted energy management.

P2.D1.4. Modern energy infrastructure and collaborative management platform (including quality and risk management)

The Deliverable reports on the modern energy infrastructure and collaborative management platform needed for coordinated energy-transition activities. The content links infrastructure planning with collaborative management, quality control, risk management and operational coordination between partners and city stakeholders. It specifically reports how energy-transition work can be governed through shared data, documented processes, responsibility allocation and continuous monitoring. Competencies developed include energy-infrastructure governance, collaborative platform planning, quality and risk management, stakeholder coordination and implementation discipline. The result is a management foundation that supports the reliable deployment, monitoring and replication of P2 energy and environment solutions.

P2.D1.6. Smart & Carbon Neutral Cities courses

The Deliverable reports the preparation of educational content dedicated to smart and carbon-neutral cities. The courses translate project knowledge on energy transition, smart infrastructure, renewable energy, carbon footprint, digitalisation and urban sustainability into learning materials for schools, public institutions and wider stakeholder groups. The content specifically supports awareness and capacity building around climate neutrality, linking technical concepts with accessible explanations and practical city examples. Competencies obtained include curriculum design, educational translation of technical content, stakeholder communication and climate-literacy development. The result is a training resource that helps embed P2 knowledge in communities and supports long-term adoption of smart and low-carbon solutions.

P2.D2.1. Digital replication of the entire infrastructure involved in energy efficiency and energy transition towards climate neutral cities, and of all kinds of green and renewable energy resources from the smart city

The NetZeRoCities project developed the digital replication logic for the full infrastructure involved in energy efficiency, environment and energy transition. The content reports the digital representation of urban energy assets, renewable resources, PV panels, energy infrastructure and data categories needed for climate-neutral planning. It supports the identification of total renewable-energy capacity at city level and the assessment of its local environmental impact. The competencies obtained include infrastructure mapping, renewable-resource modelling, PV asset representation, data structuring and digital-twin scoping. The presented result is a first operational layer for representing energy-transition infrastructure and green resources in a smart-city Digital Twin environment.

P2.D2.2. Digital replication of the full community of actors representing energy providers, consumers and prosumers from the smart city

We present an extension of the Digital Twin approach from physical assets to the community of actors involved in the local energy ecosystem. Based on Task 2.2, the report structures the representation of energy providers, consumers, prosumers, public authorities and other city stakeholders through roles, interactions, data flows and decision points. It specifically reports how demand, distributed generation, prosumer participation, feedback loops and brainstorming inputs can be translated into a digital actor model. The competencies developed include stakeholder mapping, socio-technical modelling, data-governance framing and collaborative energy-management analysis. The presenteed result is a basis for digital-twin components that reflect both the technical and organisational dimensions of urban energy transition.

P2.D2.3. Digital replication of energy-efficient buildings to be represented on the Digital Twin platform with their specific energy related characteristics

The Deliverable reports the digital replication of energy-efficient, nZEB and positive buildings with their specific energy-related characteristics. Based on Task 2.4, the report addresses the virtualization of buildings, automation devices, sensors, actuators and contextual parameters that must be represented on the Digital Twin platform. It specifically supports the integration of building energy consumption, operational features and monitoring data into city-level energy analysis. Competencies developed include building energy modelling, digital-twin representation of automation components, sensor-data structuring and interoperability planning. The result is a reusable digital model layer for analysing energy-efficient buildings and connecting them with urban decarbonisation scenarios.

P2.D2.4. The Digital Twin of specific data architecture related to energy efficiency

The Deliverable reports the Digital Twin of the specific data architecture related to energy efficiency. Based on Task 2.5 in NetZeRoCities, the deliverable consolidates data sources, interfaces, entities, relationships and real-time transfer requirements needed to update energy and infrastructure data dynamically at smart-city Digital Twin level. It specifically includes the lifecycle representation of PV panels and the integration of energy-efficiency data with the wider platform. Competencies obtained include data-architecture design, real-time interface planning, digital-twin implementation logic, interoperability modelling and analytics-oriented data structuring. The result is a demonstrator-level architecture that enables monitoring, benchmarking and scenario analysis for climate-neutral energy planning.

P2.D3.1. Digital online smart tools – knowledge sharing hubs and replication

The deliverable presents the details behind the digital online smart tools for knowledge sharing, replication and stakeholder engagement. The content reports hubs and online resources for citizens, civil society, professional associations, the public sector and the business environment. It also integrates inputs for specification definition and prepares the transfer of methodologies, datasets, lessons learned, technical recommendations and pilot knowledge between lighthouse and follower cities. The competencies developed include digital knowledge management, replication planning, stakeholder-oriented communication and structuring of reusable energy-transition resources. The

result is a practical online basis for making P2 solutions visible, accessible and transferable beyond individual reports and local demonstrators.

P2.D3.2. Designing the piloting coordinates of the 3 lighthouse cities -Bucharest Sector 2, Suceava and Cluj-Napoca, and their followers

The Deliverable presents an analysis of piloting coordinates for the three lighthouse cities - Bucharest Sector 2, Suceava and Cluj-Napoca - and for estimated follower cities. Based on Task 3.2 in NetZeRoCities, the report structures the territorial logic, stakeholder context and replication conditions needed to transfer P2 energy and environmental solutions. It specifically reports the criteria for linking smart tools, PV solutions, energy-transition methods and knowledge-sharing outputs to city needs. Competencies obtained include pilot-design planning, replication strategy, stakeholder alignment and city-context assessment. The result is a coordination framework that connects lighthouse pilots with follower-city adoption and enables the scaling of non-polluting energy and green-environment solutions.

P2.D3.5. Intelligent systems for the automatic rotation of solar panels in the direction of the sun

The report on intelligent systems that automatically rotate solar panels towards the sun is connected to Task 3.5, and it covers the concept, design, development, implementation and testing of solar-tracking functionality. It specifically shows how continuous orientation can improve PV energy yield and how the tracking system can be integrated into smart solar panel networks. The competencies obtained include solar-tracking system design, control logic, mechanical/electrical integration, prototyping and test-based performance interpretation. The result is an intelligent support system that increases the effectiveness of renewable generation and strengthens the technological maturity of smart PV solutions for climate-neutral cities.

P2.D3.6. Intelligent/robotic systems for continuous cleaning of solar panels& IoT based smart solar panels networks management

The Deliverable reports on the development of intelligent and robotic systems for

continuous cleaning of solar panels together with IoT-based management of smart solar panel networks. Linked to Task 3.6 in NetZeRoCities, the content covers the concept, design, development, prototyping, implementation and testing of cleaning and monitoring systems. It specifically addresses the need to preserve PV performance by reducing soiling losses and by managing PV assets through sensor and IoT data. Competencies obtained include robotic-system conception, PV maintenance automation, IoT network management, prototyping and operational testing. The result is an integrated technological solution that improves reliability and efficiency of solar generation in smart-city and smart-campus contexts.

P2.D3.7. Smart Grid / block chain based smart contract technology

The Deliverable presents the development details behind the Smart Grid and blockchain-based smart contract technology. The content is linked to Task 3.7 in NetZeRoCities and covers specification work for smart contracts, trusted data exchange, automated energy rules, prosumer coordination and possible decentralised transactions. It specifically reports how blockchain concepts may support transparent, programmable and auditable energy interactions in smart-city contexts. Competencies developed include smart-contract specification, distributed-ledger awareness, smart-grid transaction modelling, trust mechanisms and evaluation of applicability for energy communities. The result is a technical-conceptual basis for decentralised energy management, supporting demand response, prosumer participation and new operational models for climate-neutral urban energy systems.

P2.D3.8. Flexible and active Demand Response individual and aggregated blocks of buildings, and AI Cognitive energy management

The Deliverable reports flexible and active Demand Response for individual and aggregated buildings together with AI cognitive energy management. The content addresses load flexibility, aggregation logic, control strategies, user/building constraints and artificial-intelligence support for optimisation. It specifically reports how buildings can shift or adapt demand in order to support grid stability, renewable integration and emissions reduction. Competencies developed include demand-response modelling, building aggregation, AI-assisted energy optimisation, flexibility assessment and decision-support design.

The result is a framework for using demand-side intelligence as a complement to energy efficiency, PV generation and Smart Grid operation.

P2.D3.9. Case analysis of the use of photovoltaic panels on a typical building in Bucharest

The Deliverable presents a case analysis of photovoltaic panel use on a typical building in Bucharest. Based on Task 3.9, the report evaluates the applicability of PV systems in an urban building context, including technical constraints, energy-generation potential, integration assumptions and environmental relevance. It specifically supports evidence-based decision-making for municipal and building-level renewable-energy investments. Competencies obtained include building-level PV assessment, case-study methodology, interpretation of local solar potential, integration with building energy demand and communication of results for urban replication. The result is a practical reference case that helps translate general PV concepts into a concrete Romanian city-building application.

P2.D4.3. Mobile application for smart lighting networks

The Deliverable presents implementation details for an Android mobile application designed and developed for the control and monitoring of smart lighting networks in the context of the NetZeRoCities project. The application uses the MQTT protocol to communicate with IoT devices (smart switches and lighting fixtures), providing functionalities for status and brightness control, automatic reconnection, and continuous background operation through a Foreground Service. The solution architecture incorporates robust security mechanisms, including encrypted communication via TLS, secure local storage of credentials, and Access Control List (ACL) policies at the MQTT broker level. These features ensure the protection of communications and system integrity both within local networks and in remote access scenarios.

P2.D4.4. User satisfaction study with human-centric lighting

The Deliverable presents a study conducted to assess users' perceptions of the Human-Centric Lighting (HCL) concept, involving 50 respondents. The results indicate a strong interest in the adoption of this type of lighting system, with more than 80% of participants positively evaluating its benefits in terms of

visual comfort, productivity, and overall well-being. The lighting personalization features and the ability to adapt lighting conditions to the natural daily rhythm were rated very favorably, confirming the usefulness and attractiveness of the proposed solution. The study also identified the need for additional awareness and educational initiatives, as well as simplification of the configuration process, to facilitate the wider adoption of user-centered lighting systems.

P2.D4.5. Architecture and technology for hybrid smart lighting network

The Deliverable presents the details behind the hybrid smart lighting system, that was designed, developed, and implemented, integrating the concepts of Human-Centric Lighting (HCL), Visible Light Communication (VLC), and LiFi into a unified architecture. The solution combines commercial components dedicated to HCL and LiFi functionalities with an internally developed VLC module, providing both advanced user-adaptive lighting services and light-based communication capabilities. The proposed architecture demonstrates the feasibility of integrating intelligent lighting and communication technologies into a single platform, with relevant applications for smart buildings and sustainable cities. The tests performed validated the functionality, interoperability, and overall performance of the integrated components within the proposed system.

P2.D5.1. Lab validated prototype for the Smart Green Environmental management platform

The deliverable reports on the laboratory validation of a prototype for the Smart Green Environmental Management platform. The deliverable is framed by the objectives fo intelligent optimisation of waste management, Landsat and environmental-data management, data-to-ontology translation and pollution reduction. It reports the platform concept, functional modules, environmental data categories, user interactions and decision-support logic for green and non-polluting solutions. The competencies obtained include platform specification, environmental-data integration, lab validation of digital services, ontology-oriented data thinking and preparation of tools for urban sustainability monitoring. The result is a validated platform prototype that supports later telemetry, pollution-monitoring, Landsat-data and carbon-footprint activities.

P2.D5.2. Environmental Telemetry System

The Deliverable presents an Environmental Telemetry System for smart cities. The content is linked to Task 5.3 in NetZeRoCities and reports time-critical telemetry, environmental data flows, interoperability principles and the use of blockchain concepts for trusted smart-city data exchange. It specifically includes the use of weather-sensor data mounted on smart solar panels and the translation of data lakes into ontologies that preserve information while enabling additional relations to be inferred. Competencies obtained include telemetry architecture, environmental sensing, blockchain interoperability awareness, ontology-based data structuring and integration of PV-mounted sensors. The result is a telemetry layer able to support environmental monitoring, traceability and decision-making in climate-neutral smart-city applications.

P2.D5.3. Intelligent/selective waste collection system

The Deliverable reports an intelligent and selective waste collection system based on low energy consumption. The content is connected to Task 5.1 in NetZeRoCities and addresses smart optimisation of waste collection using route-reduction algorithms and smart bins able to signal when they are full and ready to be discharged. It specifically reports how supply-chain optimisation can reduce collection costs, fuel consumption and environmental impact. Competencies obtained include smart waste-management design, optimisation logic, sensor-enabled bin monitoring, low-energy operational planning and urban service efficiency analysis. The result is a practical system concept for cleaner and more efficient waste collection as part of Smart Green Environmental management.

P2.D5.4. Environmental data management platform– including data from Landsat monitoring

The Deliverable reports an environmental data management platform that includes data from Landsat monitoring and other geospatial sources. The content covers environmental-data management, satellite imagery, UAV and vector data, geoportal data and statistical sources that can be analysed in GIS. It specifically supports the identification of pollution, subsidence, urban expansion, property boundaries, green spaces and vacant lands, as well as AI processing of environmental patterns. Competencies obtained include geospatial-data integration, remote-sensing interpretation, GIS-based environmental analysis, data-platform design and urban sustainability diagnosis. The result is a data platform that combines local and satellite-based evidence for decision-making.

P2.D5.5. IoT-based pollution monitoring system
The Deliverable reports an IoT-based pollution monitoring system for smart-city environments. The content is linked to Task 5.4 and Task 5.5 in NetZeRoCities, and covers pollution monitoring with IoT, urban demonstrations, conceptual development of an air-quality smart monitoring network, prediction and early-warning functions. It specifically reports sensor nodes, data collection, communication, monitored parameters and integration with environmental platforms. Competencies obtained include IoT system design, pollution-data acquisition, environmental analytics, smart monitoring-network planning and transformation of measurements into actionable indicators. The result is a monitoring system that supports urban diagnosis, pollution reduction and evidence-based environmental management.
P2.D5.6. Carbon footprint assessment
The Deliverable reports carbon footprint assessment activities relevant to cities, campuses and buildings. The content is directly linked to Task 5.5 in NetZeRoCities, which includes carbon-footprint assessment, early-warning logic and a roadmap for complete decarbonisation with smart tools. It reports emissions sources, calculation boundaries, data requirements, interpretation of results and links with energy and environmental measures. Competencies obtained include GHG accounting, carbon-data analytics, interpretation of reduction potential, roadmap development and preparation of evidence for local climate contracts or action plans. The result is an assessment layer that allows P2 stakeholders to measure progress towards net zero and prioritise decarbonisation measures.
P2.D7.1. Awareness and dissemination activities – final report and results document
The Deliverable reports awareness and dissemination activities for non-polluting energy and green-environment solutions. Based on Task 7.1 in NetZeRoCities, the report consolidates communication actions, workshop materials, events, city interactions and stakeholder engagement used to explain the value and necessity of adopting P2 solutions. It specifically includes dissemination towards citizens, public authorities, professional communities and the business environment, including PV-related workshop materials and technical-assistance

activities. Competencies obtained include dissemination planning, public communication, stakeholder engagement, technical presentation of climate-neutral solutions and impact documentation. The result is a final evidence base showing how P2 outputs became visible, understandable and usable for wider urban communities.

P2.D7.2. Education and training documents – guidebook

The Deliverable provides education and training documents in the form of a guidebook for non-polluting energy and green-environment solutions. Linked to Task 7.2, the deliverable structures practical knowledge for citizens, public administration staff and technical stakeholders. It reports concepts, recommended practices, solution categories and training logic related to renewable energy, energy efficiency, environmental monitoring and climate-neutral planning. Competencies obtained include training-material development, technical communication, stakeholder capacity building and educational structuring of project outputs. The result is a guidebook that facilitates wider understanding and adoption of P2 (green energy) solutions and supports the transfer of research results into local administrative and community practice.

P2.D7.3. Adoption report concerning the non-polluting energy and green environment solutions, referring to all the sectors where these solutions are implemented and exploited – report

The Deliverable reports the adoption of non-polluting energy and green-environment solutions across the sectors where they are implemented or exploited. Linked to Task 7.3 in NetZeRoCities, the content examines public administration, residential buildings and other smart-city sectors, identifying adoption conditions, barriers, enabling factors, benefits and transferability. It specifically connects renewable energy, smart PV systems, energy efficiency, environmental telemetry, pollution monitoring, waste management, digital platforms and carbon assessment with real use contexts. Competencies obtained include adoption analysis, cross-sector synthesis, replication and condition mapping and recommenddation development. The result is an exploitation-oriented report that connects technical deliverables with practical municipal and stakeholder uptake.