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DELIVERABLE D1.3.1
TOR FOR REC OR SELF-CONSUMPTION SCHEME DEVELOPMENT

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Deliverable ID

Project acronym	EnerCmed
Project title	Testing energy-community & climate-resilient integrated paradigm for carbon neutrality and energy poverty shielding in MED city-port hinterlands
Project mission	Promoting green living areas
Project priority	Greener MED
Specific objective	RSO2.4: Promoting climate change adaptation and disaster risk prevention, resilience, taking into account eco-system-based approaches
Type of project	Test project (Thematic Project)
Project duration	01/01/2024 – 30/09/2026 (33 months)

Deliverable title	Methodological ToR by PAT for social engagement of vulnerable populations. UNIGE & ETRA design technical parameters for REC setup. SNL develop legal framework for REC. UNICY proposes UHI integration. Conceptualizing a multicriteria decision-making protocol for marginalized neighborhoods
Deliverable number	D.1.3.1
Deliverable type	Guideline
Work package number	WP1
Work package title	Transnational paradigm of energy-positive & climate resilient MED hinterlands centred on REC & NBS
Activity name	Proposition of a new Hinterland Renewables Communities Action Plan for energy-positive & climate resilient planning paradigm around the concept of Renewable Energy Communities
Activity number	1.3

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Version 3.0	29/06/2025	final	UNIGE

Table of contents

Abbrevations

REC	Renewable Energy Community
KFI	Knowledge Facility Instrument
NBS	Nature-Based Solutions
RES	Renewable Energy Sources
UHI	Urban Heat Island effect
SCS	Self-Consumption Scheme
GSE	Energy Service Manager

Executive summary

This executive summary introduces the Terms of Reference (ToR), a strategic framework designed to guide the establishment of Renewable Energy Communities (RECs) and Self-Consumption Schemes (SCSs) in marginalized hinterland areas, through an integrated approach that combines technical, social, economic, governance, and environmental dimensions.

Framed within a transnational action plan, the ToR offers a unified yet adaptable methodology for project partners to assess feasibility, design interventions, and implement community-based energy solutions that are both energy-positive and climate-resilient. Central to this vision is the incorporation of Nature-Based Solutions (NBS), which strengthen microclimatic performance and contribute to sustainable urban regeneration.

Rather than prescribing a one-size-fits-all model, the ToR enables context-sensitive decision-making through structured chapters, task-based workflows, and validation tools. It lays the groundwork for a systematic, participatory, and replicable model of community energy planning that addresses energy poverty while fostering long-term socio-environmental value.

By aligning diverse expertise and territorial realities within a shared framework, the ToR advances a new paradigm for inclusive and regenerative energy transitions across Europe's hinterlands.

1. Introduction

1.1 Background information of the project

The Clean Energy for All Europeans Package marks a significant milestone in placing citizens at the center of the clean energy transition, establishing a framework that empowers consumers to actively participate in and benefit from clean energy initiatives. As part of it, RECs or SCSs are a way to organize collective and citizen-driven energy action and provide environmental, social and economic benefits to the community members. To contribute to RSO2.4: Promoting climate change adaptation, disaster risk prevention, and resilience while considering ecosystem-based approaches, EnerCmed proposes a new paradigm for energy-positive and climate-resilient hinterlands. This concept focuses on RECs or SCSs and aim to empower marginalized neighborhoods in port hinterlands, where residents such as the elderly, low-income tenants, immigrants, etc. are often vulnerable to energy poverty and struggle to access and organize within RECs or SCSs.

The paradigm will be tested by the activation of 6 RECs or SCSs in marginalized hinterlands of Genova, Valencia, Patras, Pula & Novigrad to gather 345 families/users exposed to energy poverty, generate 278 MWh/y from renewable sources corresponding to 160 tons CO2/year reduction and reduce by 15-20% the energy bills. For each REC or SCSs created, one Nature-Based Solution investment is implemented within the target neighborhoods, serving as a natural heat sink to reduce residential cooling demand and mitigate the Urban Heat Island (UHI) effect.

The innovative idea of this project is to integrate three technical-driven principles, such as the REC SCS, the NBS, and the energy poverty shielding. In this perspective, EnerCmed integrates the traditional REC or SCS trilemma (engaging people, ideal business model and governance structure, system engineering/interoperability/digitalization) with the energy planning principle at the micro-site climate & social dimension (marginalized neighborhoods) level. In EnerCmed, the cornerstone of the transnational cooperation is represented by the Knowledge Facility Instrument (KFI), a comprehensive support mechanism where a pool of highly specialized partners helps the pilot partner to transpose the transnational Hinterland Renewables Communities Action Plan into applicable Renewable Energy communities or Self-Consumption schemes and NBS pilots.

The overall methodology is thoughtfully structured into three dynamic work packages, each designed to drive impactful results:

WP1 focuses on developing an innovative Mediterranean paradigm that fosters an energy-positive and climate-resilient hinterland by integrating RECs or SCSs with NBS to address energy poverty and the environmental impact. The Ecosystemic Transition Unit of the Interreg MED Renewable Energy community adapts the Terms of Reference (ToR) to urban contexts and identifies six prospective RECs or SCSs based on key factors such as REC norms, public infrastructure, and energy poverty hotspots.

WP2 implements this paradigm through a pilot action that includes six RECs or SCSs and six NBS, organized into four steps:

I. Engaging families and users within the REC framework.

II. Defining optimal business and legal model for each pilot REC or Self-Consumption scheme.

III. Engineering and installing photovoltaic (PV) systems on public infrastructure and smart home meters.

IV. Deploying NBS as natural heat sinks.

Moreover, a platform will be developed to monitor energy production and consumption within communities, exploring virtual peer-to-peer trading based on the HESTIA project while assessing its broader impacts.

WP3 is dedicated to sustainability and replication, supported by four Action Plans (Genova, Patras, Valencia, IRENA) and service portfolios that aid urban authorities in promoting RECs or SCSs for socio-economically challenged residents. Larnaca will serve as a "meta-replicator" to test a standardized diagnostic model, followed by a multi-city replication initiative led by UNIGE to engage 15 core cities.

1.2 Project objective

The objective of this project is to develop and implement a common, innovative, and scalable model for low-carbon residential hinterlands in the Mediterranean, through the activation of six RECs or SCSs integrated with NBS in marginalized neighborhoods of Genova, Valencia, Patras, Pula, and Novigrad fostering the climate neutrality investments in vulnerable urban areas by promoting the active involvement of disadvantaged groups in the energy transition, addressing energy poverty, and reducing urban thermal stress at the microclimate level. This objective responds to INTERREG Euro-MED's goal of facilitating plans and strategies for energy transition and resilience in cities, reinforcing citizens' engagement for more sustainable living areas, and delivering a multi-city replication programme to enable further MED cities to adopt the solutions.

2. Overview of the Terms of Reference

The Terms of Reference document provides a comprehensive framework detailing the fundamental stages in the development of RECs SCSs. It ensures coherence with the overarching project objectives and deliverables, thereby facilitating effective planning, execution, and long-term success.

2.1 ToR Purpose

The ToR aims to conceptualize a transnational Hinterland Renewables Communities Action Plan for marginalized neighborhoods. That is meant to be an innovative multicriteria decision-making protocol that gathers all the key aspects such as the social engagement, the energy dimension (technical aspects) and the economic/financial/governance dimension enhanced with the principles related to microclimate actions and deliver an efficient energy-positive & climate resilient planning paradigm around the concept of REC through the implementation of 6 NBS.

This Action Plan will provide a common diagnosis and feasibility framework for developing the pilots (WP2) under a unified transnational approach.

2.2 ToR Composition

The ToR will be subdivided into the following sections, and checklists will be provided for each of them to check whether all the necessary information is included in the document.

I. ToR for social engagement of vulnerable Populations

II. ToR for energy community technical design & digitalization of the RECs or SCSs

III. ToR to build a legal, administrative and management structure of the RECs or SCSs

IV. ToR for the application of Nature-Based Solutions (NBS) to mitigate Urban Heat Island (UHI) effects

In order to effectively develop the four main pillars of the project previously mentioned, the process illustrated in Figure 1delineates a comprehensive and iterative process comprising key interlinked steps.

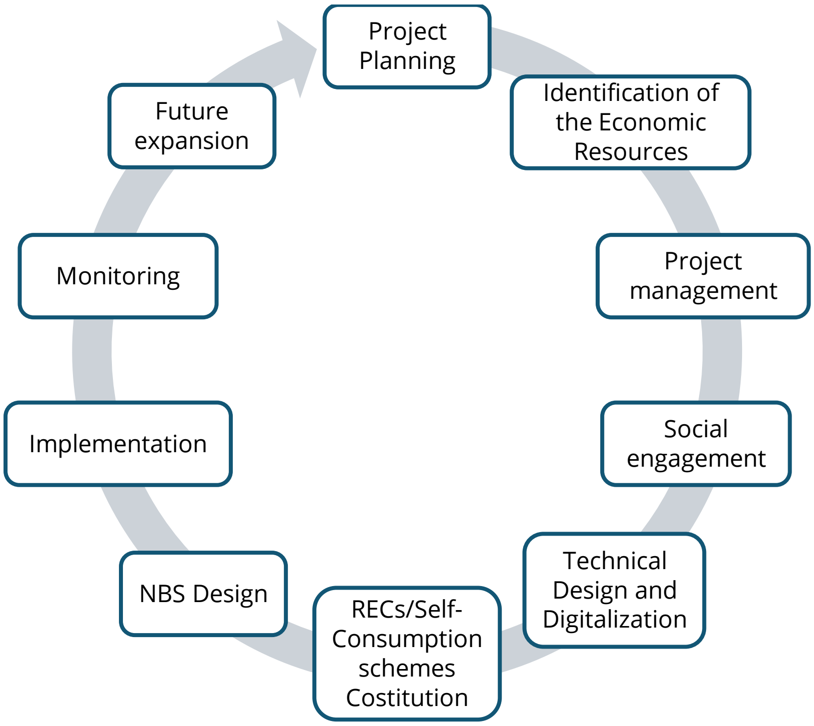

Figure 1. Process Flow for the Implementation of RECs and Self-Consumption Models

The process begins with **Project Planning**, where the strategic vision, goals, and scope of the RECs or SCSs are defined. This is followed by the **Identification of Economic Resources**, ensuring that the necessary financial means, both public and private, are mapped and mobilized to support the initiative.

Next, **project management** must be established as a cross-cutting function to coordinate activities, timelines, and responsibilities across all stakeholders involved. With the project structure in place, the process moves into **Social Engagement**, which focuses on building awareness, participation, and trust among local communities, particularly targeting vulnerable populations. This step ensures that the energy transition is inclusive and community-driven.

Following social engagement, the **Technical Design and Digitalization** phase lays out the necessary engineering, including the integration of renewable energy sources (RES), smart metering, and grid compatibility. At this point, the **Constitution of RECs or Self-Consumption Schemes** is addressed, involving the legal formation of the community or scheme, as well as the development of governance, administrative procedures, and business models suited to local legislative contexts.

In parallel, the **Design of Nature-Based Solutions (NBS)** is carried out, contributing to the environmental pillar of the project. This step focuses on selecting and integrating interventions that mitigate the Urban Heat Island (UHI) effect and enhance urban resilience, thereby fostering energy-positive and climate-adaptive neighborhoods.

Once the structural and technical foundations are in place, the **Implementation** phase commences. This includes the physical deployment of energy infrastructure, digital tools, and the activation of community governance structures. Post-implementation, the **Monitoring** stage ensures continuous evaluation of performance, social impact, and environmental benefits, enabling data-driven adjustments where necessary.

Finally, insights and lessons from the initial cycle are used to inform the **Future Expansion** of the REC or SCS. This stage supports scalability and replicability, extending the project's benefits to additional areas or communities and reinforcing its long-term sustainability.

By following this structured and interconnected process, the project ensures that all technical, financial, legal, social, and environmental dimensions are not only addressed but harmonized. This integrated approach enables the robust, inclusive, and scalable implementation of RECS and SCSs across diverse urban contexts. Each step of the process will be further detailed and analyzed in the following chapters, providing methodological guidance and operational tools for their effective implementation.

2.3 ToR organization

As previously mentioned, this document presents an innovative multicriteria decision-making protocol for establishing RECs or SCSs in energy-deprived port hinterlands, which aims to provide economic, social, and environmental benefits. Each ToR is systematically structured into chapters, serving as a clear, step-by-step guideline. Within each section, clearly defined tasks are articulated, accompanied by comprehensive explanations to ensure clarity of purpose and methodological coherence.

3. ToR for Social Engagement of the vulnerable population

Task: Provide a comprehensive overview of the chapter content, including its aim, significance, and the methodology employed.

The Terms of Reference for Social Engagement of Vulnerable Populations aim to define and systematize guiding principles for developing an inclusive engagement strategy tailored to port hinterland communities. The focus is on ensuring the active participation of marginalized and vulnerable groups in RECs or SCSs, through the identification of effective approaches and the establishment of a common framework for community involvement.

3.1 Introduction

Task: Describe the concept of social engagement, with a particular focus on vulnerable populations, their composition, and related aspects.

Social engagement of vulnerable populations refers to the efforts and strategies implemented to actively involve marginalized or at-risk groups, such as low-income families, the elderly, immigrants, socially marginalized communities, and individuals affected by energy poverty, in community initiatives and social activities. These initiatives are designed not only to foster a sense of belonging and social inclusion but also to empower these groups by ensuring their perspectives are acknowledged, their needs are effectively addressed, and they are meaningfully included in decision-making processes that shape the policies and services impacting their daily lives. Such engagement promotes equity, enhances community cohesion, and supports the creation of more inclusive societies.

Figure 2 outlines the key elements of the social engagement strategy targeting vulnerable populations, which will be examined in detail in the subsequent subchapters. These elements include contextual understanding of the vulnerable population aimed at understanding community profiles, identifying specific vulnerabilities and their cultural values; forms of social engagement designed to promote inclusive and participatory approaches; mechanisms for monitoring, evaluation, and feedback to assess impact and ensure continuous improvement; and the integration of engagement strategies with national and regional policies to maintain alignment with broader regulatory and governance frameworks.

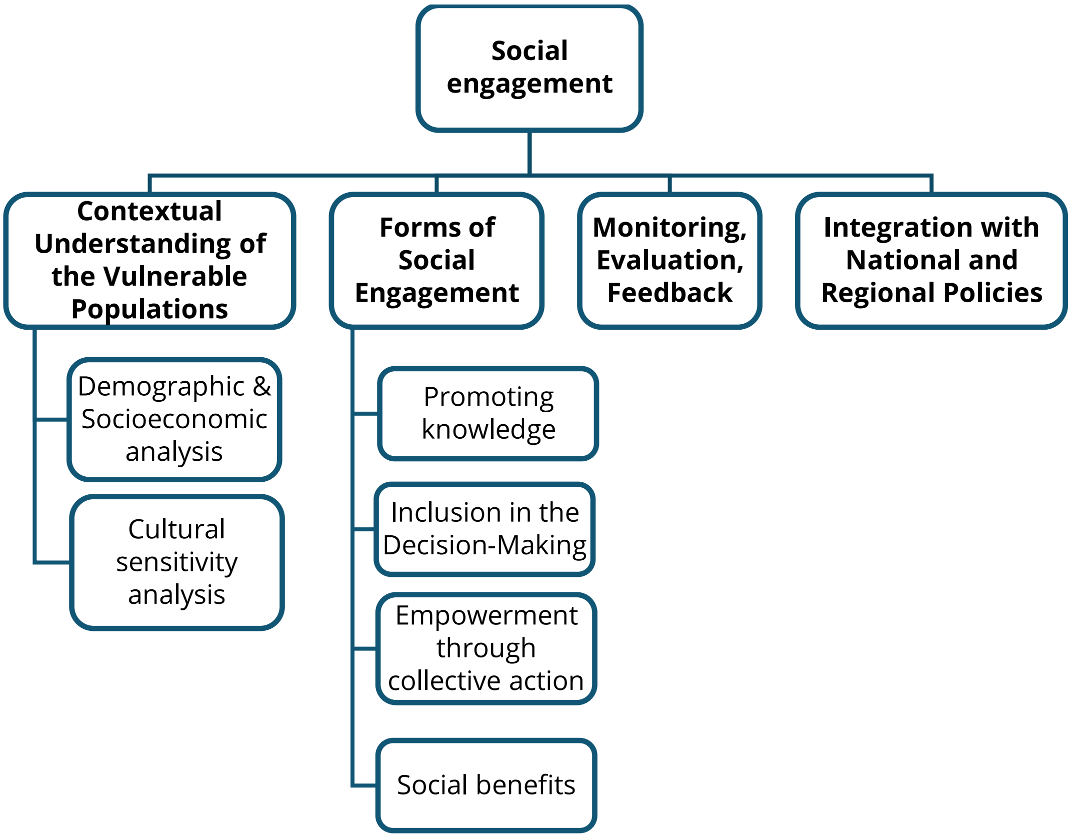

Figure 2. Pillars of Inclusive Social Engagement in Renewable Energy Initiatives

3.2 Contextual Understanding of the Vulnerable Populations

Task: Provide a summary of the analysis needed to assess the vulnerable population.

To identify the social composition in target energy poverty neighborhood hotspots, which are often inhabited by vulnerable populations, some analysis must be carried out, such as Demographic, Socioeconomic and Cultural Sensitivity analysis.

3.2.1 Demographic and Socioeconomic Analyses

Task: Perform a detailed demographic and socioeconomic analysis to assess the composition, living conditions, and cultural context of the target population, to identify specific needs, challenges, and opportunities to support inclusive and effective engagement in the energy transition.

This stage involves comprehensive assessments aimed at gaining a deep understanding of the demographic, cultural, and socioeconomic characteristics of the target population. It includes analyzing factors such as age distribution, income levels, educational attainment, employment status, cultural background, and living conditions. The objective is to identify the unique needs, aspirations, and challenges these communities face, as well as potential opportunities for meaningful engagement. Such analyses provide a solid foundation for designing tailored strategies that are responsive to the realities of the population, ensuring that initiatives, particularly those related to social inclusion in the energy transition, are relevant and effective.

3.2.2 Cultural Sensitivity Analysis

Task: Conduct a Cultural sensitivity analysis to understand the unique values and practices of vulnerable communities, ensuring inclusive and respectful engagement in the energy transition.

This analysis involves recognizing, understanding, and respecting the unique cultural values and practices of vulnerable communities to ensure effective social engagement. Culturally sensitive approaches build trust and ensure that participation is inclusive and respectful, enabling these communities to actively contribute to and benefit from the energy transition.

3.3 Forms of Social Engagement

Task: Provide a summary of the possible forms of social engagement.

Forms of social engagement include promoting knowledge through targeted training and support, involving communities in decision-making processes, empowering vulnerable groups, and delivering tangible social benefits.

3.3.1 Promoting Knowledge, Tailored Outreach and Support

Task: Describe the activities to raise awareness among vulnerable populations using accessible and culturally appropriate tools to promote informed, inclusive participation in Renewable Energy Communities (RECs) and the broader energy transition.

Effective engagement begins with building awareness and understanding among vulnerable populations. This involves organizing targeted open days, workshops, outreach campaigns, utilizing appropriate technologies, such as mobile platforms or community radios, and community events designed to inform and involve marginalized groups. These activities aim to communicate the benefits of initiatives such as renewable energy programs in a clear, accessible, and culturally sensitive manner. In particular, tailored outreach should focus on explaining the concept and functioning of RECs or SCSs, emphasizing their role in promoting clean energy, reducing energy costs, and fostering social inclusion. By equipping vulnerable populations with the necessary knowledge and support, these efforts empower them to participate actively and confidently in the energy transition.

3.3.2 Inclusion in Decision-Making

Task: Describe how to achieve social engagement through inclusion in decision-making.

The active involvement of vulnerable populations in the planning and implementation of community initiatives ensures that programmes such as energy-sharing schemes are effectively tailored to address their specific needs and circumstances.

Early engagement through dialogue, consultations, and participatory workshops allows communities to contribute their perspectives, while collaborative governance platforms ensure their voices are reflected in strategic decisions, leading to more inclusive and effective outcomes.

3.3.3 Empowerment through Collective Action

Task: Describe how the empowerment of vulnerable populations can be achieved through collective action.

RECs or SCSs offer a powerful tool for empowering vulnerable populations by enabling them to collectively own, manage, and benefit from local renewable energy resources.

Through models such as energy-sharing schemes, marginalized groups, including low-income households, can actively participate in energy production and distribution. This collective approach not only helps reduce individual energy costs but also fosters social cohesion, strengthens local networks, and promotes a sense of shared responsibility. By involving these communities in the governance and operation of RECs or SCSs, they gain greater control over their energy future and become active contributors to the clean energy transition.

3.3.4 Social Benefits

Task: Describe and evaluate how participation in the REC can provide social benefits.

Engagement in RECs or SCSs offers substantial social benefits for vulnerable populations. These benefits include enhanced living conditions through sustainable housing solutions and strengthening community support networks. Such improvements help alleviate energy poverty, promote social inclusion, and foster resilience in disadvantaged neighborhoods, ultimately contributing to an overall enhancement in the quality of life.

3.4 Monitoring, Evaluation, and Feedback

Task: Assess the effectiveness of the social engagement strategy through systematic monitoring, evaluation, and responsive feedback mechanisms.

Performance Metrics: Establish a system for monitoring and evaluating the impact of the engagement strategy. Key performance indicators (KPIs) might include participation rates, community satisfaction levels, and evidence of economic and social improvements.

Feedback Loops: Create mechanisms for continuous feedback from the population to refine and improve the strategy over time. To ensure responsiveness and continuous improvement, structured feedback mechanisms should be implemented, such as regularly scheduled community meetings, surveys and questionnaires, or interactive digital platforms can be used for this purpose.

Means of Verification: To comprehensively evaluate the strategy's impact, a combination of quantitative and qualitative tools should be employed: Quantitative Metrics (Participation data, survey results, digital engagement analytics), Qualitative Assessments (Focus groups, semi-structured interviews, direct observations), Feedback Mechanisms (Event-specific feedback forms, post-activity surveys, and open communication channels), Behavioral Indicators (Monitoring shifts in community practices, particularly regarding sustainable behaviors), Longitudinal Evaluation (Tracking stakeholder attitudes and behavioral trends over time through follow-up evaluations).

3.5 Integration with National and Regional Policies

Task: Ensure the social engagement strategy aligns with the National and Regional Policies.

The strategy should align with national and regional policies on economic development, social inclusion, and sustainability. This alignment enhances institutional support, increases access to funding, and ensures the strategy complements existing government priorities, improving its legitimacy, effectiveness, and long-term viability.

4. ToR for Technical Design and Digitalization

Task: Provide a comprehensive overview of the chapter content, including its aim, significance, and the methodology employed.

This chapter establishes the Terms of Reference for Energy Community Technical Design & Digitalization, outlining the development of a methodological framework that comprehensively addresses all parameters pertaining to the technical design and digitalization of RECs or SCSs.

4.1 Introduction

Task: Give a summary of the technical issues treated in this document and highlight the importance of a common ToR for the Renewable Energy Community technical design and digitalization.

The ToR for Technical Design and Digitalization of the RECs or SCSs encompasses the development of a comprehensive methodological framework. As shown in , this framework is aimed at guiding the technical configuration, including the verification and assessment of the regulatory context for REC or SCS constitution and PV plant design, the key technical parameters such as the availability and exploitation of endogenous renewable energy sources (RES), the capacity and structure of the existing grid infrastructure, and the compatibility of RECs or SCSs with territorial planning and landscape regulations. Furthermore, the scope includes the strategic integration of digitalization processes, specifically by establishing advanced management systems designed to ensure the efficient operation, monitoring, and maintenance of the Energy Community infrastructure.

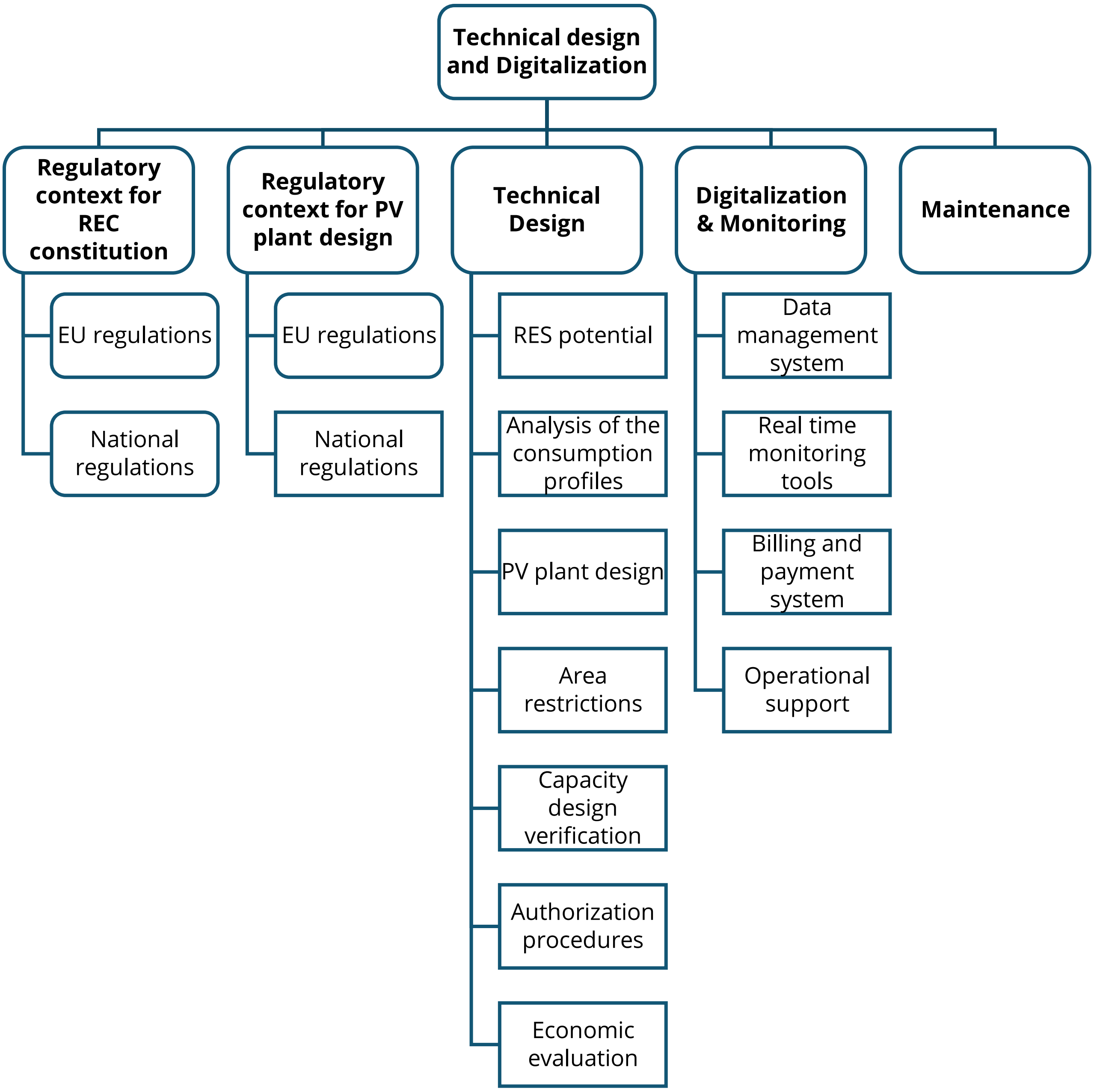

Figure 3. Development Scheme for Technical Design and Digitalization of the RECs or SCSs

4.2 Legal and Regulatory context

Task: Describe the EU, national, provincial, and municipal regulations referring to RECs.

In this section, a comprehensive overview of the European Union, national, provincial, and municipal regulatory frameworks governing RECs or SCSs must be provided. The analysis should encompass relevant EU directives, such as the Renewable Energy Directive (EU) 2018/2001 (RED II) and its recast (RED III), which establish the foundational principles for promoting and governing RECs across Member States. At the national level, the section must detail how these directives have been incorporated into national legislation, including legal definitions, eligibility criteria, operational guidelines, and support mechanisms tailored explicitly to RECs or SCSs. Particular attention should be paid to regulatory instruments that facilitate citizen participation, collective self-consumption, and decentralized energy production. Provincial and municipal regulations must also be examined in case of any modification of the national regulation.

This section should ultimately demonstrate how the multi-level regulatory landscape enables or hinders the practical implementation of RECs or SCSs and provide recommendations for aligning local governance with overarching EU energy and climate objectives.

4.3 Approach to the establishment of a REC or SCS

Task: Describe the overall methodology used for the establishment of the RECs or SCSs energy infrastructure.

The establishment of a REC or SCS is a multi-phase process that requires a strategic, inclusive, and technically sound approach aligned with European Union directives and national energy transition goals. RECs or SCSs serve as innovative models for decentralized, citizen-led energy generation and consumption, fostering local empowerment, environmental sustainability, and social cohesion.

This section outlines the key steps and considerations in creating a REC or SCS, from the initial identification of members to the technical and organizational design of the community.

4.3.1 Identification of the REC or SCS Members: Producers/Prosumer and Consumer

Task: Describe Producers/Prosumers and Consumers as part of the REC or Self-Consumption scheme.

The establishment of a REC or SCS begins with the precise identification and categorization of its members, in accordance with the definitions and eligibility criteria outlined in relevant EU and national legislation. RECs or SCSs must reflect a balanced and inclusive composition of energy producers, prosumers, and consumers, each playing a vital role in the community's operation, governance, and sustainability.

The identification process must be guided by criteria such as geographical proximity, legal eligibility, interest in collaborative energy governance, and technical compatibility. It should also assess the motivations, consumption profiles, and potential contributions of each member type to optimize the REC's or SCS's structure, capacity planning, and economic model. Special consideration should be given to encouraging the participation of vulnerable households, public bodies (e.g., municipalities, schools), and local enterprises, in alignment with the EU's objectives for inclusive energy transitions.

4.3.2 Identification of economic resources

Task: Description of the project, budget, or other possible economic resources.

Identify and secure various economic resources essential for the successful implementation of the REC or SCS, as well as for long-term sustainability. This includes seeking financial support through grants, loans, and strategic partnerships, as well as exploring alternative funding mechanisms such as private investments, public funding, or other funding opportunities.

By diversifying the sources of financial support, the project ensures a solid foundation for the establishment, operation, and eventual expansion of the RECs or Self-Consumption schemes, thereby maximizing its impact and sustainability.

4.3.3 Checking and verification of the primary cabin (for Italy only)

Task: For REC in Italy, further verification from the GSE (Energy Service Manager) website is required to determine whether the same primary cabin serves all prosumers.

In the context of the REC established in Italy, a critical technical verification concerns the identification and assessment of the primary cabin to which the REC members are connected. This step is essential, as Italian regulatory provisions, particularly those defined by ARERA (Italian Regulatory Authority for Energy, Networks and Environment) and GSE (Energy Service Manager), stipulate that all members of an REC must be connected to the same primary cabin to qualify under the REC framework and benefit from related incentives.

4.3.4 Verification of potential additional participants within the area

Task: Evaluate the potential opportunities for including additional participants in the project.

A brief evaluation of potential additional participants should be conducted in case of an expansion of the energy community.

4.3.5 Technical Feasibility and Energy Modelling

Task: Provide a brief summary of the importance of a technical feasibility study and its key phases.

Before establishing a REC or Self-Consumption scheme, it is essential to conduct a feasibility study to obtain a preliminary technical, economic, and energy assessment of the community to be created.

4.3.5.1 Regulatory context

Task: Describe national, provincial and municipal regulations regarding photovoltaic plants.

National, provincial, and municipal regulations must be examined, particularly in terms of their role in spatial planning, permitting procedures, integration with local energy strategies, and any specific incentives or constraints that impact the development and operation of the PV plant design.

4.3.5.2 Identification of the area of interest

Task: In this section, the installation area of the PV plant and the master plans must be defined.

In this section must be identified the reference area for the PV plant installation and gathering some information regarding the geographical area composition, buildings or terrain typology (in terms of flat or pitched roof or flat or inclined terrain) and the corresponding weather data (such as solar radiation, mid-winter and summer temperature, wind speed, humidity and precipitation).

4.3.5.3 Integration of ECs into territorial/landscape regulations

Task: Perform some checks to determine if the area is subject to landscape, architectural, or archaeological restrictions, or if there are critical infrastructures.

Some verifications must be performed to assess the suitability of the areas identified for establishing the photovoltaic plant. Specifically, it is essential to determine whether the proposed locations are subject to landscape, architectural, or archaeological restrictions, in accordance with national and local heritage protection regulations. These constraints may limit the installation of renewable energy technologies or require special authorizations from competent authorities. In parallel, an evaluation must be conducted to identify the presence of critical infrastructure that may reduce the available installation area or impose additional technical, safety, or legal limitations.

This preliminary screening is a fundamental step in the planning process, ensuring that the REC complies with territorial regulations, minimizes environmental and cultural impacts, and avoids conflicts with protected or sensitive areas.

4.3.5.4 Authorization procedures

Task: Identify the necessary permits for PV plant installation.

This section must examine the authorization procedures required for PV plant installation, considering factors such as the PV plant's peak power, positioning, and area restrictions.

4.3.5.5 RES endogenous potential

Task: Provide a rough estimation of the RES endogenous potential based on the solar radiation of the area.

It is possible to roughly estimate the endogenous potential of solar radiation for the area based on its geographical position by referring to maps or tables of solar radiation, scientific papers, or by using different calculation software, such as QGIS, PVsyst, or PVcase.

4.3.5.6 Analysis of the consumption profiles

Task: Define the electric energy consumption profile.

To understand the energy balance between the electric energy needed and the energy produced by the PV plant, it is necessary to define the consumption profile. This can be achieved through data acquisition from Energy Smart, Energy Audit, electricity bills, or ARERA, which provides hourly consumption data for residential buildings in Italy.

4.3.5.7 Quantification of PV Plant peak power installed

Task: Perform an evaluation of the PV plant peak power.

Considering the available installation area, the buffer zones to be respected, and the PV panel typology (Power peak, efficiency, surface, and inclination angle), as well as the inter-row space, it is possible to evaluate the peak power installed of the PV plant.

4.3.5.8 Quantification of PV plant producibility according to various scenarios

Task: Provide an evaluation of the energy produced by the plant, considering the PV plant components (such as Panels, inverters, optimizers, and panel distribution in modules and strings), orientation, detailed losses, and shading.

By utilizing appropriate software capable of calculating the solar radiation specific to the area through the integration of comprehensive meteorological datasets along with the assessment of near and horizon shading profiles and the implementation of peak power data derived from the previous section, it is possible to estimate the system's energy losses and consequently determine the actual overall energy yield of the photovoltaic (PV) installation. Different scenarios, such as variations in orientation and tilt angle of PV panel positioning, must be evaluated to determine the optimal configuration.

Particular attention must be paid to the identification and dimensioning of the other components of the PV plant, such as inverters, batteries, string panel components (protection switches, surge protectors, disconnectors), power optimizers and Cable protection devices.

4.3.5.9 Detailed Electrical design and generation of the electrical scheme.

Task: Provide a general electrical schematic of the plant, functional for evaluation of the plant's energy losses and component mapping within the installation area.

The preliminary electrical schematic must include all plant components and their connections to provide a comprehensive mapping of the system, which is essential for evaluating energy losses. However, for the final project, a much more detailed schematic must be presented, describing all the connections between the panels, the string connections, and other components up to the primary cabin.

4.3.5.10 Verification of the roof's design capacity or the terrain's consistency.

Task: Define the roof design capacity or the terrain consistency.

For rooftop installations, a structural analysis must be conducted to verify the roof's load-bearing capacity, ensuring it can support the additional weight of the photovoltaic system. For ground-mounted installations, a geotechnical assessment of the soil composition and bearing capacity is required. In both scenarios, the selection of support structures and anchoring systems must account for site-specific climatic conditions, including wind loads, snow loads, and seismic activity, in accordance with relevant engineering standards and codes.

4.3.5.11 Choice of the supporting elements

Task: Choose the most appropriate supporting elements based on the roof or terrain typology.

Selecting suitable supporting structures for PV panels requires consideration of both structural and waterproofing aspects. Excessive weight can compromise the integrity of existing roofs or surfaces, requiring structural verification to ensure compliance with load-bearing capacities.

Additionally, poorly installed supports may damage waterproofing layers, increasing the risk of water infiltration. To mitigate these risks, lightweight, non-invasive, or ballast-based systems should be prioritized, particularly on rooftops, with all fixings adequately sealed to maintain the building envelope.

4.3.5.12 Economic Evaluation of the PV Plant

Task: Conduct an economic evaluation of the PV plant, covering all phases from initial conceptualization up to the long-term maintenance.

The economic evaluation must include authorization, design, installation and maintenance costs. Moreover, the Payback Period must be estimated.

4.3.5.13 Energy Services Manager

Task: Provide and submit the documentation required to the Energy Services Manager.

Verify, prepare, and submit all necessary project documentation to the Energy Services Manager, taking into account the PV plant's capacity, location, and any applicable local regulations.

4.3.5.14 Communication of the project to the municipality

Task: Provide and submit the required documentation to the municipality.

Verify, prepare, and submit all necessary project documentation to the municipality. Must also be verified if further environmental impact evaluation or other permissions are needed by the municipality, such as environmental impact evaluation, fire protection controls, and safety regulations for the execution of work on rooftops.

4.3.5.15 Grid connection - Energy Service Provider practice

Task: Verify compliance with the regulations referring to the grid connections and submit all the required documents to the Energy Service Provider.

Various national regulations regulate the grid connection to facilitate the exchange of energy between RECs, SCSs, or individual plants. For example, the energy produced by the plant must be fed into the grid at the same voltage. The main regulations in Italy, D.P.R. 445/00, CEI 0-2, CEI 0-16, and CEI 64-8, must be respected, which also mandates the use of protection devices to prevent electrical faults and fires.

4.3.5.16 A thorough examination of legal and tax aspects

Task: Evaluate possible incentives for the Energy fed into the grid.

In this section, the possible incentives must be defined, specifically the prices that the Energy Service Manager Institution pays the REC for the energy fed into the grid.

(For Italy, the prices are referred to the Art. 13.4, “Allegato A”, deliberazione AEEG 280/07)

4.3.5.17 Identification of potential installers and service providers, and comparison of supply and service conditions

Task: Identify and evaluate potential installers and service providers in proximity to the installation site.

A further step from the Technical-Energy Assessment is the evaluation of potential installers and assessment of the services they offer in the nearby area, to promote local inclusion and support regional economic development.

4.3.6 Maintenance

Task: Develop an ordinary maintenance program and prepare the necessary contracts with selected service providers.

PV plant maintenance program should be adapted to the site's characteristics, taking into account the area typology (urban, rural, coastal, etc.), which affects cleaning needs, and the climatic conditions (snow, wind, humidity), which influence inspection frequency. Common faults, such as inverter or string failures, require regular monitoring and diagnostics to ensure optimal performance and system longevity.

4.4 Monitoring & Digitalization

Task: Provide a comprehensive overview of the subchapter content, including its aim, significance, and the methodology employed.

This section should provide an overview of the importance of real-time monitoring in RECs or SCSs. It must include the need for smart metering systems to track energy production and consumption, the integration of Energy Storage Systems (ESS) to enhance self-consumption and reduce grid dependency, and the role of standardized communication protocols to ensure device interoperability. Additionally, the methodology for selecting and integrating the necessary monitoring devices should be outlined, considering the specific energy requirements and infrastructure of the community.

4.4.1 Introduction

Task: Describe the concept of real-time monitoring and the importance of monitoring devices.

Regarding RECs or SCSs, real-time (or near real-time) data monitoring is essential. This ensures that a manager will be able to 1) elaborate a plan to balance both consumption and production,

2) detect (or predict) possible problems or anomalies as soon as possible, 3) have a support to take decisions, 4) automatize tasks.

To enable real-time energy monitoring and billing in REC or SCSs, a detailed assessment must first be defined (since at the design phase) the number and types of smart meters required, tailored to the specific energy usage and infrastructure of each community. This involves conducting desk research to identify commercially available smart meter technologies, ensuring they support the needed functionalities such as real-time data transmission, load profiling, and remote control.

Additionally, integrating Energy Storage Systems (ESS), such as batteries, is crucial to enhance self-consumption of locally generated energy, reduce dependency on the grid, and improve energy autonomy. Based on expected load and production patterns, the system design should specify if batteries are needed. All devices involved, including smart meters, PV inverters, and battery inverters, must be interoperable and communicate efficiently through standardized protocols like IEC 60870-5-102, DLMS/COSEM, Modbus, MQTT, or HTTP REST, ensuring seamless data flow across the entire energy management system.

4.4.2 Monitoring and Digitalization Tools for REC or SCS

Task: Provide a general description of the monitoring tool to be used and the key parameters to be monitored.

In terms of real-time monitoring, digital tools must ensure that the information offered is reliable and useful for both technical operators and community members. With this in mind, the tool definition is to design an intuitive interface accessible from various devices (computers, mobiles, tablets) and consider different levels of access depending on the user type.

In addition, it is necessary to define what variables will be monitored and visualized (production, consumption, physical device status, etc.), as well as what elements are configurable to maintain the system working correctly (alarms, settings, etc.). The identification of needed variables includes basic ones like energy generated and consumed, and additional ones such as battery charge level, weather information, or aggregated data to be calculated (efficiency, self-consumption, energy balance, …). On the other hand, the frequency of data retrieval and the latency in refreshing changes are factors to consider.

Other elements to be considered are defined below.

4.4.2.1 Definition of Data Management System

Task: Define the characteristics of the data management system.

The Data Management System must be scalable, full accessible and supporter of the data quality. With this aim, the design process must:

- **Consider technical aspects:** assets integration, data ingestion, storage and access mechanisms.
- **Provide governance mechanisms** to users: data retention policies and lifecycle management.
- Consider the **type of systems** most appropriated to the problem: Relational Databases, Data warehouses, ETL (Extract, Transform, Load) y ELT (Extract, Load, Transform) tools
- Consider the challenges related to **data quality**: Open refine, Talend Open Studio or DataCleaner.

4.4.2.2 Definition of tools for Real-Time Monitoring

Task: Identify the necessary tool for Real-Time Monitoring.

A proper tool for that monitoring must be defined. This means to consider the energy production and energy exchanged within the grid (energy added to the grid and the energy drawn from the grid). The tool must include dashboards and interfaces able to represent this kind of data.

On the other hand, scalable and interoperable solutions are a key part, being better than a vendor-restricted tool. Some examples of this are InfluxDB, Grafana, etc.

4.4.2.3 Billing and Payment Systems

Task: Describe the requirements for Billing and the Payment system.

The design of automated systems for billing and payment involves evaluating features like: Billing, energy credits and community transactions. The Renewable Energy Community or Self-Consumption scheme can operate by giving credits to the members for saving energy or participate in demand response campaigns. Also, economical transactions must be considered. Some examples of tools for these features are:

- **Billing:** QuickBooks, FreshBooks, Xero
- **Energy Credits:** EnergyHub, Enphase Energy, Power Ledger
- **Community Transactions:** Venmo, PayPal, Zelle

4.4.2.4 Operational Support

Task: Provide a description of the operational support system.

Having robust operational support is essential to ensure that reliability, agility and sustainability are incorporated to the real-time monitoring system. Important elements to be addressed are related to incidents supervision and their resolution, preventive maintenance, data management, among others. Some examples of them:

- Remote Monitoring Tools: Datadog
- Security Tools: OpenVAS
- Performance Monitoring: AppDynamics

4.4.2.5 User Engagement Platform

Task: Describe the requirements for the User Engagement Platform.

The user engagement must cover insights into the REC or Self-Consumption scheme members energy usage and enables feedback. In addition, guide the members participation towards attractive activities or operations is essential not to lose users already belonging to a community. This may be also supported with mechanisms to analyse user behavior and extract patterns and profiles of users.

- Effective notification tools: OneSignal, Firebase Cloud Messaging or Intercom
- Members guiding: Appcues, UserGuiding
- Users segmentation: AnalyAmplitude or mixplanel
- Gamification: set up teams, objectives, rewards, surveys, notifications, etc.

4.4.2.6 Cybersecurity Measures

Task: Provide a description of the tools necessary for data protection.

Sensitive data like home consumption must be protected. Not only in terms of avoiding access to forbidden people or systems but also protecting data from unauthorized modifications. The design must consider the next points among others, evaluating the related tools:

- Data classification, to identify and categorize sensitive data: Apache Atlas, Amundsen, CKAN or Data Hub

- Authentication mechanism and access control: Multi-factor authentication (MFA) mechanism, Role-based access control (RBAC).
- Data encryption for both transmission and storage: AES-256 or RSA
- Firewalls: Network firewalls and intrusion detection systems (IDS).

4.4.2.7 Interoperability and scalability

Task: Provide a description of the interoperability and scalability requirements for monitoring and digitalization tools.

Each physical element has its own features and protocols, so digital tools must be compatible with different data sources, protocols and so on. In that sense, implementation of adaptors should be considered to make the high-level graphical interfaces independent on the environment.

Moreover, each REC can have a huge number of members or PV installed. Then, solutions such as microservices, cloud storage, load balancing, efficient APIs and so on must be considered during the design. The use of scalable databases (MongoDB, InfluxDB) are options to be taken into account.

4.4.3 Further 'operations' of the Monitoring and Digitalization system

Task: Provide a summary of the Monitoring and digitalization system usability.

The monitoring and digitalization system supports advanced operational functions beyond basic monitoring. It enables continuous performance evaluation, identifies optimization opportunities, and provides insights to align consumption with generation, enhancing system reliability, efficiency, and user engagement.

4.4.3.1 Functionality check of the plant

Task: Conduct periodic functionality checks of the PV system using the monitoring platform to ensure early detection of issues.

The monitoring system continuously tracks the performance and status of each component in the photovoltaic (PV) plant, including inverters, modules, and meters. This ensures the early detection of faults, malfunctions, or inefficiencies, allowing for timely maintenance and minimizing downtime.

4.4.3.2 Producibility check of the plant

Task: Conduct periodic monitoring using the monitoring platform to ensure optimal performance.

Digital tools analyze both real-time and historical data to assess the actual energy production of the plant against its expected performance, based on weather conditions and system specifications. This helps identify potential losses in generation capacity and supports the optimization of performance.

4.4.3.3 Possible adjustments of the consumption based on the PV plant production

Task: Evaluate potential adjustments to consumption profiles based on the PV plant's energy production capacity.

By providing real-time insights into the plant’s energy generation, the system enables users to adjust their energy usage patterns accordingly. For example, high-consumption activities can be scheduled during peak solar production periods, thereby maximizing self-consumption, improving energy efficiency, and reducing reliance on the grid.

5. ToR for Legal, Administrative and Management structure

Task: Provide a comprehensive overview of the chapter content, including its aim, significance, and the methodology employed.

The ToR aims to establish a methodological approach to guide the creation of legal, administrative, and managerial structures for Renewable Energy Communities (RECs) or Self-Consumption schemes.

5.1 Introduction

Task: Give a summary of the issues treated in this document and highlight the importance of a common ToR for Legal, Administrative and Management structure.

This methodology outlines a comprehensive and replicable approach for establishing the legal, administrative, and management framework of RECs or SCSs, aligned with six key structural areas (as shown in Figure 3): regulatory context, governance, execution, platform integration, impact assessment, and risk evaluation. It aims to support REC administrators in navigating EU and national regulations, defining juridical entities, preparing statutes and contracts, managing procurement and installation phases, and ensuring grid connection and fiscal compliance. The methodology also includes economic assessments (costs, revenues, payback period), environmental and social impact evaluations (including CO_2 emissions), and risk analysis related to energy prices, policy changes, and plant performance.

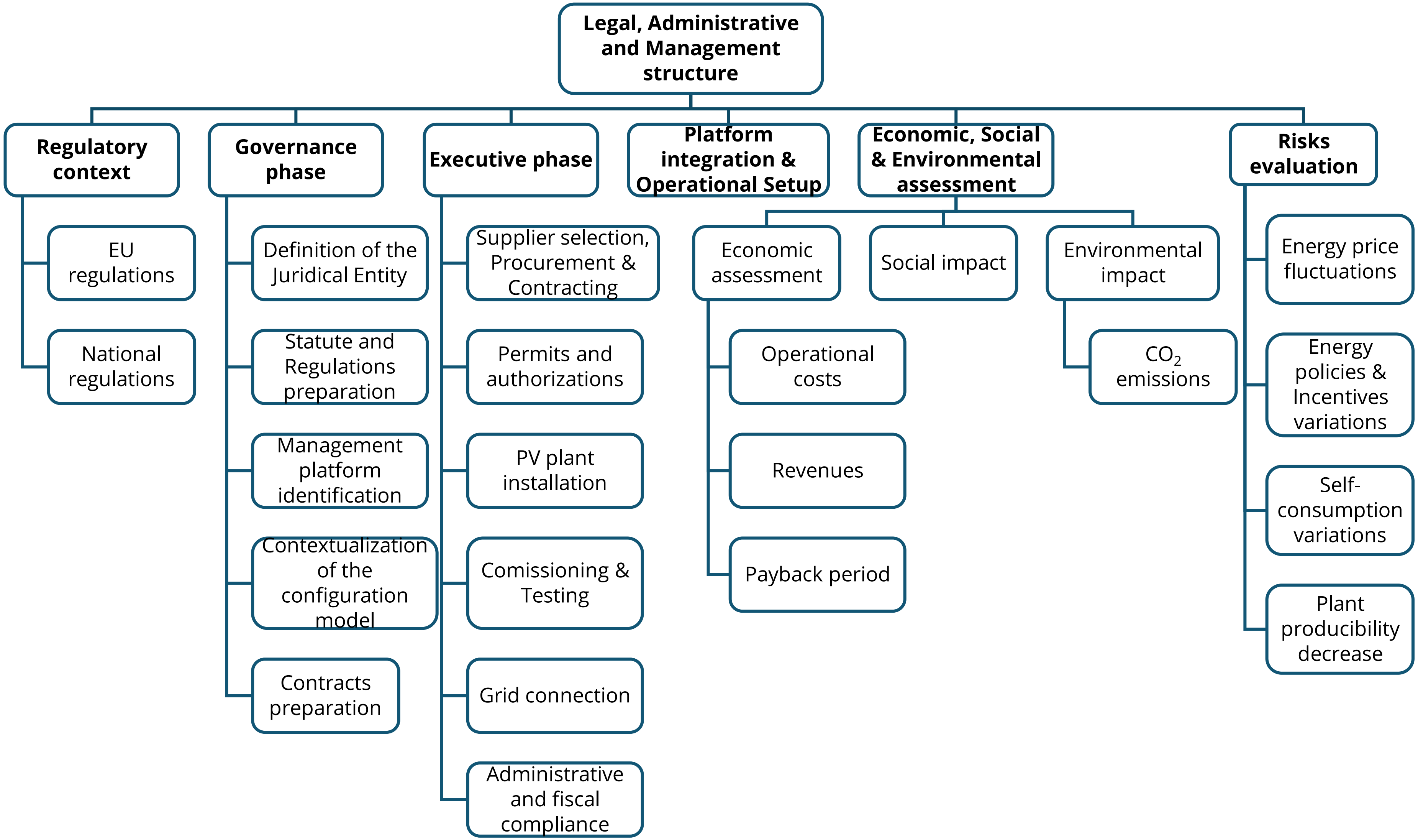

Figure 4. Framework for the Legal, Administrative, and Operational Development of RECs or Self-consumption schemes

5.2 Regulatory context

Task: Describe the importance of compliance with the regulatory framework for the establishment of Renewable Energy Communities.

Compliance with the regulatory framework is essential for Renewable Energy Communities (RECs) to operate legally, access financial incentives, ensure grid integration, and protect members' rights. It enables RECs to contribute effectively to the energy transition while aligning with environmental and social goals.

5.2.1 European regulations

Task: Describe the European regulations for the constitution and management of the Renewable Energy Communities.

Provide a description of the European regulatory framework for the constitution and management of Renewable Energy Communities (RECs), based on Directive (EU) 2018/2001 (RED II), which introduces RECs, and Directive (EU) 2019/944, which defines Citizen Energy Communities (CECs). The legal definitions, governance principles, and participation criteria for both RECs and CECs should be clearly explained, along with their respective scopes and roles. It should also outline the obligations placed on Member States, including ensuring energy market access, creating enabling frameworks with simplified procedures, and promoting fair competition without discrimination and pointing out also the requirement of the European Directives that each Member State transpose the provisions into national law through appropriate legislative and regulatory measures.

5.2.2 National regulation

Task: Describe the main national regulations for the constitution and management of the Renewable Energy Communities.

Provide a description of the national regulations governing the constitution and management of Renewable Energy Communities (RECs) in selected EU Member State. The description should focus on each country's legal definitions of RECs and related models (such as Renewable Energy Communities, Citizen Energy Communities, collective self-consumption, or joint prosumers), the recognized legal forms (e.g., cooperatives, associations), governance and participation requirements, geographic or grid constraints (such as substation or market zone limitations), and access to incentives or public support schemes. In Italy, attention should be given to the CACER framework and the role of Decree MASE 414/2023; in Spain, to Law 24/2013, Royal Decree

244/2019, and the emerging Royal Decree on RECs; in Croatia, to the Electricity Market Act (OG 111/2021 and 83/2023) and the Law on Renewable Energy Sources and High-Efficiency Cogeneration; and in Greece, to the evolution from Law 4513/2018 to the updated framework under Law 5037/2023 and Law 5106/2024. The task should also note how each country is responding to the requirements of EU Directives 2018/2001 and 2019/944.

5.3 Phases for the constitution of the REC or Self-Consumption schemes

Task: Give a short description of the preliminary information needed before starting up with the constitution of the REC and an introduction to the main phases.

For the establishment of a Renewable Energy Community (CER) or Self-Consumption schemes, it is necessary to comply with all the requirements set by the regulations outlined in the previous chapter. Before that, it is essential to frame the context in which one operates and address preliminary issues such as, by way of example:

- identification of citizens, SMEs, and public bodies that can become members;
- identification of economic resources;
- technical support for evaluating a CER model (feasibility study);
- assistance to the energy community for potential regional, national, or community incentives.

Which are already treated in the common ToR for energy community technical Design & Digitalization: Design by UNIGE & ETRA.

5.3.1 Governance phase

Task: Give a short summary of the governance phase.

Provide a short summary of the governance phase in the development of a Renewable Energy Community (REC) or Self-Consumption scheme, focusing on the definition of its institutional structure, decision-making processes, and internal rules. The summary should address the identification of an appropriate governance model, the formalization of voting rights and participation mechanisms, the setup of management and control structures, and the regulation of energy sharing, incentives, and revenue reinvestment. It must also briefly describe the governance model adopted, such as the Public-Led Foundation Model (a top-down approach with municipal control and passive participants), the Participatory Cooperative Model (a bottom-up approach with active, voting members), or any other model.

5.3.1.1 Definition of Juridical Entity

Task: Provide an evaluation of the risks, opportunities, and suggest the most appropriate juridical form of governance.

In this section must be evaluated one specific legal form for establishing a Renewable Energy Community (REC), analyzing its risks, opportunities, and suitability based on the community's objectives, size, member composition, and regulatory context. The analysis should conclude with a recommendation of the most appropriate legal form among the following options:

Associations and cooperatives are generally considered the most suitable for RECs, particularly in the early stages or for socially oriented projects. They inherently support the principles of open, voluntary participation and democratic governance promoted by EU Directives. Associations, in particular, offer a simplified administrative setup and reduced costs, making them attractive for small-scale or community-driven initiatives.

However, as the scope of the REC expands or involves commercial activities, other forms such as foundations or limited liability companies may be considered. These structures, while potentially offering more operational capacity, entail higher setup and compliance costs, including accounting, governance, and personnel requirements. These costs can erode the financial returns of the REC if not proportionate to the scale of the activity.

It is therefore essential to conduct a thorough assessment of needs, stakeholders, and long-term goals before selecting the legal form. Special attention should be paid to voting rights and decision-making mechanisms, particularly when public entities are involved, to ensure transparency, accountability, and alignment with the community-oriented mission of the REC.

5.3.1.2 Preparation of Statute and Regulations

Task: Define the Statute of the REC, focusing on the members' rights and duties, mechanisms for the distribution of the incentives or revenue, etc.

Once the most appropriate juridical entity has been selected, the next step is the drafting of the Statute and internal Regulations of the Renewable Energy Community (REC) or Self-Consumption scheme. These documents should define the institutional and operational framework of the community and are legally binding for all members.

The **Statute** should establish the REC's or Self-Consumption scheme fundamental elements, including:

- **Purpose and Objectives:** Alignment with the principles of environmental, economic, and social benefit over profit-making, in compliance with EU and national definitions.

- **Legal Structure and Governance:** Description of the legal form adopted (e.g., association, cooperative), the governing bodies (e.g., general assembly, board), their roles, composition, and election procedures.
- **Membership Rules:** Clear criteria for admission, withdrawal, and exclusion of members. This includes provisions for public entities, individual citizens, SMEs, and social actors.
- **Rights and Duties:** Specification of the members' responsibilities (e.g., data sharing, participation in meetings, compliance with energy-sharing rules) and entitlements (e.g., access to shared energy, voting rights, share of benefits).
- **Voting and Decision-Making:** Mechanisms for deliberation, quorum requirements, and differentiation of voting rights if needed (especially in hybrid governance models involving public authorities).

The **Internal Regulations** should detail the practical aspects of REC operation, including:

- **Rules for Energy Sharing:** Methods for allocating self-produced energy (e.g., static vs. dynamic coefficients), based on technical configurations and consumption profiles.
- **Distribution of Revenues and Incentives:** Criteria for distributing incentives (e.g., GSE tariffs, CAPEX subsidies) and any revenues from surplus energy or additional services, ensuring transparency and proportionality.
- **Financial Contributions:** Definition of potential membership fees, operational cost recovery mechanisms, and reinvestment strategies.
- **Monitoring and Compliance:** Procedures for performance tracking, auditing, and sanctioning non-compliant behaviours.

The statute and regulations must be designed to ensure **clarity, legal compliance, and fair governance**, while maintaining flexibility to evolve as the REC or the Self-Consumption scheme grows or as the regulatory framework changes.

5.3.1.3 Identification of the Management Platform

Task: Provide a description of the Management platform.

The definition of the platform is aimed at managing the economic and financial flows of the Community Energy Renewable (REC) or tSelf-Consumption scheme, as well as the potential optimization of the same. In an initial phase, these systems will focus on redistributing, according to the rules defined in the statute, the incentives that the "Energy Services Manager Institution" provides to the REC or Self-Consumption scheme. In a subsequent phase, based on the evolution of the models, these systems could serve as the foundation, for example, for managing additional financial flows, such as revenues from electricity trading, as well as those arising from participation in dispatching markets.

5.3.1.4 Contextualization of the configuration model

Task: Provide a description of how the REC's technical and organizational setup is tailored to the specific local, regulatory, and social context in which it operates, defining the member roles, customizing energy-sharing and decision-making models, and ensuring regulatory compliance, transforming a general concept into a tailored, implementable framework.

This phase entails the strategic adaptation of the technical and organizational architecture of the Renewable Energy Community (REC) or Self-Consumption scheme to reflect its unique local, regulatory, and socio-cultural context. It encompasses:

- **Articulating clear roles and responsibilities** for all participants—producers, consumers, and prosumers ensuring clarity and cohesion within the community framework.
- **Modifying the energy-sharing mechanisms** to align with the capabilities of the local grid infrastructure, prevailing regulatory requirements, and the specific energy demands of the community.
- **Designing bespoke governance structures**, including decision-making procedures, voting mechanisms, and ownership models, tailored to harmonize with national legislation and the collective values of the community.
- **Securing compliance with all applicable legal, environmental, and technical regulations**, as mandated by local and national energy authorities.

The overarching objective is to evolve from a standardized or conceptual model into a context-sensitive, operational framework that is both actionable and sustainable.

5.3.1.5 Preparation of contracts and bureaucratic documents

Task: Provide drafting and finalizing of all legal, financial, and administrative documentation necessary to formalize the REC's or Self-Consumption scheme structure and operations.

This phase encompasses the meticulous preparation and formalization of all legal, financial, and administrative instruments essential to establishing the operational and institutional framework of the Renewable Energy Community (REC) or Self-Consumption scheme. It typically involves:

- **Crafting membership agreements** that clearly delineate the rights, duties, and entitlements of all participants within the community.
- **Developing energy-sharing contracts** that govern the allocation, pricing, and potential monetization of the energy produced and consumed within the REC.
- **Negotiating connection and service agreements** with external stakeholders such as energy suppliers, grid operators, and technology partners to ensure seamless technical integration.
- **Completing regulatory submissions**, including licenses, tax registrations, and compliance declarations required by public authorities and regulatory bodies.

- **Establishing governance statutes or bylaws**, which codify the internal decision-making processes, conflict resolution mechanisms, and operational protocols guiding the REC's day-to-day activities.

This phase lays the legal and bureaucratic foundation necessary to ensure regulatory alignment, mitigate risk, and support the long-term viability and credibility of the REC.

5.3.2 Executive/Realization phase

Task: Provide a general summary of the execution phase encompassing all critical activities required to bring the photovoltaic plant design into operation.

The Executive Phase marks the transition from planning to implementation and encompasses all technical, administrative, and organizational activities necessary to realize the Renewable Energy Community's (REC) photovoltaic (PV) infrastructure and begin operations. This phase must be managed with precision to ensure compliance with technical specifications, safety standards, and legal obligations.

The execution of the REC or the Self-Consumption scheme should involve procuring contractors, obtaining permits, installing PV infrastructure, ensuring grid connection, activating the management platform, and training local stakeholders. This phase concludes with the operational launch of REC's energy-sharing model.

5.3.2.1 Supplier Selection, Procurement, and Contracting

Task: Describe the process for identifying, selecting, and contracting qualified suppliers, contractors, and technical partners for the delivery of the photovoltaic (PV) plant.

This sub-phase entails launching public or private procurement procedures to select qualified contractors for the supply, installation, and commissioning of the PV systems. The selection process prioritizes local involvement, with the dual aim of stimulating regional economic development and cultivating a robust ecosystem of reliable and experienced stakeholders. By harnessing local competencies and fostering synergistic collaborations, this phase lays the groundwork for enduring community energy resilience and capacity building. Beyond ensuring technical excellence and cost-effectiveness, the process is designed to generate tangible social and economic value within the territory, reinforcing the REC's or Self-Consumption schemes role as a catalyst for sustainable local transformation. Tender documentation must align with the technical specifications defined in the feasibility study and comply with national procurement regulations.

5.3.2.2 Permits and Authorizations

Task: Verify and provide the necessary permits and authorizations for PV plant installation in compliance with national, provincial, and municipal regulations.

Securing any outstanding authorizations necessary for installation, including electrical permits, building permits (where required), and interconnection agreements with the Distribution System Operator (DSO).

5.3.2.3 Photovoltaic Plant Installation

Task: Describe the necessary steps for PV plant execution according to the project Management, which must comply with the standards and the Project Design.

The installation phase is a critical step in ensuring the long-term efficiency, safety, and reliability of a photovoltaic plant. Proper execution directly influences system performance, durability, and compliance with technical and regulatory standards. Key factors to consider include structural preparation (e.g., roof reinforcement, waterproofing membranes if needed), correct panel orientation and tilt, secure and structurally sound mounting of supports, accurate electrical connections, and adherence to safety protocols during on-site operations. Special attention must also be paid to the cable management, grounding systems, and the proper configuration of inverters and monitoring equipment. A qualified and certified installation team is essential to ensure quality control and to prevent defects that may lead to energy loss or system failure over time.

5.3.2.4 Commissioning and Testing

Task: Perform and document the commissioning and testing of the PV system to verify correct installation, operational functionality, and compliance with safety and technical specifications.

Commissioning and Testing of the system are mandatory to ensure proper functionality, efficiency, and compliance with technical specifications. Commissioning is the final and essential step before a photovoltaic (PV) plant becomes fully operational. It involves verifying that all components, such as panels, inverters, wiring, protections, and monitoring systems, have been correctly installed and function according to design specifications and safety standards.

Key activities include functional testing, grid connection checks, and review of compliance documentation. Commissioning must be carried out by qualified personnel, and results must be documented in an official report. The plant can be connected to the grid only after successful commissioning and qualifying for incentives or compensation schemes.

5.3.2.5 Grid Connection

Task: Coordinate and complete the integration of the PV plant into the local electricity grid in compliance with Distribution System Operator (DSO) requirements and national regulations.

Following successful commissioning, this phase involves the formal connection of the photovoltaic system to the local electricity network. It requires coordination with the Distribution System Operator (DSO) to activate the grid connection, complete necessary administrative procedures, and ensure compliance with all technical and legal requirements. This step enables the Renewable Energy Community (REC) or Self-Consumption scheme to begin energy sharing and access financial incentives or compensation schemes

5.3.2.6 Administrative and Fiscal Compliance

Task: Ensure all administrative and fiscal requirements are completed for the PV plant's legal operation.

Submitting necessary documentation to public institutions, registering the plant fulfilling tax obligations.

5.3.3 Platform Integration and Operational Setup

Task: Develop a comprehensive platform and operational Setup for the long-term management of data to enable data-driven governance of the energy and financial systems throughout the entire lifecycle of REC or SCS.

This task involves activating a digital platform to monitor energy flows, implement incentive-sharing mechanisms, and track real-time performance data in alignment with the REC's or SCS's governance and reporting requirements. Effective management is essential to ensure systematic handling of energy and data flows, creating long-term value through advanced analytics. The platform should evolve beyond basic energy distribution to support integrated services, enabling optimization of energy performance, maximization of shared energy, and increased economic returns for the community.

5.3.4 Training and Handover

Task: Ensure training activities for the REC or SCS managers and communities on platform use and understanding.

The focus should be on organizing and delivering targeted training sessions to REC or SCS managers and community representatives, with the aim of enabling independent operation and management of the REC after installation. Training should cover the functionality of the energy management platform, including system monitoring, performance analysis, incentive distribution, and data interpretation. The objective is to build technical capacity, promote self-sufficiency, and ensure that local stakeholders are fully equipped to manage the day-to-day operations of the REC or SCS. The process should conclude with a structured handover, ensuring a clear transfer of knowledge and responsibilities to the community.

5.3.5 Economic, Social, and Environmental Assessment

Task: Provide an overall description of Economic, social, and environmental assessment of the entire project, including all its phases.

This chapter should present an integrated appraisal of Renewable Energy Community initiatives, combining economic, social, and environmental lenses. Investment sustainability should be assessed through payback analysis, while societal value creation is to be measured by evaluating shared savings and contributions to alleviating energy poverty. Carbon mitigation should be quantified by comparing actual CO_2 emissions after the intervention including emissions generated during the production of PV plant components with baseline consumption levels. Together, these evaluations offer stakeholders a robust, multidimensional decision-making framework tool.

5.3.5.1 Economic assessment

Task: Perform an Economic evaluation of the total investment and the verification of the sustainability of the investment (considering inflows from the sale of energy/incentives and the energy savings and outflows for the management, maintenance, energy taken from the grid) for the REC creation and evaluation of the Payback Period over the 20 years life span duration of the REC incentive.

Estimating Investment Costs

The first step in evaluating the total investment is to estimate the investment costs. This is done by multiplying the cost of the installations and the necessary connections (unit cost, in €/kWp) by the estimated capacity of the photovoltaic system installed and connected to the grid (in kWp). The result of this multiplication represents the total estimated expenditure, which will be distributed among the stakeholders.

- Investment costs (€) = Unit cost (€/kWp) × Estimated capacity (kWp)

Calculating Operational Costs

The second step is to calculate the operational costs. This is similarly carried out by multiplying the constant average operating cost (unit cost, in €/kWp) by the estimated capacity (kWp). It is important to note that the average operating cost should cover all expenses related to the maintenance and management of the system.

- Operational costs (€/year) = Unit cost (€/kWp year) × Estimated capacity (kWp)

Estimating Revenues, Savings, and Incentives

To evaluate revenues, savings, and potential incentives, it is first necessary to estimate the annual electricity production of the system (in kWh), considering the solar radiation levels of the location. Additionally, you should calculate the average self-consumption level and the percentage of energy shared among users, both expressed in kWh/year.

- Average self-consumption (kWh/year) = % self-consumption × Total annual production (kWh)
- Energy shared among users (kWh/year) = % energy shared × (1 - % self-consumption) × Total annual production (kWh)

Calculating Profits for Stakeholders

By knowing the unit value of savings from self-consumption and the compensation for feeding electricity into the grid, it becomes possible to calculate the profits obtained by stakeholders.

- Profits from self-consumption (€) = Average self-consumption (kWh/year) × Unit savings (€)
- Profits from energy sharing (€) = Energy shared among users (kWh/year) × Unit of remuneration or balancing[1] (€)

Calculating a Payback Period

Finally, the payback period equals the investment costs divided by the total profits generated over a specific number of years, minus the total operational costs incurred over the same period.

- The payback period (Y) = investment costs (€) / average annual net profit
- Where average annual net profit =1/n x $\sum_{1}^{y} Total\ revenues - total\ costs$

5.3.5.2 Estimation of the social impact

Task: Assess the broader societal benefits generated by the Renewable Energy Community.

The incentives described above could be used to support the social objectives of the energy community, thanks to the way they are shared. Firstly, the possibility of generating additional

[1] According to different national regulations

income through energy-sharing incentives without bearing any direct costs can serve as a powerful tool in helping lift vulnerable households out of energy poverty.

Apart from the possibility to save the money on energy bills, thanks to being allocated a specific share of the plant's output and virtually consuming a proportional amount of the produced energy, any surplus energy not consumed by participants can be sold back to the grid or to other entities. The revenue from these energy sales is typically distributed among community members based on their allocated shares. While cost savings from self-consumption often have a higher financial impact due to the higher price of purchasing energy from the grid compared to selling surplus energy, both mechanisms contribute to the overall economic benefit for participants. And of course, the distribution of revenues generated from feeding energy into the grid, depends on the number of participants involved in the allocation of incentives. The more citizens that participate, the smaller the share received by each household.

Nonetheless, the opportunity to receive a financial return on energy costs fosters a sense of fairness. Operating a power plant already provides a feeling of empowerment, as it allows users to decide when to consume energy, unlike, for example, centralized heating systems. But actually receiving even a partial refund reinforces the sense of inclusion and equal treatment, making people feel acknowledged as active members of the system.

5.3.5.3 Estimation of the environmental impact

Task: Assess the ecological benefits in terms of CO2 emissions reduction.

Beyond economic benefits, renewable energy communities play a key role in environmental sustainability. By producing and using clean energy, they help cut greenhouse gas emissions and combat climate change. While the environmental gains may not be immediately local, their global impact is significant. At the local level, access to cheaper and cleaner electricity over the long term can encourage the adoption of sustainable technologies, such as EV charging stations and electric heat pumps. These technologies replace fossil fuel-based systems, further reducing emissions and improving air quality.

Environmental KPIs are used to evaluate the impact of RECs on the local environment. The main KPI measures the total CO_2 emissions produced by a single household, calculated using local energy conversion factors. It provides a quantified estimate of the environmental impact of energy consumption at the household level, taking into account both heat and electricity use.

The emissions are computed using the following formula:

- Total CO_2 emissions = Total energy consumed × CO_2 conversion factor for electricity

The CO_2 conversion factor is determined based on the national electricity grid mix and, where applicable, on specific fuel types used for heating. The KPI is expressed in kilograms of CO_2 per year (kg CO_2/year).

The main objective of this indicator is to assess the environmental benefits brought by a Renewable Energy Community (REC). Specifically, it quantifies how the REC contributes to reducing greenhouse gas emissions when compared to conventional energy consumption patterns, such as full reliance on grid electricity in a given geographic zone.

This KPI directly contributes to the evaluation of Strategic Objectives STO5 and STO6, which are focused on sustainability and the environmental performance of the REC.

To compute this KPI, the following data points are necessary:

- Total energy consumed (including both thermal and electrical energy)
- CO_2 conversion factors for each fuel type used
- National electricity grid CO_2 emission factors

To this consumption, add also the CO2 emissions due to the production of the PV plant components.

5.3.6 Evaluation of the risks

Task: Examine the main external factors that can impact the operation, performance, and overall impact of the ongoing project.

This chapter examines the primary risk factors that can undermine the profitability, sustainability, and resilience of community energy projects. The analysis focuses on fluctuations in energy prices, volatility in incentive policies, variability in self-consumption, and the degradation of photovoltaic system productivity over time.

5.3.6.1 Energy price fluctuations

Task: Describe the nature of energy price fluctuations and its impact on energy projects, in particular, on grid selling price.

Energy price fluctuations are a key factor affecting the profitability and impact of energy projects. Two interconnected prices matter: the selling price of renewable energy and the purchase price of energy from the grid. The first affects investors' ability to recover costs, while the second impacts consumer benefits. This chapter explores how both prices' variability influences projects.

Impact of Renewable Energy Selling Price

Renewable project profitability depends heavily on the market price of energy sold. Higher prices boost revenue and shorten payback periods. Unlike fossil fuels, renewables like solar have no fuel costs, so price increases directly raise profits. However, intermittent generation limits the ability to respond to price changes, exposing projects to market volatility. Technologies like battery storage and demand response become more cost-effective amid volatile prices, enabling energy to be stored when prices are low and used when high. The European spot market, with hourly or sub-hourly price shifts driven by supply, demand, and external factors, adds unpredictability for renewables relying on steady income. Stable pricing mechanisms like feed-in tariffs (FiTs) and power purchase agreements (PPAs) reduce risk by guaranteeing fixed or long-term prices, fostering investor confidence.

Effect of Grid Purchase Price

Grid energy prices strongly influence the savings possible for consumers involved in renewable projects. Higher grid prices increase the value of self-consumption and make local generation more attractive, encouraging both individual and collective projects like Renewable Energy Communities, which further reduce costs through shared infrastructure.

Price variations across Italy, Spain, Croatia, Greece, and Cyprus reflect differing national market conditions affecting renewable project economics. Between 2020 and 2024, the energy crisis heightened volatility: Italy saw sharp price swings due to high electricity costs and gas dependency; Spain maintained elevated but more stable prices thanks to diversified imports; Greece experienced the highest peaks, increasing the economic appeal of renewables as alternatives to grid reliance.

5.3.6.2 Energy policies and incentives change

Task: Analyze the role of energy policies and incentives in renewable energy projects, including their impact on project profitability and the risks associated with policy dependency.

Energy policies and incentives play a key role in the profitability of renewable projects, offering benefits like tax breaks and favorable tariffs. However, relying on them introduces risks, especially if policies are changed or withdrawn, potentially compromising investment returns.

Policy dependency carries several risks:

- Volatility: Frequent policy changes can create uncertainty, affecting access to subsidies or tariffs and discouraging investors. Reduced support, such as lower feed-in tariffs, can make previously viable projects financially unstable, especially smaller or community-based ones.

- Investment timing: Anticipated policy shifts can lead to delays in investment or rushed decisions to secure existing incentives, disrupting market stability.
- Implementation delays: Even supportive policies may suffer from bureaucratic slowdowns, delaying permits, grants, or approvals, increasing project costs.

To reduce these risks, projects should aim for financial resilience by relying less on incentives and more on stable income sources like self-consumption savings, energy sales, or long-term PPAs. Developers should also plan for various policy scenarios to ensure adaptability and long-term sustainability.

5.3.6.3 Self-consumption variation

Task: Explain a key operational risk in community-based renewable energy projects, focusing on how fluctuations in self-consumption levels affect energy sharing and participant benefits.

A key risk in community-based renewable energy projects, like those supported by EnerCmed, is the fluctuation in self-consumption levels. These models rely on sharing renewable energy among participants, who benefit through reduced-cost energy or other value-sharing mechanisms. However, the more energy generation owners consume themselves, the less is available for the community.

When self-consumption increases significantly, often to cut individual energy costs, it reduces the surplus energy that can be shared. This directly affects participants without their own installations, who rely on the shared pool for affordable energy. As a result, rising self-consumption can lower the overall benefits for non-owner participants in the community.

5.3.6.4 Plant producibility decrease

Task: Explain how a decrease in plant productivity can affect the progress and outcomes of the project.

An additional key operational risk in renewable energy projects based on photovoltaic systems is the gradual decrease in plant productivity over time. Solar panels naturally degrade, typically losing efficiency at a rate of 0.4% to 0.6% per year, depending on technology and environmental conditions. As a result, the annual electricity output of the plant declines, reducing the quantity of energy available for self-consumption or sharing within the community.

If this degradation is not adequately considered in the planning phase, it may lead to overestimated financial and social returns, especially in projects involving energy sharing mechanisms where participants expect stable energy benefits over the plant's lifetime. Furthermore, the absence of a mid-life revamping strategy—such as inverter replacement or partial module substitution—can exacerbate this decline, causing underperformance and weakening the economic viability of the initiative. Therefore, long-term operational plans must account for declining productivity and include financial provisions for maintenance or partial system upgrades around the 10th or 15th year of operation to maintain performance and ensure sustained value for all participants.

6.ToR for implementing NBS to support REC integration in Energy-Positive, Climate-Resilient Neighborhoods

Task: Provide a comprehensive overview of the chapter content, including its aim, significance, and the methodology employed.

This section outlines the ToR for implementing NBS in support of REC or Self-Consumption scheme within the broader framework of achieving energy-positive and climate-resilient urban neighborhoods. The aim is to guide pilot cities in operationalizing a set of site-appropriate, scalable, and sustainable NBS interventions that can enhance REC functionality and urban resilience, particularly in marginalized, next-to-port areas affected by UHI phenomena and energy poverty.

6.1 Introduction

Task: Give a summary of the issues treated in this document and highlight the importance of a common ToR for NBS implementation.

This section addresses the role of NBS in enhancing the environmental performance and social resilience of RECs or SCSs in the Mediterranean port hinterlands. It explores how NBS can mitigate UHI effects, reduce energy demand, and improve microclimatic conditions, especially in marginalized districts. The development of a common ToR offers a structured and replicable framework for the integration of NBS into the planning and implementation of RECs or SCSs. As illustrated in Figure 5, this framework follows a step-by-step approach starting with problem localization, regulatory analysis, and stakeholder engagement, progressing through feasibility studies and impact evaluation, and culminating in implementation and long-term maintenance. This shared methodology allows pilot cities to align strategies and scale up effective solutions for achieving energy-positive and climate-resilient urban neighborhoods.

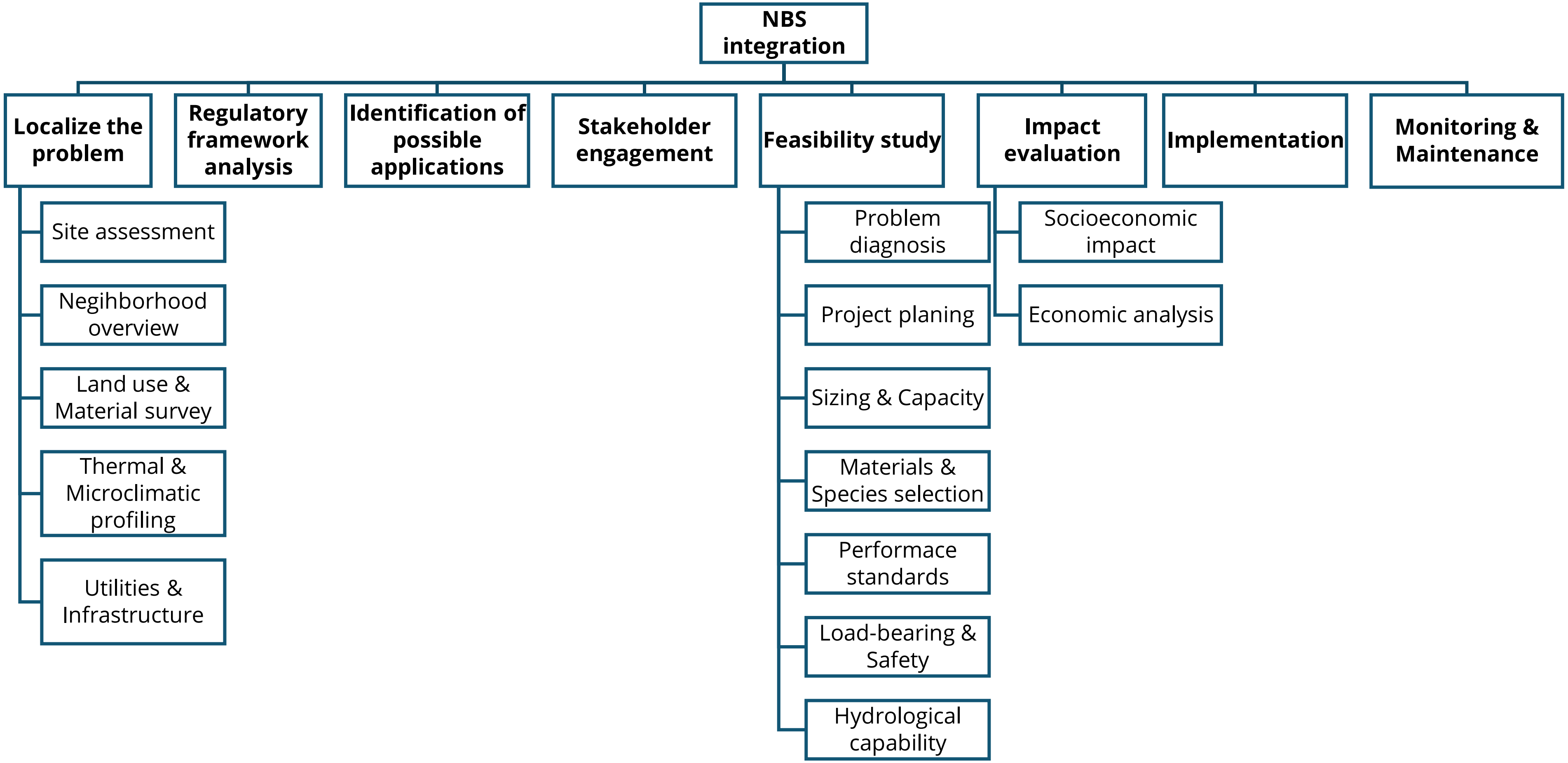

Figure 5. Scheme for the NBS Integration to support REC integration in Energy-Positive, Climate-Resilient Neighborhood

6.2 Internal alignment with the project organization (experts)

Task: Ensure internal alignment within the project organization by coordinating and harmonizing expectations and ideas regarding the goals of implementing Nature-Based Solutions (NBS) for mitigating the Urban Heat Island effect.

Effective implementation of NBS requires early and sustained coordination among the project's technical and research partners. This internal alignment process ensures that all involved stakeholders, including environmental engineers, urban planners, climate scientists, and municipal representatives, share a unified understanding of the strategic goals, technical criteria, and expected outcomes of the NBS interventions. Regular coordination meetings, thematic workshops, and shared working documents are essential tools to harmonize methodological approaches, align terminology, and clarify each actor's role within the planning and implementation cycle. This phase reinforces collective ownership of the NBS strategy and enhances the project's capacity to deliver context-specific, high-impact interventions that are technically sound, socially inclusive, and ecologically resilient. A clear distribution of responsibilities also supports seamless integration of NBS with broader project components, such as energy community planning and microclimatic performance evaluation.

6.3 Conceptualize the problem

Task: Assess the issue of urban overheating driven by dense development and heat-retaining surfaces, including black PV panels, and evaluate how Nature-Based Solutions can mitigate these impacts to enhance the Urban Heat Island Effect.

Urban overheating represents a complex, multi-scalar problem arising from the interaction between built form, materiality, and climatic exposure. Addressing this challenge requires a diagnostic framework that supports the identification of conditions under which Nature-Based Solutions (NBS) can be effectively deployed to mitigate thermal stress. This phase focuses on identifying and defining the core urban challenges related to heat-related hotspots, particularly those linked to dense morphological configurations, low vegetation cover, and the presence of heat-retaining materials in the built environment. Among these, special attention should be given to surfaces with low albedo such as asphalt, concrete, and black PV panels, which significantly contribute to localized heat accumulation and intensify the UHI effect.

Partners are expected to carry out a structured conceptualization of how these elements interact to influence urban microclimates, with a focus on their impact on thermal comfort, cooling energy demand, and public health vulnerabilities. This conceptual understanding serves as a foundational step in aligning NBS interventions with the specific conditions and constraints of each urban area.

The process should incorporate a preliminary typological mapping of NBS categories that are functionally suited to mitigate these stressors.

6.4 Localize the problem

Task: Identify and analyze how the Urban Heat Island (UHI) effect and urban overheating manifest within the specific local context of the project area.

Following the conceptual framing of urban overheating, this phase requires translating the problem into a site-specific analysis that captures how the UHI effect manifests within each pilot area. The local urban form, land cover, and environmental conditions must be assessed to identify spatial patterns of thermal stress and determine which zones are most affected.

The assessment must include the analysis of land use typologies, surface material composition, and vegetation distribution. Local climatic variables including solar radiation, wind patterns, humidity, and seasonal temperature trends should be incorporated to understand how heat accumulates and disperses. Additionally, the presence and configuration of PV installations must be reviewed, with particular attention to surface orientation, panel type, and their potential contribution to localized heating.

Where feasible, in-situ measurements or datasets should be used. This localized diagnostic will support the identification of priority zones for NBS implementation and guide the selection of interventions that are tailored to the environmental characteristics of each site.

6.4.1 Site assessment

Task: Provide an overview of the various types of analyses used to determine the most suitable site for implementing Nature-Based Solutions (NBS).

Site assessment is a critical initial step in identifying suitable locations for the effective implementation of NBS within RECs. This process combines multiple layers of spatial, environmental, and social analysis to ensure that selected interventions address the specific vulnerabilities and characteristics of each urban context.

The assessment includes microclimate and UHI analysis to identify heat-prone zones where NBS can improve thermal comfort and reduce cooling demand. Land use and vegetation cover mapping are employed to locate impervious areas and assess green space availability, while hydrological and drainage studies help to detect flood-prone zones that may benefit from water-based NBS such as bioswales or rain gardens.

Additionally, socio-demographic profiling of neighborhoods is conducted to reveal the populations most at risk from heat stress and energy poverty. Integration of existing infrastructure audits and building typology evaluations further guides the technical feasibility and scale of NBS application.

This holistic site assessment ensures that NBS deployment is both targeted and impactful, enabling cities to prioritize actions where they are most needed and most effective.

6.4.2 Neighborhood overview

Task: Provide a brief description of the neighborhood's geographical setting, urban morphology, and land use.

In this section, the neighborhoods under consideration should be identified and described, along with their location, terrain typology, type of construction, and available green areas.

The targeted neighbourhoods within the EnerCmed pilot areas are typically situated in port-adjacent hinterlands, characterized by dense urban fabric and limited open green spaces. These areas often present a mix of industrial, residential, and infrastructural land uses, shaped by historical development linked to maritime activity. Urban morphology is compact, with a predominance of impervious surfaces, low vegetation cover, and high building density; factors that intensify UHI effects.

Geographically, the neighbourhoods are influenced by coastal microclimates, but experience localized overheating due to limited airflow, inadequate shading, and heat retention from built materials. This spatial context highlights the urgency for integrating Nature-Based Solutions (NBS) that can mitigate environmental stressors while adapting to complex land-use constraints.

6.4.3 Land Use and Material Survey

Task: Identify the thermal properties of the building elements and the surrounding environment.

For neighborhoods where microclimate simulations are planned, a detailed land use and material survey is a critical step. Geographic Information Systems (GIS) and remote sensing tools, or, in simpler applications, platforms like Google Earth Pro, can be used to classify roofing materials, assess vegetation coverage, and analyze surface characteristics such as albedo. These methods support the evaluation of thermal properties, including thermal conductivity, heat capacity, and emissivity, for both building elements and the surrounding environment.

6.4.4 Thermal and Microclimatic Profiling

Task: Perform a geospatial analysis utilizing high-resolution temperature datasets and thermal mapping to identify zones most impacted by the Urban Heat Island (UHI) effect.

Thermal and microclimatic profiling is needed to identify areas most affected by the UHI phenomenon. This assessment involves geospatial analysis using high-resolution temperature datasets, satellite-derived thermal imagery, and in-situ data, where available. The process focuses on generating surface temperature and air temperature maps, as well as thermal stress indicators, to spatially delineate critical urban heat hotspots.

By identifying zones with the highest thermal burdens, this profiling supports the prioritization of NBS interventions. It informs the strategic placement of vegetation-based, water-based, or urban design solutions to reduce localized heat accumulation and enhance thermal comfort in vulnerable areas.

6.4.5 Utilities & Infrastructure

Task: Map underground services and existing networks

Identify and map all existing underground utilities and infrastructure (e.g. water, sewage, gas, electricity, telecom) within the project area. This includes reviewing as-built plans, conducting site surveys or geophysical investigations if needed, and assessing potential conflicts with proposed NBS installations. Accurate mapping ensures safe implementation, avoids service disruption, and informs design adjustments to align with existing networks.

6.5 Regulatory framework analysis

Task: Define the normative dashboard related to the application of green roofs, facades, and green areas associated with the spatial planning and regulatory context at the regional and municipal level.

This task involves conducting a structured review of the existing regulatory and planning frameworks that influence the implementation of NBS at both the municipal and regional levels. The analysis should cover spatial planning instruments, zoning ordinances, environmental regulations, and building codes that govern the deployment of green infrastructure such as vegetated roofs and facades, as well as other NBS typologies including blue-green infrastructure (e.g., bioswales, rain gardens), permeable surfaces, and ecological restoration.

The review must identify any legal enablers or constraints, including permit requirements, construction guidelines, design standards, and possible incentives for green infrastructure adoption. Special attention should be given to land-use restrictions, historic preservation areas, and technical specifications related to structural safety, water management, and vegetation integration.

In cases where national or EU-level directives or funding frameworks influence local NBS implementation, these should also be referenced. The aim is to ensure all proposed interventions are aligned with existing regulations, and to highlight any gaps or barriers that may require administrative adaptation or policy support to facilitate broader adoption of climate-resilient practices.

6.6 Spatial planning analysis

Task: Perform spatial planning analysis to identify critical infrastructure and local conditions to determine the optimal location for Nature-Based Solutions.

This section involves the evaluation of the spatial planning framework and urban development conditions that affect the siting and implementation of NBS. The analysis includes reviewing the current urban master plan, zoning regulations, and land-use classifications to identify spatial constraints, critical infrastructure, and potential synergies with existing public spaces and utilities.

Integrating regulatory requirements with geospatial assessments, this phase aims to define the most feasible locations for deploying NBS interventions, ensuring compatibility with legal, technical, and environmental conditions. The output of this task is the preliminary decision on the specific sites where NBS will be implemented within the pilot area.

6.7 Identification of the possible NBS applications

Task: Identify the potential NBS application/s.

Once site-specific conditions have been assessed, each case must identify NBS with the highest potential to address local manifestations of urban overheating. This task involves aligning the functional characteristics of NBS such as shading, evapotranspiration, stormwater retention, and biodiversity support with the environmental stressors and spatial opportunities identified in the earlier assessment phases.

Potential applications may include, but are not limited to:

- Green roofs and green facades
- Urban tree planting and shading corridors
- Blue-green infrastructure such as bioswales, rain gardens, and retention ponds
- Pocket parks, community gardens, and rewilded zones

- Slope vegetation for stabilization and evapotranspiration
- Climatic-sensitive pavement and permeable surfaces

Each option should be evaluated against key criteria including:

- Cooling performance and UHI mitigation potential
- Compatibility with land availability and physical constraints
- Maintenance requirements and lifecycle costs
- Institutional feasibility and regulatory alignment
- Co-benefits such as flood control, habitat creation, and public amenity

This identification phase does not yet require full feasibility validation but should generate a prioritized shortlist of NBS types tailored to each site. These selections will be further refined during the project planning and design stages.

6.8 Strategize a multi-stakeholder approach

Task: Design an inclusive and effective multi-stakeholder strategy that ensures meaningful participation throughout the project.

The successful implementation of NBS requires coordinated involvement of a diverse group of stakeholders, each contributing specific knowledge, interests, and responsibilities. In this phase, pilot partners must develop a comprehensive multi-stakeholder strategy that ensures inclusive participation and aligns actors toward a shared vision of urban resilience.

Stakeholders should be identified across categories including local authorities, technical services, environmental agencies, neighborhood associations, NGOs, educational institutions, vulnerable community representatives, and private sector actors such as developers or utilities. Each stakeholder's potential influence, interest, and capacity to contribute should be mapped.

A tailored communication and engagement plan must be prepared, specifying appropriate tools and channels based on stakeholder profiles ranging from public consultations and focus groups to bilateral meetings and digital platforms. The plan should outline how project objectives, expected benefits, implementation roles, and decision-making processes will be communicated in a transparent and accessible manner.

6.9 Plan with the local stakeholders

Task: The task is to actively engage local stakeholders in the co-development of Nature-Based Solutions (NBS) by facilitating collaborative planning processes.

Building on the stakeholder strategy, this phase focuses on engaging local actors in the co-development of NBS interventions through participatory planning processes. Partners must facilitate inclusive dialogue to ensure that proposed solutions reflect the needs, values, and knowledge of the communities most directly affected by urban overheating and environmental vulnerability.

Activities may include collaborative workshops, co-design sessions, mapping exercises, and scenario testing that enable stakeholders to review and adapt preliminary NBS proposals. This co-creation approach should seek to balance technical feasibility with local relevance, addressing both environmental performance goals and community priorities.

The process should also document local concerns, barriers to implementation, and suggestions for stewardship, ensuring that proposed interventions are not only technically sound but also socially accepted and maintainable over time. The outcomes of this phase will feed into the final design and implementation strategy, reinforcing the legitimacy and sustainability of NBS within the broader REC framework.

6.10 PV Heat Impact Analysis (only if software will be used for Microclimate simulations)

Task: Evaluate the PV module surface temperatures and radiant heat emissions.

If a simulation tool is utilized to analyze the neighborhood's microclimate, this task aims to assess the thermal impact of photovoltaic (PV) installations on the surrounding urban environment. Specifically, the analysis should evaluate PV module surface temperatures, radiant heat emissions, and their contribution to local thermal dynamics.

By modeling the interactions between PV systems and urban surfaces, the assessment can reveal how large-scale PV deployment may influence temperature patterns, particularly in areas already vulnerable to the UHI effect. This information supports the strategic integration of NBS to mitigate any adverse thermal impacts.

6.11 Feasibility Study for NBS Implementation

Task: Summarize the steps for performing the feasibility study regarding the NBS implementation.

The feasibility study for integrating NBS into the EnerCmed project is a foundational preparatory step that ensures the effective incorporation of NBS into RECs and the wider strategy for creating energy-positive, climate-resilient neighborhoods. As detailed in *Chapter 3 of Deliverable D2.4.1*, the methodology for selecting and customizing NBS follows a holistic, iterative project cycle (Figure

13), comprising stakeholder engagement, problem diagnosis, project and action planning, implementation, and continuous monitoring and evaluation.

6.11.1 Problem diagnosis

Task: Identify and analyze the specific environmental, spatial, and socio-economic challenges within the project area that Nature-Based Solutions (NBS) are intended to address.

This task requires a structured diagnosis of the primary challenges that NBS interventions should respond to. The analysis should cover three core dimensions:

- **Environmental factors:** including local manifestations of the UHI effect, lack of vegetation, poor air quality, and inadequate stormwater management.
- **Spatial and morphological constraints**: such as limited open space, high building density, impervious surfaces, or conflicting land uses.
- **Socio-economic vulnerabilities:** including populations affected by energy poverty, lack of access to green space, or increased exposure to climate risks such as heatwaves or flooding.

The diagnostic should integrate data from site assessments, spatial planning reviews, microclimate modeling, and stakeholder engagement activities. Outputs should include a clear identification of problem hotspots, affected populations, and the specific environmental or regulatory conditions that constrain or enable NBS implementation to form as the foundation for developing context-specific intervention strategies in the following planning stages.

6.11.2 Project planning

Task: Describe the main steps for NBS planning.

Project planning for NBS involves structuring the development process from concept to execution through a series of interconnected steps. These include defining clear objectives based on the diagnostic findings, setting spatial and functional targets, and preparing a timeline that integrates design, permitting, stakeholder involvement, and implementation. Planning should account for technical specifications, local constraints, and logistical considerations such as phasing, procurement, and contractor selection. Risk assessment and mitigation strategies must also be embedded early in the process to ensure resilience against disruptions. Importantly, planning activities should remain iterative, allowing feedback from co-design sessions and feasibility evaluations to refine the intervention strategy before finalization.

6.11.3 Sizing and Capacity

Task: Define the methodology for calculating the physical dimensions and performance capacity of Nature-Based Solutions (NBS).

This step involves developing a sizing methodology to ensure that selected NBS systems deliver effective thermal, hydrological, and ecological performance. The methodology should begin with an assessment of key site-specific parameters, including local rainfall intensity and frequency, runoff volumes, infiltration capacity, and evapotranspiration potential.

For cooling-focused interventions (e.g. green roofs, tree planting), calculations should incorporate vegetation type, density, and canopy coverage, as well as expected temperature reduction impacts. For stormwater-related NBS, such as rain gardens or bioswales, sizing should consider catchment area, soil permeability, substrate depth, and required retention volumes.

Structural considerations, including load-bearing capacities of rooftops or underground constraints, must be integrated into the design parameters, particularly in retrofit applications. Where applicable, the use of simulation tools or climate models is encouraged to test system performance under future conditions, including extreme weather events.

The output of this task should be a clear, replicable methodology that informs the physical design of NBS elements across varied site conditions, ensuring alignment with performance targets and safety standards.

6.11.4 Materials and Species Selection

Task: Select appropriate soil media, vegetation, and structural components for the Nature-Based Solution (NBS) system.

Identify and specify materials that support the functional and ecological performance of the NBS. This includes selecting soil media with adequate drainage and nutrient properties, drought-tolerant and native plant species suited to local climate and NBS type, and structural layers such as filter fabrics, drainage mats, and waterproofing membranes (e.g., for green roofs or bioretention systems). Selection should ensure system longevity, low maintenance, and compliance with relevant technical standards.

6.11.5 Performance Standards

Task: Ensure the NBS design meets the required performance criteria.

To ensure that NBS deliver measurable environmental and social benefits, clear performance standards must be defined for each intervention. These standards should be function-specific and reflect the intended outcomes such as minimum evapotranspiration rates for vegetated systems, surface temperature reductions for shading elements, or runoff detention capacity for stormwater infrastructure.

The performance criteria should be aligned, where applicable, with existing national or EU environmental regulations, urban sustainability frameworks, and climate adaptation targets. In addition, project-specific Key Performance Indicators (KPIs) should be established to track progress and assess effectiveness across both implementation and operational phases.

KPIs may include quantitative targets such as:

- Surface/Air temperature reduction (°C)
- Increase in shaded area coverage (% or m^2)
- Improved thermal comfort index (e.g., PET, UTCI scores)
- Stormwater retention volume (m^3)
- Vegetation coverage increase (%)
- Reduction in peak runoff rates (%)
- Energy savings linked to cooling demand (kWh)
- Estimated energy cost savings due to cooling (€/year)
- Increase in biodiversity indicators (e.g., pollinator species count, Shannon Index)
- Number of users engaging with NBS spaces (footfall or survey)
- Reduction in heat-related health incidents (%)
- Community satisfaction or perception indices (% positive responses)

These indicators should be integrated into the design, monitoring, and reporting cycles to support evidence-based validation and adaptive management. Standardization of performance benchmarks across pilot areas will also facilitate comparison, replication, and knowledge transfer throughout the project lifecycle.

6.11.6 Load-bearing and Safety: Structural and Architectural Assessment

Task: Based on the different typologies of Nature-Based Solutions (NBS), outline the key analyses necessary to assess their implementation.

The structural and architectural assessment is a critical step in assessing the feasibility of incorporating NBS into existing urban districts. This analysis aligns the physical constraints of built infrastructure with the technical requirements of different NBS typologies to ensure long-term safety and functionality.

As described in *Deliverable D2.4.1*, NBS are grouped into three principal categories; vegetation-based, water-based, and urban-design interventions, each imposing distinct structural demands and spatial integration criteria.

- Vegetation-based systems (e.g., green roofs and vertical greening) require a detailed inspection of the building's load-bearing capacity is essential. The evaluation should differentiate between extensive systems, which are lighter and suitable for most retrofits, and intensive systems, which are heavier, and demand reinforced structural support. Engineering assessments must be conducted to verify the permissible dead and live loads of rooftops, including factors such as substrate thickness, saturated weight, and potential snow accumulation.

- For vertical greening installations, such as living walls or green facades, the facade's load-transfer capacity and anchorage details must be verified. This includes examining the façade's material type, anchorage conditions, and insulation performance, especially where vegetation may influence thermal bridges or water infiltration.

- At the ground level, the assessment must identify available open spaces suitable for greening interventions, such as tree planting, bioswales, or pocket parks. This involves mapping the unsealed or potentially convertible surfaces, analysing soil depth and permeability, and checking for underground utilities that might constrain root growth or excavation.

In line with microclimatic considerations discussed in the EnerCmed report, such architectural evaluations should also consider orientation and exposure to sun and wind, which influence both the effectiveness of shading and evapotranspiration and the health of vegetation. For water-based solutions like rain gardens or infiltration trenches, proximity to drainage infrastructure and slope gradients are key architectural variables to determine.

These assessments enable a realistic and site-specific selection of NBS, ensuring compatibility with existing urban structures and maximizing their environmental and social co-benefits. The outcomes of this phase directly inform the technical design and planning of the interventions in the subsequent stages of the NBS project cycle.

6.11.7 Hydrological Compatibility

Task: Provide an evaluation of hydrological capability.

An assessment of hydrological compatibility is essential for the successful integration of NBS such as green roofs, facades, and ground-level vegetation in urban contexts. As outlined in the final version of *Deliverable D2.4.1*, this evaluation helps determine whether proposed NBS can function effectively in relation to local rainfall patterns, drainage infrastructure, and water management strategies, while also supporting microclimatic benefits and resource efficiency.

For green roofs, the hydrological assessment includes the quantification of rainwater retention capacity based on the type and depth of substrate, vegetation layer, and roof slope. Extensive green roofs, which typically have shallower substrates, offer limited but valuable retention performance, reducing peak stormwater runoff and mitigating urban flooding risks. Intensive systems, with deeper substrates, provide higher water retention but also require more robust structural support and irrigation management. Crucially, when applying green roof systems, it is important to determine whether the roof can collect and temporarily store rainwater. This water storage contributes to the system's weight and therefore must be factored into the load-bearing assessment to ensure the building's structural integrity.

Green facades, while offering less storage capacity than horizontal surfaces, also contribute to stormwater management by slowing down rainwater flow and supporting local humidity regulation. Their hydrological compatibility must be analysed in terms of facade exposure, plant species used, and the capacity of growing media or modular systems to absorb and slowly release moisture.

Moreover, the analysis must evaluate the need for supplementary irrigation systems. Depending on the local climate and plant selection, passive systems (e.g., rainwater harvesting, capillary irrigation from reservoirs) may suffice, while in more arid conditions, active irrigation may be required. Deliverable D2.4.1 stresses the importance of using drought-tolerant or native species to reduce water demand and recommends integrating rainwater harvesting systems wherever feasible to enhance self-sufficiency.

Finally, the hydrological assessment must consider seasonal rainfall distribution, risk of drought or heavy rainfall events, and the relationship between green surfaces and existing stormwater networks. This ensures that the selected NBS not only contributes to localized cooling and biodiversity enhancement but also strengthens the climate resilience of neighborhoods by improving water retention, reducing runoff, and supporting sustainable water cycles

6.11.8 Comparison of different possible scenarios

Task: Conduct an analysis to identify the optimal solution from a cost-benefit perspective, maximizing environmental and social impact while minimizing costs.

To ensure the most effective and context-specific NBS are selected, a comparative assessment of alternative implementation scenarios should be conducted. This process involves evaluating a range of NBS options (e.g., green roofs, permeable pavements, tree planting, vertical greening) based on technical feasibility, environmental effectiveness, social acceptance, and economic viability.

Each scenario should be analysed using a cost-benefit approach, taking into account initial investment, operational and maintenance costs, and expected benefits such as UHI mitigation, improved air quality, enhanced biodiversity, and reduced energy demand. Non-monetary co-benefits, such as community wellbeing and climate resilience, should be qualitatively or quantitatively assessed where feasible.

This analysis should build on the multicriteria framework presented in Chapter 3 and follow the structure of the NBS Project Cycle (Figure 13), incorporating stakeholder input and localized data. The outcome should support evidence-based decision-making to identify the optimal NBS configuration that delivers maximum environmental and social gains at the lowest cost, ensuring replicability and long-term sustainability.

6.12 Impact Evaluation of the NBS

Task: Provide a short description of the impact of the NBS.

The impact evaluation of NBS interventions should provide a synthesized overview of how implemented measures contribute to environmental resilience, social well-being, and economic viability. This integrated assessment captures both the tangible and intangible outcomes of NBS in relation to project goals, such as mitigating UHI effects, enhancing local biodiversity, and improving quality of life in vulnerable urban neighborhoods.

The evaluation process draws on quantitative and qualitative methods, including geospatial analysis, environmental monitoring, stakeholder feedback, and economic modeling. It links design objectives to measurable performance outcomes, ensuring that benefits such as air quality improvement, thermal comfort enhancement, increased property value, and energy demand reduction are documented and communicated.

This summary consolidates the key findings from the subsequent sub-sections (6.12.1 to 6.12.3), creating a picture of how NBS support climate adaptation, urban livability, and long-term sustainability in the context of REC and next-to-port districts. The impact evaluation also informs replication potential and future investment priorities.

6.12.1 Environmental Impact

Task: Evaluate the environmental performance of implemented Nature-Based Solutions (NBS).

The environmental impact of NBS should be assessed through quantifiable indicators that reflect improvements in urban ecological health and climate resilience. These include reductions in ambient and surface temperatures, improvements in air and water quality, enhanced biodiversity through habitat creation, and decreased surface runoff. Evaluation methods may involve in-situ monitoring, remote sensing data, or ecological surveys to assess flora and fauna diversity. The analysis should be contextualized within the urban ecosystem, highlighting how NBS contribute to UHI mitigation, increased permeability, and ecological connectivity. The evaluation should be aligned with the project's overall monitoring framework to support adaptive management, inform decision-making, and provide replicable results for similar urban contexts.

6.12.2 Socio-Economic Impact

Task: Assess the socio-economic benefits and feasibility of the implemented Nature-Based Solutions (NBS).

Socio-economic impact assessment focuses on the broader human-centered outcomes of NBS implementation. These include improvements in public health due to better air quality and reduced thermal stress, increased access to green spaces contributing to social cohesion and mental well-being, and direct economic benefits such as energy savings and enhanced property values.

Particular attention should be given to how NBS affect vulnerable populations, supporting equity and inclusivity objectives. The assessment may involve surveys, interviews, or statistical analysis of economic indicators. Ensuring strong community involvement throughout the project lifecycle increases social acceptance and long-term commitment to the maintenance of the intervention.

6.12.3 Economic analysis

Task: Evaluate the economic feasibility, value, and financing options for Nature-Based Solutions (NBS) in REC areas.

Economic analysis is important for assessing the feasibility and long-term value of NBS in REC areas. This involves estimating capital and operational costs for different NBS types.

Benefits include energy savings (e.g., reduced cooling demand), increased building lifespan, stormwater management, and improved property value. Tools like cost-benefit analysis and life-cycle costing can support the evaluation, along with ecosystem service valuation as outlined in Chapter 3 of the *Deliverable D2.4.1*.

Stakeholder engagement, as recommended in the NBS Project Cycle (Figure 13), is critical for aligning economic priorities and exploring funding opportunities such as public subsidies, EU programs, and citizen or private investment schemes. A solid economic analysis strengthens the case for NBS as scalable, cost-effective climate solutions.

6.13 Action planning

Task: Prepare an action plan.

This phase includes the development of a detailed action plan that outlines each phase of the NBS project, including implementation strategies, timeline, and resource allocation. Incorporate a thorough economic evaluation covering initial costs, funding sources, and cost-benefit analysis. Plan for long-term operation and maintenance activities to ensure durability and effectiveness throughout the system's lifespan. The action plan should prioritize sustainability, optimize lifecycle costs, and integrate monitoring and adaptive management to support ongoing performance and resilience.

6.14 Implementation

Task: Manage and execute the construction and installation of the NBS according to design specifications, ensuring quality control, adherence to timelines, and regulatory compliance.

The implementation phase involves the physical realization of the NBS as defined in the approved technical design and project plan. This includes site preparation, coordination of material delivery, and execution of works related to structural water and vegetative elements.

Implementation must adhere strictly to quality standards, safety regulations, and environmental guidelines. Responsibilities include coordinating contractors and suppliers, resolving on-site challenges, and ensuring that any deviations from design specifications are properly addressed and documented.

Regular inspections and milestone-based progress checks should be conducted to ensure that installation is on schedule, compliant, and aligned with design expectations. Implementation must also be responsive to site-specific conditions identified during earlier phases, including structural load assessments, hydrological capacity, and local stakeholder input.

Effective communication among project managers, local authorities, and community stakeholders is key to minimizing delays and ensuring accountability. Documentation of the implementation process will support future evaluation, reporting, and potential replication.

6.15 Continuous monitoring and maintenance

Task: Establish and implement ongoing monitoring and maintenance protocols to ensure the long-term health, functionality, and sustainability of NBS.

Long-term performance of NBS requires a structured approach to monitoring and maintenance that begins immediately after implementation. A tailored monitoring framework should be established, linked to the performance standards and Key Performance Indicators (KPIs) defined during the design phase.

Monitoring activities must include both quantitative and qualitative assessments of ecological function, system integrity, and user interaction. This includes measuring indicators such as vegetation health, soil moisture, biodiversity levels, evapotranspiration, water retention, and thermal performance.

A maintenance strategy should be developed that addresses routine tasks (e.g., pruning, irrigation, litter removal), seasonal adjustments, and adaptive interventions in response to observed system performance. The strategy should specify roles, timelines, and resource allocation, and be designed to minimize long-term operational costs.

Stakeholder involvement is needed for ensuring transparency and building local ownership. Local authorities, maintenance teams, and community groups should be involved in both monitoring and maintenance activities to support stewardship and system resilience.

Data collected through ongoing monitoring should feed into adaptive management cycles and inform potential upscaling or replication of NBS in similar urban contexts.

Annexes

Annex 1 – Checklists

These checklists serve as a foundational guide for the constitution and operationalization of Renewable Energy Communities (RECs) and self-consumption schemes integrated with Nature-Based Solutions (NBS) for energy-positive and climate-resilient neighborhoods.

Checklist 1: Social Engagement of the Vulnerable Population

Checklist for the Social Engagement of the Vulnerable Population		
Contextual understanding of the vulnerable population	**Yes/No**	**Comments**
Does the demographic analysis include key data such as age distribution, population size, household structure, and population density?		
Are key socioeconomic indicators covered (e.g., income levels, employment status, education levels, housing conditions, access to basic services)?		
Does the assessment consider cultural, ethnic, or social characteristics relevant for inclusive energy planning?		
Are the specific needs, challenges, and vulnerabilities of the target population in relation to the energy transition clearly identified?		
Does the analysis identify opportunities for engagement and participation in the energy transition (e.g., local initiatives, existing actors)		
Has the analysis identified and described the key cultural values, traditions, or practices relevant to the target communities?		
Has the analysis been validated or informed by direct input from community members or local stakeholders?		
Forms of Social Engagement	**Yes/No**	**Comments**
Promoting Knowledge, Tailored Outreach and Support		
Are outreach and awareness-raising activities described, using accessible and culturally appropriate formats (e.g., workshops, community radios)?		
Do the materials and methods clearly explain RECs or Self-Consumption schemes, including their benefits for vulnerable populations?		
Are the communication strategies tailored to the specific needs and capacities of the target population (e.g., literacy, language, technology access)?		
Inclusion in Decision-Making	**Yes/No**	**Comments**
Are mechanisms described for involving vulnerable groups in planning and implementation (e.g., participatory workshops, local forums)?		
Is there a plan to ensure that community input influences decisions at governance or operational levels of RECs or energy schemes?		
Are efforts described to build trust and ensure transparency in decision-making processes involving the target population?		
Empowerment through Collective Action		

Are models of collective action or community ownership (e.g., energy cooperatives) proposed to engage vulnerable groups in RECs?		
Does the strategy emphasize community empowerment through roles in management, operation, or governance of energy projects?		
Are examples or pathways provided that show how collective action can build social cohesion and reduce energy vulnerability?		
Social Benefits	**Yes/No**	**Comments**
Are specific social benefits identified (e.g., reduced energy bills, improved housing, stronger community ties)?		
Does the analysis demonstrate how RECs contribute to broader social inclusion and community resilience in marginalized areas?		
Is there a focus on long-term benefits such as reduced energy poverty, improved quality of life, and increased local capacity?		
Monitoring, Evaluation, Feedback	**Yes/No**	**Comments**
Are there defined performance indicators (e.g., participation rates, satisfaction levels, behavior changes) to monitor engagement impact?		
Are feedback mechanisms described (e.g., surveys, community meetings, digital platforms) to refine engagement activities over time?		
Are both quantitative and qualitative tools proposed for evaluation (e.g., data analytics, interviews, behavioral tracking)?		
Integration with National and Regional Policies	**Yes/No**	**Comments**
Does the engagement strategy align with relevant national/regional policies on energy, social inclusion, and sustainability?		
Are references to specific policy frameworks, funding programs, or legal instruments provided to demonstrate alignment?		
Is there a rationale showing how policy alignment supports long-term viability, legitimacy, and institutional support for the REC initiatives?		

Checklist 2: Energy Community Technical Design & Digitalization

Checklist for Energy Community Technical Design and Digitalization		
Legal and Regulatory context for RECs	**Yes/No**	**Comments**
Has the EU Renewable Energy Directive (RED II and RED III) been fully transposed into national law, and what provisions are made for Renewable Energy Communities (RECs) and self-consumption schemes?		
What specific national laws or regulations have been established to facilitate the implementation of RECs, including eligibility criteria, support mechanisms, and operational guidelines		
Are there any provincial or municipal regulations that modify or adapt national REC frameworks		
How do existing regulations enable or hinder citizen participation in RECs, and what regulatory barriers exist that may limit collective self-consumption and decentralized energy production at local levels		
Identification of the REC or Self-Consumption scheme Members: Producers/Prosumer and Consumer	**Yes/No**	**Comments**
Have all members (producers, prosumers, and consumers) of the REC or Self-Consumption scheme been clearly identified and categorized based on legal eligibility, geographical proximity, and technical compatibility		
Does the membership plan include vulnerable households, public bodies, and local enterprises, in alignment with EU objectives for an inclusive energy transition?		
Has the potential for adding additional participants to the REC or Self-Consumption scheme been evaluated for future expansion?		
Identification of Economic Resources	**Yes/No**	**Comments**
Have various economic resources, such as grants, loans, strategic partnerships, and private investments, been identified to support the establishment and sustainability of the REC or Self-Consumption scheme?		
Has a diverse range of financial support mechanisms been considered to ensure the project's long-term sustainability and expansion?		
Technical Feasibility and Energy Modelling	**Yes/No**	**Comments**
Have national, provincial, and municipal regulations regarding photovoltaic (PV) plants been thoroughly reviewed, particularly in terms of spatial planning, permitting procedures, and integration with local energy strategies?		
Has the installation area for the PV plant been clearly defined, including the type of terrain (flat or inclined) and the characteristics of surrounding buildings or land (e.g., roof type, land usage)?		
Have key environmental factors (solar radiation, temperature, wind speed, humidity, and precipitation) been gathered for the identified installation area?		
Have the installation area's landscape, architectural, and archaeological restrictions been checked, in accordance with heritage protection regulations?		
Have potential conflicts with critical infrastructure that may affect the installation been assessed?		
Has the local solar potential been fully assessed?		
Have the necessary permits and authorizations for the PV plant installation been identified, taking into account the plant's size, location, and area-specific restrictions?		

Has the electricity consumption profile been defined?		
Has the peak power installed been evaluated?		
Has the producibility of the PV system been evaluated?		
Have different scenarios been considered?		
Has a detailed electrical schematic been created, including all plant components, connections, and mapping to evaluate energy losses and system layout, up to the primary cabin?		
Has the environmental impact of RES installations been evaluated (if required)?		
Are done the verification of the weight capacity of the roof or consistency of the terrain?		
Have the most suitable supporting elements been chosen for the PV panels, considering the roof or terrain type, and ensuring structural integrity and waterproofing?		
Are all the necessary permissions defined for the installation of the PV plant?		
Territorial & Landscape Regulations	**Yes/No**	**Comments**
Are energy installations compliant with local zoning and land-use regulations?		
Has the visual and ecological impact of the REC been assessed?		
Are all installations compliant with local building codes and regulations?		
Has stakeholder consultation been conducted with local authorities and communities?		
Additional requirements	**Yes/No**	**Comments**
Has the necessary documentation been submitted to the municipality, and has it been verified whether additional permissions (e.g., environmental impact evaluation, fire protection, or safety regulations) are required?		
Have the applicable incentives for energy fed into the grid been identified?		
Have potential installers and service providers near the installation site been identified and evaluated, with a focus on local inclusion and regional economic development?		
Has an ordinary maintenance program been developed, tailored to the site's characteristics and environmental conditions, and have contracts been prepared with selected service providers for regular monitoring and diagnostics?		
Economic Evaluation of the PV Plant	**Yes/No**	**Comments**
Has a comprehensive economic evaluation been conducted for the PV plant, covering design authorization costs, installation, maintenance, and estimated payback period?		
Grid System & Smart Meters	**Yes/No**	**Comments**
Has all required project documentation, including details about the PV plant's capacity, location, and applicable regulations, been prepared and submitted to the Energy Services Manager?		
Have suitable grid connection points been identified for the REC?		
Are smart meters correctly installed and integrated for real-time monitoring?		
Is the grid system capable of handling the energy output from the REC?		
Are energy storage systems included in the design for managing surplus energy?		
Will the measurements from the installed devices be available to the management tools?		
Is there any system considered to ensure data quality?		
Management Tools	**Yes/No**	**Comments**
Are data management systems in place for monitoring REC operations?		
Are data governance mechanisms properly defined?		
Do REC members have access to user-friendly tools for monitoring energy consumption?		
Are billing and payment systems automated and integrated into the REC platform?		
Do REC members have clear protocols to report issues and request assistance?		

Have cybersecurity measures been included to protect data and system integrity?		
Does the REC manager have tools to incentivize and maintain REC members in the community?		
General Verification of Technical Parameters	**Yes/No**	**Comments**
Have the energy production capacities been verified?		
Is there an alignment between energy production and consumption in the REC?		
Are smart metering systems calibrated and functional?		
Have all technical systems (grid, storage, metering) been tested for compliance?		

Checklist 3: Energy Community Legal, Administrative and Management structure

Checklist for Energy Community Constitution		
National Regulatory Assessment	**Yes/No**	**Comments**
Has the national legislation on Renewable Energy Communities (RECs) been analysed and updated?		
Have any implementing decrees or secondary regulations still pending been identified?		
Are there dedicated incentives or tariffs (CAPEX/OPEX, premium tariff, collective self-consumption, etc.) compatible with the project?		
Do the timelines of the incentives match the REC implementation schedule?		
Contextualization of the Configuration Model	**Yes/No**	**Comments**
Has the collective energy profile (load vs RES production) been simulated?		
Has the best scheme been chosen among: collective self-consumption, diffused self-consumption, multi-site REC, etc.?		
Have options for storage, demand response or virtual PPAs been assessed?		
Governance Set-up	**Yes/No**	**Comments**
Has a promoter group been established with representation from all stakeholders (citizens, SMEs, public authorities, etc.)?		
Have roles, responsibilities and decision-making processes (e.g. simple majority, qualified majority, consensus) been defined?		
Is the appointment of a Technical-Administrative Manager (Energy/Community Manager) foreseen?		
Definition of the Juridical Entity	**Yes/No**	**Comments**
Has the most suitable legal form (cooperative, association, consortium, benefit corporation, etc.) been selected?		
Does the founding act include participation limits and voting rights consistent with the legislation?		
Preparation of Statute and Internal Regulations	**Yes/No**	**Comments**
Does the Statute cover: corporate purpose, admission/exit procedures, quorum for assemblies, allocation of profits?		
Is there a Technical Regulation defining energy-sharing criteria (sharing key, dynamic coefficient, etc.)?		
Are mechanisms for transparency, reporting and periodic review provided?		
Identification of the Management Platform	**Yes/No**	**Comments**
Has a digital platform for monitoring, billing and user support been selected?		
Does the platform comply with GDPR, cybersecurity and interoperability with DSO/TSO?		
Do members have a user-friendly interface for consumption data and economic benefits?		
Preparation of Contracts and Administrative Documents	**Yes/No**	**Comments**
Has the grid connection and exchange contract with the DSO been prepared?		
Has the internal service/energy supply contract between REC and members been drafted?		
Are price-adjustment clauses, exit strategy and force majeure included?		
Supplier and Partner Selection	**Yes/No**	**Comments**
Has a tender or comparative procedure been carried out for EPC, O&M and legal consultancy?		
Do the award criteria include quality, price, references and ESG requirements?		

Are framework agreements or service-level agreements foreseen for post-installation?		
Permitting	**Yes/No**	**Comments**
Have all necessary building and landscape permits been obtained?		
Does the project comply with power, distance and primary substation limits imposed by regulation?		
Has compliance with any constraints been verified?		
Photovoltaic Plant Installation	**Yes/No**	**Comments**
Has the executive design been drafted in conformity with CEI/UNI standards?		
Have load calculations and structural verifications of the roof been performed?		
Is a site safety plan and works schedule defined?		
Management Phase	**Yes/No**	**Comments**
Is there a preventive and corrective maintenance (O&M) contract with clear KPIs?		
Are procedures for meter reading, billing and benefit redistribution established?		
Is a reserve fund for technological renewal and contingencies planned?		
Estimation of the Social Impact	**Yes/No**	**Comments**
Has the number of vulnerable households involved and the expected average saving (€/year) been assessed?		
Have awareness and training sessions been planned for users?		
Is periodic measurement of member satisfaction (surveys, focus groups) foreseen?		
Estimation of the Environmental Impact	**Yes/No**	**Comments**
Has the annual CO_2 reduction (tCO_2/y) and other local pollutants been calculated?		
Does the initiative contribute to local climate/SECAP targets?		
Are synergies with Nature-Based Solutions or energy-efficiency measures on buildings foreseen?		
Risk Evaluation	**Yes/No**	**Comments**
Has a Risk Register covering regulatory, financial, technical and reputational risks been drafted?		
Are adequate insurance policies in place (third-party liability, indirect damage, business interruption)?		
Is a mitigation and business continuity plan (BCP) defined in case of faults or regulatory changes?		

Checklist 4: Nature-Based Solutions (NBS) Integration in REC Neighborhoods

Checklist for Nature-Based Solutions (NBS) Integration in REC Neighborhoods		
Context & Diagnosis	**Yes/No**	**Comments**
Is urban heat stress recognized as an issue within the neighborhood?		
Have environmental and social challenges been identified using available data?		
Is the role of NBS in reducing heat and increasing resilience clearly understood?		
Site-Specific Analysis	**Yes/No**	**Comments**
Have hot spots and land surface features been identified through mapping or field surveys?		
Is vegetation cover, surface reflectivity, and PV panel influence assessed per zone?		
Have possible places for NBS been mapped, considering land use and space?		
Are existing utilities and underground infrastructure mapped for conflict prevention?		
Legal & Planning Compliance	**Yes/No**	**Comments**
Do the proposed NBS follow local building, planning, and environmental regulations?		
Have existing legal or administrative barriers to NBS implementation been identified?		
Are incentives or supportive policy instruments for green infrastructure available?		
Feasibility & Technical Assessment	**Yes/No**	**Comments**
Has the building or site been checked to make sure it can support the NBS?		
Have local soil, water availability, and climate been considered for the design?		
Are the chosen materials and plants suitable for the local climate and long-lasting?		
Has the interaction with solar panels and possible heat effects been accounted for?		
Have risks, technical, environmental, or social, been identified and plans made to reduce them?		
Stakeholder Involvement	**Yes/No**	**Comments**
Have all relevant groups (community, authorities, experts) been identified and involved?		
Is there a clear process to include community ideas and feedback in planning?		
Are responsibilities and communication channels for stakeholder engagement defined?		
Are plans in place to educate and raise awareness about NBS benefits?		
Design Standards & KPIs	**Yes/No**	**Comments**
Are clear goals set for performance (e.g., temperature drop, water retention)?		
Has a cost-benefit or full lifecycle analysis been done for each NBS?		
Are key performance indicators (KPIs) aligned with project goals and measurable?		
Is there a plan to evaluate before and after impacts on environment and community?		
Implementation Readiness	**Yes/No**	**Comments**
Are roles, timelines, and resources clearly defined and agreed?		
Have construction steps, safety measures, and compliance checks been planned?		
Is contractor guidance aligned with technical design specifications for NBS systems?		
Monitoring, Maintenance, and Replicability	**Yes/No**	**Comments**
Is there a clear plan to monitor progress, including who collects data, how often, and reporting?		
Are there ways to adjust and improve NBS based on monitoring results?		
Are local communities or authorities involved in maintenance of NBS?		
Are lessons learned recorded to help expand or replicate in other areas?		

List of figures

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