Ref. Ares(2025)2512580 - 28/03/2025

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Deliverable 6.1 – Pilot sites integration and demonstration planning

28 March 2025

Funded by the European Union

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Deliverable details

Title	WP	Version
D6.1 – Pilot sites integration and demonstration planning	6	V1.0

Contractual delivery date	Actual delivery date	Delivery type*	Dissemination**
March 2025 (M18)	March 2025 (M18)	R	Pu

* Delivery type: R: Document, report; DEM: Demonstrator, pilot, prototype; DEC: Websites, patent fillings, videos, etc; DMP: Data management plan.
** Dissemination Level: PU - Public; SEN – Sensitive, limited under the conditions of the Grant Agreement.

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Version	Date	Person	Action	Status***
V0.1	14/11/24	Karin Kruusmaa, Kristjan Täll	New Document	Draft
V0.2	21/11/24	Kristjan Täll	Revision of the draft template version	Draft
V0.3	13/01/25	All partners	Pilot Area info	Draft
V0.3	27/01/25	Sheila Sánchez Mínguez (ETRA), Kristjan Täll (EULS)	Revision of 1st version	Draft

V0.4	17/02/25	All partners	Revision of 2nd version	Draft
V0.4	21/02/25	Karin Kruusmaa, Kristjan Täll	Revision of the 3rd version	Draft
V0.5	10/03/25	UPV, IRI UL, TRU	Peer Review	Draft
V0.6	17/03/25	All partners	Revision of the 4th version	Draft
V1.0	28/03/25	Kristjan Täll (EULS), Sheila Sánchez Mínguez (ETRA)	Final review and revision	Submitted

***Status: Draft, Final, Approved, Submitted (to European Commission).

Keywords

Pilot Areas, planned activities, deployment planning, Use Cases, detailed Gantt diagram, risk management, 1st and 2nd phase of demonstration, Horizon Europe, Open Access

Index

List of figures

List of tables

Executive Summary

This deliverable covers the work done by all ECOLOOP Pilot Areas under T6.1 "Overall coordination of Pilot Sites and living lab activities". The main objective of this report is to identify and describe the activities, corresponding timelines, and related risks during deployment and demonstration activities.

Every Pilot Area has a short description of the overall structure of Pilot build-up, the sites and equipment available. Project partners have used the project Use Cases (UCs) previously identified in *Work Package 2 (WP2) - Project foundations and living labs implementation*, to map the detailed activities necessary for Pilot site deployment and demonstration activities. The process of identifying the activities was approached by each UC. In many instances, several background or overlapping activities between different UCs were identified. The planned timeline for each activity is represented. Furthermore, Milestone 6 (MS6) "Launch of the 1st phase of demonstration" (M30) and Milestone 8 (MS8) "Launch of the 2nd phase of demonstration" (M36) fall solely under WP6. Therefore, the prerequisites, activities during, and outcome of the phases are also mapped out in this document. Preliminary mapping of the assets going to be tested was done for each Pilot Area.

All the Pilot Areas followed a similar structure to report the planned activities with some flexibility to suit the different Pilot needs. This document includes a general overview of the timeline and risks related to Pilot Area activities. A more detailed Gannt diagram for planned timeline and more detailed risk mitigation table has been internally defined for all the pilot site partners and is uploaded into the shared repository.

Copyright statement

1. Introduction

1.1. Purpose of the document

This deliverable gives an overview of the management and coordination of the deployment and demonstration activities on the various Pilot areas of the ECOLOOP project. The Pilot areas are categorized per project partner country: Spain, Estonia, Slovenia, Bulgaria. The deployment and demonstration activities may be performed at several sites per Pilot.

This document shows the overall scheme of activities performed per Pilot site and gives a short overview of each one of them, as well as the Use Cases (UCs) to be implemented. More thorough Pilot sites and UCs descriptions can be found in D2.1 (Deliverable 2.1 - Pilot site analysis and use cases, requirements and KPIs definition). A detailed list of the planned activities, their due dates and responsible partners are described. The activities' timeline is presented in a general Gantt diagram per pilot in this document. A more detailed timeline of each planned activity and the necessary steps to carry out each activity per Pilot area has been internally shared with the rest of the partners and is uploaded into the shared repository. The deployment and demonstration processes are split into 2 phases which are defined by Milestones 6 and 8. The necessary prerequisites, activities during and the expected results for both phases are established in this deliverable.

A detailed risk management table per Pilot is represented. The risks are defined according to the *Deliverable 1.1 - Project Management Plan v1* and the methodology described there. Furthermore, this planning document includes the first mapping of assets to be tested during the deployment activities. More detailed Test Cases for each pilot will be identified at the beginning of the first demonstration phase (MS 6).

1.2. Scope of the document

Project partners across all ECOLOOP Pilot Areas have built upon the mapping of Use Cases and requirements to create a handbook detailing how activities should be structured to achieve the proposed ECOLOOP objectives. This process involved breaking down each Use Case into specific activities and drafting a reasonable timeline for each activity to ensure that the objectives are met within the intended project timeline.

Based on this timeline, the first and second phases of demonstration activities (MS 6 and MS8) were defined. Assets to be tested under the Use Cases during demonstration and deployment activities were identified. Finally, based on the activities, risks were identified, and risk management/mitigation strategy was developed.

1.3. Structure of the document

The first chapter presents the introduction of the deliverable which provides the basic information and rationale behind the content and the structure of the rest of the document.

The order of the following chapters follows the same one as the Pilot Areas presented in the WP6 Tasks (T6.2; T6.3; T6.4; T6.5) of the Grant Agreement:

1. Spain (Chapter 2)
2. Estonia (Chapter 3)
3. Slovenia (Chapter 4)
4. Bulgaria (Chapter 5)

Each Pilots' chapter includes the following content:

- Pilot Area description
- Use Cases overview
- Planned activities
- General Gannt diagram of planned activities
- Definition of two phases of deployment and demonstration
- Risk management plan

In addition to the previous, the Spanish Pilot chapter includes the description of SOIL Living Lab (SOIL LL, or simply LL) activities on the Spanish Pilot which are more thoroughly defined during T2.4 (Implementation of ECOLOOP-SOIL Living Lab for experimentation) and presented in *D2.2 – ECOLOOP SOIL Living Laboratory description.* The Estonian chapter includes a more detailed plan of the wide-scale chemical testing of wood from different forestry plantations, in addition to the plan of testing timber at the Fibenol biorefinery.

2. Spanish Pilot

2.1. Pilot Area Description

The Spanish pilot site in the L’Horta Sud district of Valencia integrates sustainable energy solutions within agricultural settings, preserving the region’s rich agricultural heritage while incorporating innovative renewable energy practices. The project encompasses multiple locations, each contributing to different aspects of sustainability, including Agri-PV systems, biogas production, and soil health improvements.

2.1.1. Picassent Pilot Site: Agri-PV and Geothermal Energy Innovations

The Picassent pilot site, located within the L’Horta Sud district of Valencia, serves as a key model for integrating renewable energy solutions into agricultural settings. The site features an Agri-PV system that merges agriculture with photovoltaic (PV) technology, supporting crops such as sub-tropical fruits, vineyards, and horticultural plants (Figure 1).

A geothermal energy system is also implemented, utilizing subsoil heat for heating, air conditioning, and hot water supply in Agri-PV structures, mushroom cultivation, and crop storage. The site includes 120 m² of bifacial PV panels installed on both the ground and rooftops, generating approximately 105 MWh annually.

Figure 1. Picassent pilot site.

2.1.2. Beniparrell Pilot Site: Biogas plant

A biogas pilot plant will be developed in Beniparrell, processing 4 tons of agricultural waste daily to produce 7–8 Nm^3 of biogas per hour. This biogas will be validated to upgrade to vehicle-grade biomethane using innovative hydrophobic membrane technology, adaptable to rural anaerobic digestion facilities. This membrane offers a modular solution for biogas upgrading, adaptable to a wide range of biogas fluxes and especially appealing for anaerobic digestion facilities in rural areas. Compared to other conventional biogas upgrading technologies, it can be operated at mild conditions of temperature and pressure, representing an important energy saving, and water can be used as a solvent.

The biogas plant will be based on a modular and compact design devoted to managing agricultural waste. The plant will include an anaerobic digestor where local agricultural biowaste will be treated. The capacity of the digestor will be between 100-120 m^3 (before final design), with hydraulic agitation (by pumping, not agitators), external heating system and a gasometer for storage of 30 m^3 capacity. The equipment for pre-treatment is a pulper (pulpering), a mechanical hydrolysis. By pulping in the presence of water, water enters the cells and promotes further digestion (Figure 2). The maximum operating capacity will be 2-Tn/h (material will arrive, be pulped and stored). To validate the biogas technology under relevant environment with a pilot plant of 50-100 l/h working capacity.

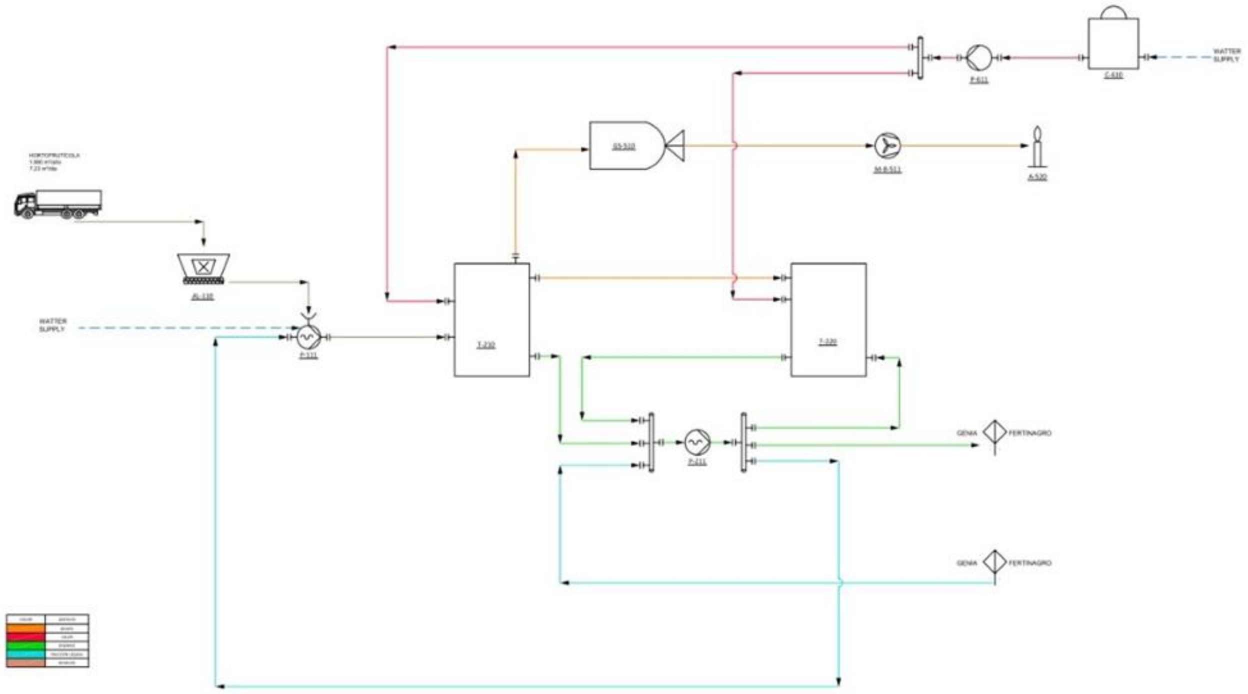

Figure 2. Design process of the biogas plant.

In the frame of the pilot a nutrients recovery system will be implemented in the biogas pilot site for biofertilizers production. The design of the anaerobic digester (AD) includes characterization of the agricultural residues and the organic fraction of urban solid waste to be digested, design of the anaerobic digester, design of the waste pre-treatment to be digested, biogas unit treatment design, auxiliary systems design and design of the process control system.

The biogas plant develops a process to produce and upgrade biogas to biomethane, using locally sourced feedstocks from agrifood wastes. A small-scale and modular pilot plant for biomethane production will be developed to validate the biomethane composition to vehicular use. Different agricultural wastes will be studied to produce biogas and biomethane production yield and also it will address vegetal agricultural wastes such as fruit and vegetable wastes.

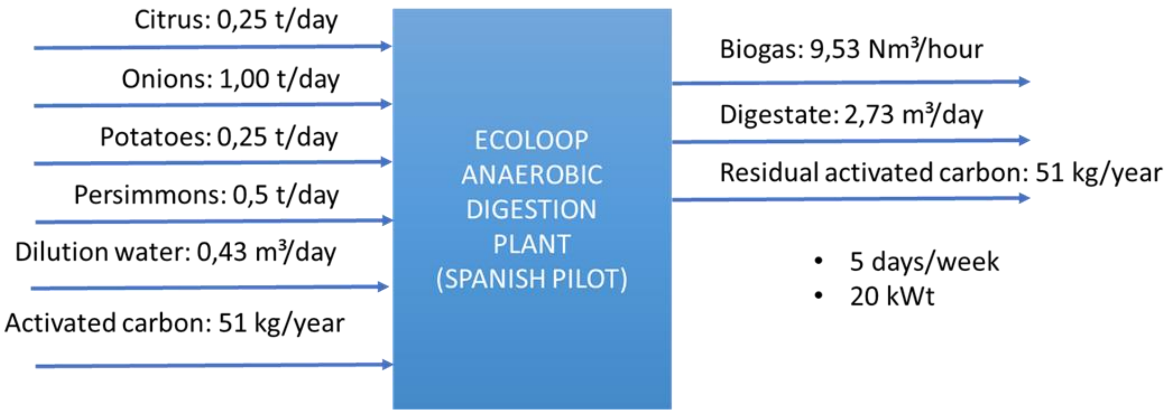

Figure 3. Proposal of mass and energy balances providing the different by-products by season or throughout the year.

Furthermore, the project will explore benefits of the produced digestate during the anaerobic digestion of agroforestry wastes able to replace mineral fertilizers (Figure 3). The system will optimize the anaerobic digestion phase to maximize both biogas and digestate production. An innovative hydrophobic membranes technology will be used to develop vehicle-grade biomethane. This solution will be cost-efficient and adaptable to the local conditions in the region of Horta Sud in the region of Valencia (Spain). Through an optimal combination of anaerobic and aerobic digestion, CMC (Component Material Category) materials will be obtained (see EC Regulation 1009/2019) for use in the production of fertilizer materials or for application as organic fertilizer. This combination converts complex organic matter into high-quality humic compounds, such as humates and fulvates, which improve soil quality as well as improve nutrient absorption by crops. The biogas digestate will be tested as biofertilizer at **Finca Sinyent**.

2.1.3. Sinyent Pilot Site: Experimental farm for agronomic validation

In 33 ha of land, the experimental farm has a representation of the most important Mediterranean crops, mainly citrus and persimmon, although we also have plots of vines, olive trees, kiwifruit and avocado. The purpose of the farm is to bring the farmer closer to the main technological advances of the sector in the field of innovation and to test new agronomic solutions in the experimental plots (Figure 4).

The biofertilizers will be trialled on horticulture and persimmon (caqui) crops, as well as other types like citrus and subtropical crops (Figure 5). These experiments aim to evaluate the effectiveness of biofertilizers in improving crop production and water efficiency. Finca Sinyent's facilities include a 1,000 m² agricultural warehouse, cold rooms, and a testing lab, supporting detailed experimental studies on agricultural innovations.

Figure 4. General view of the Sinyent experimental farm

Figure 5. Validation trials in horticultural crops (lettuce) and foliar applications in persimmon

2.1.4. SOIL Living Lab

In addition, in the Spanish Pilot of the project, a Living Lab on soil health will be implemented in the region of l'Horta Sud. This innovative space will bring together different actors of the territory, from farmers and technicians to researchers and policy makers, to foster the exchange of knowledge and experiences. The Living Lab approach will ensure the integration of scientific, technical and traditional knowledge, promoting practical and sustainable solutions for the improvement of soil quality and the resilience of the agricultural ecosystem. For this purpose, there are two experimental areas in the UPV facilities, one located in the cultivation plots next to the campus (Figure 6). The other one is the greenhouse Nº 19 inside the campus (Figure 7).

Figure 6. Aerial view of the plot where the experiments included in the UPV's Living Lab will be carried out.

Figure 7. UPV greenhouse where the tests included in the Living Lab will be carried out.

2.2. Use Cases overview

UC ES.01 - An Agri-PV and geothermal energy community for sustainable introduction of sub-tropical and horticultural crops

The aim is to develop a Spanish Agri-PV pilot site in Valencia, integrating a greenhouse with geothermal and biogas production to create a sustainable energy system. The site, with a 1.5 MW capacity, will support sub-tropical, vineyard, and horticultural crops under a renewable energy community model. The photovoltaic system includes 320 m² of bifacial panels generating 105 MWh annually, with 70 kW of power. Solar energy will drive a geothermal system providing heating, cooling, and hot water for greenhouses, mushroom cultivation, fruit storage, and offices. A 30-kW heat pump ensures stable year-round production and efficient temperature control, reducing energy cost sensitivity.

UC ES.02 - Biogas biomethane production from agricultural wastes

The main objective of this use case is to produce biogas in a biogas plant based on a modular and compact design devoted to managing agricultural wastes from crops and to validate biomethane production from agricultural residues to vehicular use. This implies get the location of the facilities and the agricultural wastes available in the vicinity of the pilot site; establish agreements with potential farmers and other stakeholders located in the pilot installation area to supply the waste necessary to generate biogas/biomethane; obtain legal permissions to install the biogas plant in the defined location; characterization of the agricultural residues and the organic fraction of urban solid waste to be digested; design of the anaerobic digester; design of the waste pre-treatment to be digested; biogas unit treatment design; auxiliary systems design and design of the process control system.

UC ES.03 - Biofertilizers production from agricultural wastes

The main objective is to use the digestate (residue from the biogas plant) to produce biofertilizers that can be used on crops in the area. In this way, the contamination that could be produced by the digestate is avoided and the nutrients that may be available are reused. The digestate will not provide high nutritional inputs, so it will be necessary to supplement it to produce a biofertilizer that meets the requirements of each crop.

UC ES.04 - Enhancement of soil properties (agriculture-forestry) bioproducts validation

The main objective of this use case is to evaluate and promote the use of bioproducts obtained from agricultural residues (such as pruning residues and weeds) to improve soil quality and reactivate agricultural activity in degraded areas. This aims to be a sustainable alternative to traditional chemical fertilization, aligning with policies such as the CAP, the SDGs and the European Green Pact. The expected result is the improvement of key soil indicators, such as organic matter content and its physical and chemical properties, in both agricultural and forestry plots.

UC ES.05 - Tests of the behaviour of the product in agronomic application

The main objective of this use case is to evaluate the benefits of reincorporating crop residues into the soil and to validate improved digestate formulations through tests in the ECOLOOP SOIL Living Lab. For this purpose, germination and early plant development trials will be conducted in different controlled environments. The trials will be designed with statistical rigor and randomized block treatments with specific crop combinations and agronomic conditions will be applied. The expected result is the improvement of soil and crop agronomic parameters.

2.3. Pilot area activities

The following Table 1 represents the planned activities and their short description of the Spanish Pilot.

Table 1. Planned activities of the Spanish Pilot

Activity	Detailed description	Related tasks	Related Use Cases
1. Installation and Setup of Agrophotovoltaic Structures	Installation of pre-purchased Agri-PV structures, focusing on the appropriate ground placement and configuration of the 320 m² bifacial panels for maximum sunlight capture. The orientation and distribution of the panels will be planned to ensure optimal energy generation and compatibility with agricultural practices. Ground preparation, securing the structures, and adjusting the panel tilt will be carried out. Additionally, electrical systems, including inverters and grid connections, will be installed and tested.	T3.3	ES.01
2. Integration of New Panels with Existing Greenhouse System	This activity focuses on connecting the newly installed Agri-PV panels with the existing photovoltaic panels already set up in the greenhouse. The process involves ensuring proper electrical integration, syncing the power outputs, and verifying the overall system's performance. Once integrated, power generation will be monitored to assess efficiency and stability. The data collected will then be incorporated into the decision support tool, enabling real-time monitoring and providing valuable insights for optimizing energy usage in agricultural operations.	T3.3	ES.01
3. Geothermal Energy System Calculation and Site Assessment	This activity involves calculating the geothermal power output necessary to meet the thermal needs of the site, including heating, cooling, and hot water for the greenhouse and other facilities. Participants will analyse factors such as thermal demand, building size, and system requirements to determine the total geothermal power needed. Additionally, a site assessment will be conducted to evaluate the terrain for drilling. The geological characteristics of the ground, including soil composition and depth, will be studied to ensure optimal conditions for probe installation.	T3.3	ES.01
4. Design the necessary equipment to produce biogas and biomethane from agricultural wastes	This activity focuses on the design of the equipment necessary to produce biogas and biomethane. Based on the characterization of the agricultural residues and the organic fraction of urban solid waste to be digested, design of the anaerobic digester, design of the waste pre-treatment to be digested, biogas unit treatment design, auxiliary systems design and design of the process control system.	T3.1	ES.02

5. Design of the necessary equipment to transform digestate into biofertilizer.	This activity focuses on the design of the equipment necessary for the transformation of digestate into biofertilizer. Based on the data supplied by Genia regarding the characteristics of the digestate to be treated, the best options are analysed in terms of the treatments to be applied and the equipment necessary for these treatments in order to achieve the most efficient and effective transformation of the digestate into biofertilizer possible.	T3.4 T3.1	ES.03
6. Installation and commissioning of equipment to produce biogas	This activity will consist of carrying out the installation of all the equipment designed for the production of biogas and the transformation of the digestate next to the biogas plant. This installation also includes the communication of the different tanks and transformation equipment with each other and with the equipment of the biogas plant to supply the part of the liquid fraction required by the biogas plant for its operation. After the installation of all the equipment, and coinciding with the commissioning of the biogas plant, the transformation equipment will be commissioned.	T3.4 T3.1	ES.02 ES.03
7. Design of the different biofertilizers to be produced	For this activity, on the one hand, the physical-chemical characteristics of the digestate will be analysed to determine the nutrients it can provide. On the other hand, UPV and AVA-ASAJA will determine the requirements of each crop at the time of application of the biofertilizer. Knowing these two data, and taking the digestate as the basis of the biofertilizer, the necessary nutrients will be supplemented until the requirements of each crop are completely covered.	T3.4 T3.1 T6.2	ES.03
8. Production of biofertilizer	In this activity, the elaboration of the different biofertilizers will be developed. A solid/liquid separation will be carried out, after which the solid fraction will be composted to give rise to a solid fertilizer, while the liquid fraction will give rise to a liquid fertilizer. After different processes, both fractions will be mixed with other components to cover the nutrient requirements of the target crops.	T3.4	ES.03
9. Living Lab for soil health	Different meetings will be organized where farmers, technicians and researchers will jointly contribute different ways of managing soil quality improvements (use of organic amendments, digestates, etc.) that can be carried out in field experiences. The exchange of knowledge between actors with different levels of experience will be encouraged.	T3.4	ES.04 ES.05
10. Soil preparation and selection of pilot plots	Degraded plots (due to agricultural abandonment or fire) are identified and prepared for the application of bioproducts and digestate. An initial soil analysis is conducted to establish a baseline for comparison.	T3.4	ES.04 ES.05
11. Trial design and planning	Experimental protocols are established to test bioproducts and digestates. The trials will be conducted in randomized blocks, combining different crops and agronomic conditions.	T3.4	ES.04 ES.05

12. Laboratory and controlled environment testing	In the ECOLOOP SOIL Living Lab, tests are conducted in controlled chambers to evaluate the effect of bioproducts and digestates on germination and early plant development.	T3.4	ES.05
13. Application of field treatments	The different formulations are implemented in the pilot plots, applying the bioproducts and digestates according to the conditions of each treatment.	T3.4	ES.04 ES.05
14. Crop growth and response monitoring	Crop morphological and physiological parameters (height, weight, biomass, fruit production, nutrient uptake) are evaluated.	T3.4	ES.04 ES.05
15. Soil analysis before and after treatment	The evolution of key soil parameters is measured: organic matter content, structural stability, infiltration, microbial activity, and organic carbon, among others.	T3.4	ES.04 ES.05
16. Comparison with conventional farming practices	The results obtained are contrasted with those of soils managed with traditional chemical fertilization to validate the effectiveness of the new treatments.	T3.4	ES.05
17. Biomethane production and validation for sustainable transport in the region.	For this activity, Conceptualization and design are conducted for a "biogas upgrading" plant applying membrane contactor technology with a processing capacity of 50-100 L/h of biogas. Optimization tests and fine-tuning of the "biogas upgrading" system, as well as validation of the vehicle quality of purified biomethane are implemented.	T3.1	ES.02
18. Analysis of results	Statistical methods are applied to ensure the robustness of the data obtained in the trials. Differences between treatments and conditions are compared.	T3.4	ES.04 ES.05
19. Dissemination and transfer of knowledge	Findings are communicated to farmers, researchers and agricultural policy makers through reports, publications and events.	T3.4	ES.04 ES.05
20. Installation and start-up of the geothermal energy system	Testing of the geothermal installation and start-up for mushroom production and optimisation of conditions for mushroom production.	T3.3	ES.01
21. Integration of the geothermal and agrivoltaics systems with the decision support system.	Integration of all assets available in the Spanish pilot in the decision system tool for the optimisation of energy and crop production.	T3.3	ES.01 ES.02 ES.03

2.4. General Gantt diagram of Pilot activities

General Gantt diagram of the Pilot activities is represented here (Table 2). The timeline is represented in quarters of the ECOLOOP project years. A more detailed version with step-by-step breakdown of each activity and a timeline in months can be found in the internal repository of the ECOLOOP project.

Table 2. General Gantt diagram of the Spanish Pilot Area activities.

No.	Activity	LEAD	FROM	TO	Year 1				Year 2				Year 3				Year 4			
					Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16
					M3	**M6**	**M9**	**M12**	**M15**	**M18**	**M21**	**M24**	**M27**	**M30**	**M33**	**M36**	**M39**	**M42**	**M45**	**M48**
1	Biogas plant	GENIA	10	36																
2	Production of biofertilizer	FERT	7	36																
3	Fertilisation plan	UPV	10	42																
4	Crop measurements	UPV	15	48																
5	Geothermal and agrivoltaics	INDEREN	10	36																

2.5. Deployment and demonstration phases

The prerequisites, activities during and the outcome of both deployment phases of the Spanish Pilot Area are represented in Table 3

Table 3. Phase 1 and 2 of the deployment activities of Spanish Pilot.

Phase	Prerequisites	Activities during	Result
1st phase of demonstration (launches M30 – Milestone 6)	• Definition of objectives of the Soil Living Lab (LL). • Definition of the study area of the LL. • Obtain legal permissions to install the biogas plant in the defined location. • Cooperation between stakeholders. • Establish agreements with potential farmers to supply the waste necessary to generate biogas/biomethane. • Define the best processes and equipment necessary to transform digestate into biofertilizer. • Sensors to be installed and deployed in the area for the DSS data retrieval (PV, weather, geothermal…)	• Meetings with stakeholders. • Bilateral meeting with partners to establish needs and objectives. • Studied different agroforestry waste to produce biogas and biomethane. • Identification of biogas/biomethane equipment and technical requirements. • Implementation of plant operation mode, creation of user manuals. • Test the products chosen by the stakeholders in the field. • Analyse the digestate to know its nutritional characteristics. • To elaborate the biofertilizer by adding the necessary nutrients to complement the nutritional supply of the digestate to cover the requirements of the crop to which it is targeted. • Perform different analyses to observe changes in soil health after applying the chosen products.	• BMP's characterization results of agricultural wastes (optimization of biogas production). • Design of biogas and biomethane processes and detail engineering (PID, PFD, Lay-out, etc). • Commissioning and operation of the biogas plant. • Production of biogas and digestate. • Laboratory scale validation of biomethane produced for vehicular use. • Transformation of a residue (digestate) into high quality biofertilizers. • Report on the efficacy of bioproducts on soil health. • Energy production/consumption to be presented in the DSS dashboard.

		• Connection with DSS for data retrieval	
2nd phase of demonstration (launches M36 – Milestone 8)	• Develop a rural based system to produce upgrade biogas to biomethane, using locally sourced feedstocks from agroforestry wastes. • Definition of the specified capacity and quality standards of biogas and biomethane.	• Data integration and implementation of improvements. • Cost-effective evaluations of all the technologies optimized. • Business and exploitation plan for biogas/biomethane production in the region Horta Sud. • Setting rules for DSS recommendations and full deployment of the tool.	• Create a network of contacts between the different stakeholders. • Report of cost-efficient Technologies and adaptable to the local conditions in the Horta Sud region. • Biogas and biomethane market considering its quality standards and the commercialization modalities. • First DSS recommendations.

2.6. Risk management plan

Risk table of the Spanish Pilot is represented here (Table 4). A more detailed risk identification matrix can be found in the internal repository of the ECOLOOP project.

Table 4. Spanish Pilot risk identification and mitigation plan

Nº Risk	Risk responsible	Risk description	Milestone or deliverable affected	Probability 4/3/2/1	Risk Assessment	Global Risk Indicator 0=Minimum, 4=Maximum	Contingency Plan
ES.01	FERT	Inadequate design of the equipment necessary to process digestate due to poor knowledge of its characteristics.	D3.2	2	LOW	1	Request information from Genia on the characteristics of the digestate to be produced in the biogas plant.
ES.02	FERT	The need to provide a large amount of nutrients to produce a biofertilizer that meets the requirements of the crop due to the low nutritional content of the digestate.	D3.2	2	MODERATE	1	Any necessary components will be available to produce a balanced biofertilizer that meets the requirements of the target crop.
ES.03	FERT	Having to produce more biofertilizers due to excess digestate at times when it is not necessary to use it in the project trials.	D3.2	2	MODERATE	1	If excess biofertilizers are produced, they will be distributed to farmers in the area for use on their crops.
ES.04	UPV	Low availability of agricultural residues for the production of bioproducts.		2	MODERATE	1.25	Plan harvesting in advance, establish agreements with farmers and diversify sources of raw material.

ES.05	UPV	Low effectiveness of the bioproduct in highly degraded soils.		2	MODERATE	0.875	Perform laboratory tests before field application, adjust the formulation according to the type of soil.
ES.06	UPV	Delays in obtaining results due to problems in the experimental design.		2	MODERATE	1	Ensure a statistically sound experimental design, with defined measurement protocols and replicability.
ES.07	UPV	Errors in soil and crop data collection and analysis.		2	MODERATE	1	Implement data validation measures, make backup copies and establish protocols for verification of results.
ES.08	GENIA	Not finding a location for the plant on time	MS5, MS7, D3.1, D3.2	4	HIGH	3.25	Intensify contact with local authorities and search for the appropriate locations; investigate alternative districts in Valencia
ES.09	GENIA	Delays with environmental permits	MS5, MS7, D3.1, D3.2	3	HIGH	2.25	Search for the most environmental-friendly solutions which require a minimum number of permits. Contact with local authorities for more information; investigate legislation for experimental plants; pay special attention to the biogas torch, gas storage and odours
ES.10	GENIA	Low technical performance of the biogas plant	MS5, MS7, D3.1, D3.2	2	MODERATE	1.375	Quality engineering; cross-validation of the calculations
ES.11	GENIA	Deviations in digestate production, not sufficient dilution, excessive water consumption	MS5, MS7, D3.1, D3.2	1	LOW	0.5625	Excessive validation of digestate calculation; make sure that the liquid fraction is sufficient both for dilution and fertilizer production
ES.12	GENIA	Insufficient equipment and facilities to perform all use cases	MS5, MS7, D3.1, D3.2	2	MODERATE	1.125	Find the best available technical solution in terms of price/quality; efficient budget management

ES.12	GENIA	Lack of the required substrates during the operation	MS5, MS7, D3.1, D3.2	2	MODERATE	1.25	Launch the plant on time, calculate correctly the dates so that the required substrates are available at the required moment
SP13	GENIA	Weather-related damage and some market price fluctuations	MS5, MS7, D3.1, D3.2	3	HIGH	2.25	Efficient budget management, avoiding floodable areas
ES.14	INDEREN	Malfunction or underperformance of bifacial PV panels.	D3.2	2	LOW	1	Regular maintenance and performance monitoring.
ES.15	INDEREN	Lower-than-expected thermal conductivity of the soil.	D3.2	2	MODERATE	1.125	Perform thermal response tests before installation and enhance heat transfer using grout with high thermal conductivity.
ES.16	INDEREN	Difficulty in drilling geothermal wells due to hard soil conditions.	D3.2	2	MODERATE	1.125	Conduct preliminary geotechnical surveys to determine soil composition and use specialized drilling equipment like rotary or percussion drills for dense soil.
ES.17	INDEREN	Inefficiency in geothermal system integration.	D3.2	2	MODERATE	0.875	Continuous system calibration and optimization.
ES.18	INDEREN	Crop yield reduction due to excessive PV shading.	D3.2	2	MODERATE	1.125	Adjust crop orientation and monitor plant growth response.

2.7. Assets to be tested

A preliminary mapping of assets going to be tested during the Spanish Pilot's activities and the expected outcome is presented in the following Table 5.

Table 5. Preliminary mapping of assets going to be tested on the Spanish Pilot.

Asset	Related UCs	Lead	Gained info	Outcome
Biofertilizers elaborated using biogas digestate	ES.03	FERT	Knowledge about the characteristics of digestate, as well as the necessary treatments to be able to use it as part of a biofertilizer.	Biofertilizers cover the requirements of different crops from contaminant waste, contributing to the reduction of contamination through the circular economy.
Biogas and biomethane production from agricultural wastes	ES.02	GEN	Characteristics of agricultural residues, anaerobic digester design, waste pre-treatment plan, biogas unit treatment plan,	Biogas and biomethane production data and quality. Self-consumption is achieved by produced biogas and biomethane. Biomethane production for sustainable transport in the region.
Geothermal and AgriPV	ES.01	INDEREN	Development of a Spanish Agri-PV pilot in Valencia integrating a 1.5 MW PV system with geothermal energy for greenhouse heating, cooling, and hot water.	Performance assessment of bifacial PV panels for different crops, and energy produced and savings. Panels shadowing effects on different crops.

3. Estonian Pilot

3.1. Pilot Area Description

The Estonian pilot area consists of the network of short-rotation forestry plantation sites established on marginal lands and the flagship biorefinery to produce biomaterials. The build-up of the Estonian Pilot Area activities, including the defined Use Cases, is represented in Figure 8.

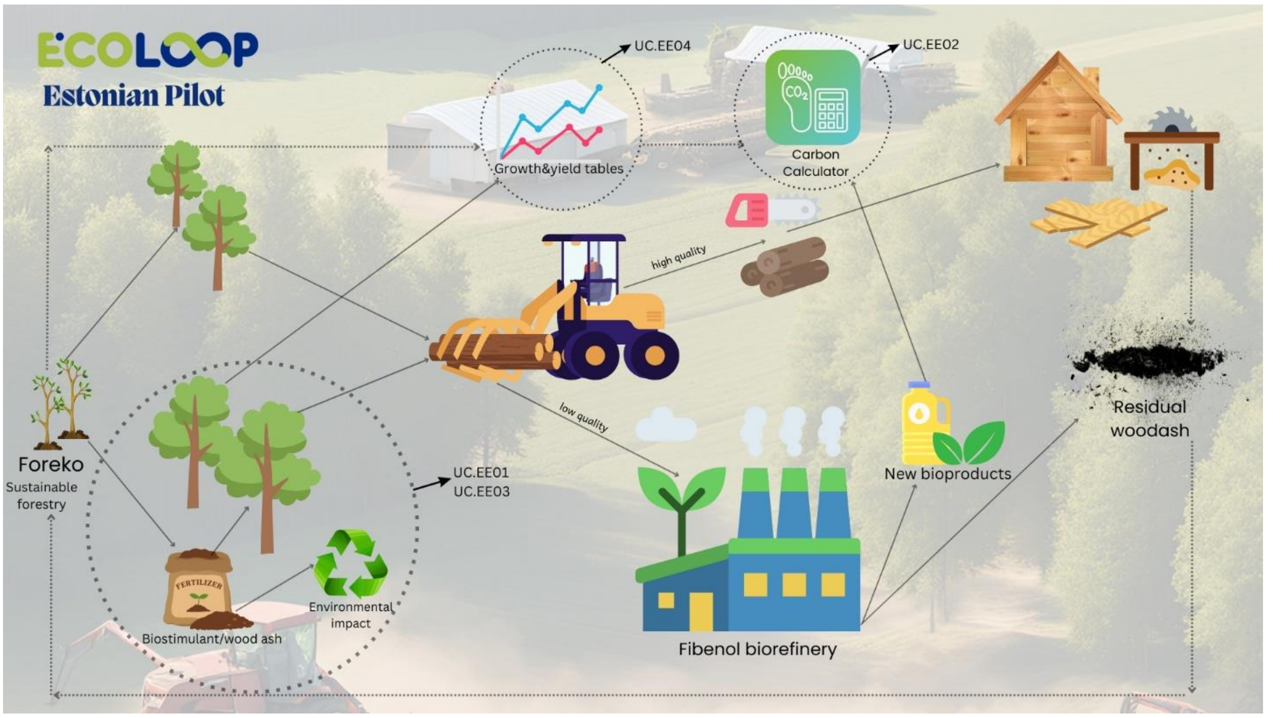

Figure 8. Estonian Pilot area infographic.

3.1.1. Network of short-rotation forestry plantations

The existing network of pilot sites consists of approximately 100 individual plots of various deciduous tree species such as hybrid aspen, silver birch and black alder, which are considered suitable for short-rotation forestry due to their fast growth in the region. The plots are located across Estonia representing different growing conditions (*Figure 9*). Therefore, they show potential for biomass production for future biorefineries and the carbon credit market in the Pilot area. The pilot sites will provide the input data, such as growth and soil quality, for the state-ofart growth and yield models. Novel growth and yield models will be the input data for the Carbon Calculator Tool (CC Tool) - an open-access web platform for estimating the climate benefits such as sequestrated carbon and the substitution effect, earned carbon credits and financial profit.

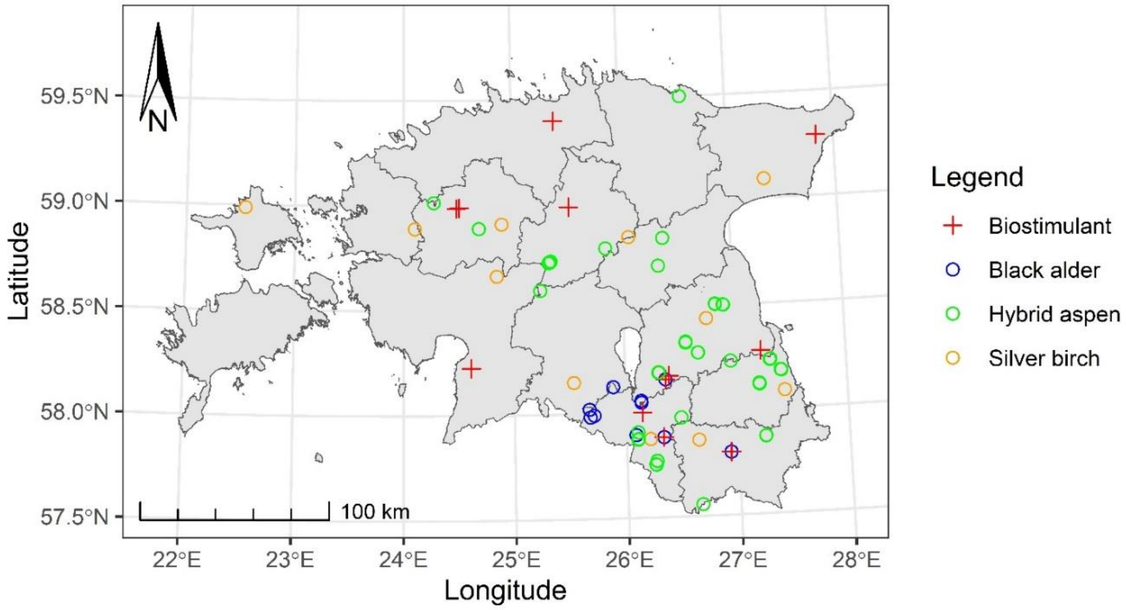

Figure 9. Estonian Pilot network of forest plantations for growth and yield monitoring

The pilot plantations will be the basis to analyse the potential of utilizing biomass as a renewable source for the production of renewable biomaterials from wood biomass. The testing with 4 new wood species from plantation forestry will take place at a Fibenol flagship biorefinery in cooperation with a private forest enterprise Foreko.

3.1.2. Fibenol biorefinery

Fibenol flagship biorefinery in Imavere, Estonia, depicted in Figure 10, valorises more than 90% of wood residues into novel biomaterials such as lignin, wood sugars and specialty celluloses with unique Sunburst technology. The process is called fractionation as wood is deconstructed into its basic components. Using heat, pressure and mechanical power, the wood chips are turned into a chocolate mousse-like slurry that can then be converted into biomaterials. Annual production capacity is around 6500 t/a of different lignin grades and 20 000 t/a cellulosic wood sugars. Fibenol plant works on 100% renewable energy with minimal water and chemicals use. The plant has a fully equipped R&D laboratory for in-house process developments.

ECOLOOP demonstration activities allow in-depth analyses for the first time of how the wood composition from novel fast-growing short-rotation forest plantations in Estonia will affect the properties of new high-value low-carbon biomaterials (lignin, wood sugars and specialty cellulose) and its production with minimal environmental impact.

Figure 10. Fibenol biorefinery.

3.2. Use Cases overview

UC EE.01 – Wood ash recycling system for forest plantations

The main aim of this UC is to utilize nutrient-rich wood ash to enhance tree growth. Wood ash, a by-product of heating systems utilizing woody biomass for energy production, contains a range of macro and micronutrients beneficial for supporting tree growth in forest plantations on abandoned extracted peatlands. Provides wood-ash treatment as an input option to the CC Tool at the plantation establishment phase.

UC EE.02 – Carbon calculator for forest plantations

The UC aims to create a carbon sequestration calculator tailored for forest plantations using data from the network of pilot sites. The calculator will estimate CO_2 sequestration, the potential profit from CO_2 credits, and climate benefits from the substitution effect by accommodating variables like tree species and soil type. Accessible as a free web platform, it will aid private landowners, forest companies, decision-makers, and non-government organizations in assessing the impact of CO_2 sequestration. Under this UC, the suitability of different deciduous tree species from plantation forestry for chemical valorisation at the Fibenol plant will be evaluated and the displacement factors for novel biomaterials calculated and their substitution effect estimated.

UC EE.03 – New environmental-friendly biostimulants and fertilizers to enhance the production of forest plantations

The Use Case investigates “arGrow”, a new biostimulant, and mineral fertilizers' impact on deciduous forest growth to develop certification systems for legalizing fertilization in forests, aiming to enhance production sustainably. Provides input data of different fertilization regimes at the plantation establishment phase for the Carbon Calculator Tool.

UC EE.04 – The potential wood production of different deciduous tree species on different soil types

This UC will examine the potential of Estonian forest plantations across diverse soils for a full rotation cycle. Monitoring 70 pilot sites and modelling their yield on different soils will inform afforestation scenarios, assessing maximum, medium, and minimum potential areas for woody biomass production in the entire country.

3.3. Pilot area activities

The following Table 6 represents the planned activities and their short description of the Estonian Pilot.

Table 6. Planned activities of the Estonian Pilot.

Activity	Description	Related tasks	Related Use Cases
1. Establishment of new sites	Mapping the gaps of missing info for data modelling. Finding suitable sites to fill the gaps with forest plantations of suitable characteristics (age, site, spacing, tree species).	Background activity	EE.01-04
2. Collection of data	Measuring new data from existing plots and the established new plots. Organizing previous and new data to suitable format.	Background activity	EE.01-04
3. Modelling growth and yield	Data will be analysed. Different site type quality and spacing identified and categorized. The suitable growth models with the best fit will be developed based on the data. Missing gaps will be filled with extra modelling. Yield of different timber assortments at the age of maturity from the plantation will be estimated. Validating and improving the development models.	T4.2 T4.4 T6.3	EE.01-04
4. Development of the Carbon Calculator Tool	Carbon Calculator demo platform will be developed (front-end and back-end development). Integration of new Growth and yield (G&Y) functions to the CC tool. Integrating data into CC Tool from other pilots before the CC tool demo version launch followed by testing and feedback. Modification based on the feedback and testing. Validation of models and CC Tool improvement with validated models. Testing the calculator with stakeholders during 1st phase of demonstration. Mapping of shortcoming/bugs and improvement of CC Tool. Addition of wood ash, bio stimulant and fertilization treatment growth models to the Carbon Calculator. Inclusion of CO2 sequestration calculation with new products to CC Tool during the deployment phases and doing final updates for security patches.	T4.2 T6.3	EE.02
5. Wood ash treatment on extracted and abandoned peatlands	Modelling the benefit gained by wood ash treatment on the growth and yield of forest plantation on suitable sites. Environmental impact will be assessed. For that lysimeters will be installed and samples from them analysed. Soil quality will be assessed. Integration of the data to growth models and inclusion to CC Tool and the DSS.	T3.4 T4.1 T4.3 T4.4 T7.1	EE.01

6. Biostimulant and fertilization treatment	Modelling the benefit gained by biostimulant and fertilization treatment on the growth and yield of plantations on suitable sites. Environmental impact will be assessed. For that lysimeters will be installed and samples from them analysed. Soil quality will be assessed. Integration of the data to growth models and inclusion to CC Tool and the DSS.	T3.4 T4.1 T4.3 T4.4 T7.1	EE.03
7. Testing new species for chemical valorisation from plantation forestry	Suitable plantations for testing at Fibenol factory will be identified. Contracts for harvesting and buying the timber will be made. During 1st phase of demonstration timber from 4 different species will be tested in 2 repetitions at the factory. Wide-scale sampling for wood chemical composition and heavy metals concentrations will be done on 10 selected pilot sites in addition to the sites where timber will be obtained for factory testing. During second phase of the demonstration, the suitability of timber from plantation forestry will be evaluated for the entire pilot area based on the wide-scale sampling. Displacement factors and substitution effect of new biomaterials will be calculated and inclusion to the CC Tool and the DSS.	T6.3	EE.02
8. Scaling up the deployment and demonstration activities	Formation of a business model based on the Estonian pilot activities. Improvement of the business model based on the findings during demonstration activities. Environmental footprint and biodiversity impact of plantation forestry for the entire country evaluated. Evaluation of the Socioeconomic impact of plantation forestry for the entire country. Dissemination of results and utilization of CC Tool.	T5.1 T7.2 T7.1 T7.2	EE.01-04

3.3.1. Testing new species for biorefining

The following sub-chapters provide a more detailed explanation of the activity no. 7 in Table 6.

3.3.1.1. Hardwood effects on chemical valorisation outcomes

The timber to be tested at Fibenol comes mainly from abandoned marginal lands, primarily abandoned agricultural lands that have been planted or naturally regenerated with certain deciduous tree species. The volume of logs to be tested per repetition needs to be between 10-15 m^3, which corresponds to 4-7 dry tonnes of biomass. The four species identified by Fibenol for testing at the factory, which show potential for future chemical valorisation, are:

1. Planted silver birch (*Betula pendula* Roth)
2. Naturally regenerated silver birch (*Betula pendula* Roth)
3. Naturally regenerated grey alder (*Alnus incana* (L.) Moench)
4. Planted black alder (*Alnus glutinosa* (L.) Gaertn.)

Once the timber reaches the demonstration plant, the logs are debarked and flaked to be compatible with the biorefining technology. The extrusion-based pre-treatment will be carried at full-scale unit, as this is the most critical and unique part of the biorefining process. The slurry resulting from the pre-treatment will be directed to pilot-scale units to perform the separation of hemicellulose-derived sugars (C5) and the following enzymatic hydrolysis of the cellulose. As a result of the trial, a couple of hundred kilograms of the C5 sugars, C6 sugars and lignin are produced from each trialled assortment. In addition, smaller samples of micro-crystalline cellulose (MCC) and acid-precipitated lignin are produced. The tested species compatibility with the demo-scale biorefinery is assessed based on the process data. The properties of the products are assessed by compositional and structural analysis.

3.3.1.2. Wide scale sampling of wood

In addition to the biomass testing at the biorefinery, wide-scale testing will be conducted. The existing network of plantation sites, along with newly established sites, will be used. The species to be tested for chemical composition and heavy metal concentration are as follows:

1. Planted silver birch (*Betula pendula* Roth)
2. Naturally regenerated silver birch (*Betula pendula* Roth)
3. Naturally regenerated grey alder (*Alnus incana* (L.) Moench)
4. Planted black alder (*Alnus glutinosa* (L.) Gaertn.)
5. Planted hybrid aspen (*Populus tremula × Populus tremuloides*)

Additionally, to the sites which provide timber for the biorefinery testing, a total of 10 sites per species will be tested. The sites are chosen from different growing conditions as much as possible based on the existing network of sites. The chosen sites are represented in Figure 11. To obtain the mean value of chemical composition and heavy metal concentrations per site, 3 subsamples from one site will be taken. The samples for testing will be taken from a total of 3 different trees with an increment borer. The trees are chosen based on the stand's diameter distribution. The samples will be taken from 1st quartile, median and 3rd quartile diameter trees.

The concentration of a total of 11 different heavy metals in the timber of the trees will be analysed using the Inductively Coupled Plasma Mass Spectrometry (ICP-MS) method. The heavy metals to be analysed are: Arsenic (As), Cadmium (Cd), Cobalt (Co), Chromium (Cr), Copper (Cu), Iron (Fe), Molybdenum (Mo), Manganese (Mn), Nickel (Ni), Lead (Pb), Zinc (Zn).

The chemical composition of the wood will be tested in two main paradigms. Firstly, the wood composition will be assessed based on their growing sites. Accordingly, this allows assessing the variance in hemicellulose composition as well as in cellulose, lignin, ash, and various extractives content. Secondly, up to three samples from each species will be picked for structural characterisation allowing us to assess the inherent nature of the tree species and corresponding valorisation potentials. Cellulose crystallinity will be assessed by x-ray diffraction (XRD). In addition, cellulose's degree of polymerisation will be measured by gel permeation chromatography (GPC) after the sample derivatisation. Alongside with the cellulose analysis, lignin composition and the abundance of different bonding motifs will be assessed by whole-cell 2D

HSQC NMR (heteronuclear single quantum coherence nuclear magnetic resonance) spectroscopy. This will provide a wide-scale overview of the chemical composition and heavy metal concentration of the trees from marginal lands. This wide-scale Pilot Area data can be connected to the knowledge gained from factory testing and the results can be extrapolated for the entire Pilot Area to estimate the amount of timber available from Estonia that is suitable for chemical valorisation.

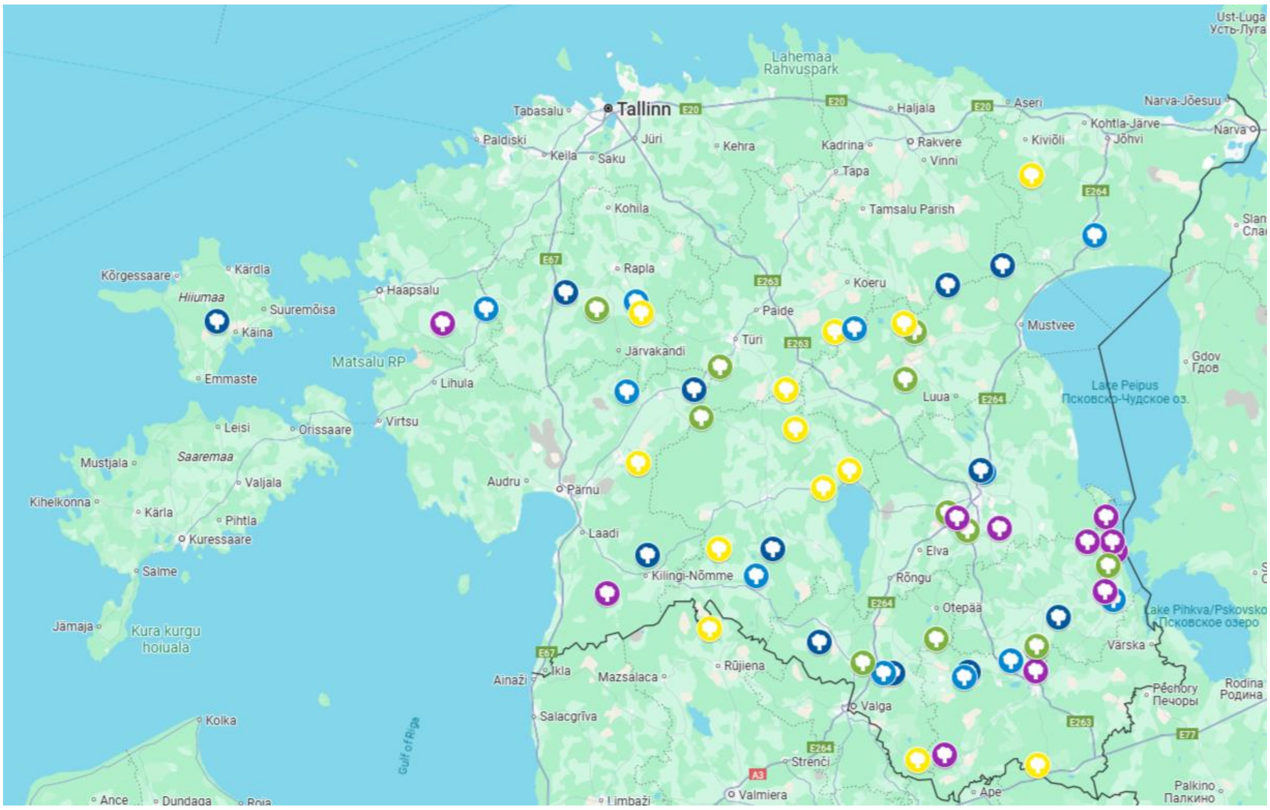

Figure 11. Forest stands for wide-scale sampling of wood.*

**Light blue represents planted silver birch, dark blue naturally regenerated silver birch, yellow grey alder, purple black alder and green hybrid aspen.*

3.4. General Gantt diagram of Pilot activities

General Gantt diagram of the Pilot activities is represented here (Table 7). The timeline is represented in quarters of the ECOLOOP project years. A more detailed version with step-by-step breakdown of each activity and a timeline in months can be found in the internal repository.

Table 7. General Gantt diagram of the Estonian Pilot Area activities.

No.	Activity	LEAD	FROM	TO	Year 1				Year 2				Year 3				Year 4			
					Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16
					M3	M6	M9	M12	M15	M18	M21	M24	M27	M30	M33	M36	M39	M42	M45	M48
1	Establishment of new sites	EULS, FORE	M2	M18																
2	Collection of data	EULS	M2	M19																
3	Modelling growth and yield	EULS	M11	M30																
4	Development of the DSS Carbon Calculator Tool	EULS	M7	M48																
5	Wood ash treatment on extracted and abandoned peatlands	EULS	M7	M48																
6	Biostimulant and fertilization treatment	EULS	M7	M35																
7	Testing new species for chemical valorisation from plantation forestry	FIBE	M19	M48																
8	Scaling up the deployment activities	EULS	M19	M48																

3.5. Deployment and demonstration phases

The prerequisites, activities during and the outcome of both deployment phases of the Estonian Pilot Area are represented in Table 8.

Table 8. Phase 1 and 2 of the deployment activities of Estonian Pilot Area.

Phase	Prerequisites	Activities during	Result
1st phase of demonstration (launches M30 – Milestone 6)	• All technical WPs are finishing their work. • Test cases defined. • All data collected and new growth and yield functions modelled. • Carbon Calculator Tool available online with new validated models for plantation forestry. • Plan for testing different timber from plantation forestry at Fibenol biorefinery. • Suitable plantations for testing pre-identified and signed contracts with the owners for harvesting.	• Testing the CC Tool with stakeholders. • Inclusion of wood ash and fertilization treatments growth and yield data to the CC Tool. • Testing timber from plantations at the Fibenol plant. • Connection with DSS and excel files import	• Feedback for the CC Tool from stakeholders. • Fertilization and wood-ash G&Y data is included in the CC Tool. • Factory testing finished at Fibenol biorefinery. • Species information included and presented in the DSS dashboard.

2nd phase of demonstration (launches M36 – Milestone 8)	• Wide-scale sampling of heavy metal and wood chemical properties for all the sites finished. • Factory testing finished at Fibenol biorefinery finished.	• Improvement of the plantation-based business model for forest owners. • Calculation of displacement factors and substitution effect of new bioproducts. • Suitability assessment of timber from plantation forestry for chemical valorisation based on the wide-scale sampling and factory testing results.	• Stakeholder tested and improved CC Tool with validated models and fertilization options and new assortments output available online. • Country-wide analyses of plantation forestry suitability and its environmental, climate and socioeconomic impact. • Knowledge about using timber from plantations for chemical valorisation gained • Datasets about tree species characteristics will be presented in the DSS.

3.6. Risk management plan

Risk table of the Estonian Pilot is represented here (Table 9). A more detailed risk identification matrix can be found in the internal repository.

Table 9. Estonian Pilot risk identification and mitigation plan

Nº Risk	Risk responsible	Risk description	Milestone or deliverable affected	Probability 4/3/2/1	Risk Assessment	Global Risk Indicator 0=Minimum, 4=Maximum	Contingency Plan
EE.01	EULS	Insufficient data to model all the necessary growth and yield for the Carbon Calculator. Additional modelling required.	D4.2 D6.2 MS6 MS8	2	MODERATE	1.125	Early on identification of the existing gaps. Fill as many gaps as possible in the data possible by finding new suitable sites. Early on modelling to identify the possibilities to fill the remaining gaps with additional modelling. Status check with the modelling team every week.
EE.02	FORE	Unfavourable weather conditions to perform logging activities to achieve wood for testing in Fibenol biorefinery factory	D6.2	1	LOW	0.375	Schedule logging works to 2025 autumn at the latest.

EE.03	FIBE	New growth techniques and wood species not compatible with Fibenol technology (e.g., different mechanical hardness such that wood is not broken down).	D6.2	1	LOW	0.375	1. Screen wood properties before testing in the plant. 2. Modify plant processing parameters to better match different wood species (e.g., increased grinding, more severe reaction conditions, etc.). 3. If some wood species are not suitable, test other species more rigorously.
EE.04	EULS	Security vulnerabilities, such as improper handling of user input and configuration errors, could expose the system to SQL injection, Cross-Site Scripting (XSS), and data leaks, which could lead to unauthorized data access, data corruption, or service disruption.	D4.2 MS6 MS8	1	MODERATE	0.625	Implement input validation and sanitization procedures to prevent malicious data processing. Regularly update and audit the application and its environment for security vulnerabilities. In case of a security breach, immediately revoke access, assess the extent of the breach, and apply patches.
EE.05	EULS	Lack of planted black alder stand on abandoned marginal lands that have reached dimensions that are suitable for wide-scale sampling.	D6.2 MS8	4	MODERATE	0.1	The majority of black alder plantations are newly planted and the trees are still extremely small. To fill the necessary repetition of wide scale sampled stands for chemical concentration and heavy metals analyses then black alder stands on the same soil type from forest lands will be included.

3.7. Assets to be tested

A preliminary mapping of assets going to be tested during the Pilot's activities and the expected outcome is presented in the following Table 10.

Table 10. Preliminary mapping of assets going to be tested on the Estonian Pilot.

Asset	Related UCs	Lead	Gained info	Outcome
CC Tool	EE.02	FORE, EULS	Potential bugs or shortcomings of the CC Tool.	Improvements of the CC Tool.
New growth and yield tables for the CC Tool	EE.04	FORE, EULS	Validation of the G&Y models	Improvements of the CC Tool. Validated new G&Y models of plantation forestry for publishing.
Wood-ash treatment plug-in for the CC Tool	EE.01	FORE, EULS	Suitability of the wood-ash treatment for CC Tool.	Improvements of the CC Tool.
Biostimulant + fertilization treatment plug-in for the CC Tool	EE.03	FORE, EULS	Suitability of the biostimulant + fertilization treatment for CC Tool	Improvements of the CC Tool.
Timber from plantation forestry for chemical valorisation	EE.02	FIBE	Output of different products from certain tree species. Feasibility of those tree species for chemical valorisation.	Suitability of timber from different tree species from different treatments of plantation forestry. Re-evaluation of gained timber assortments from harvests and calculation of displacements factors for new products.
Upscaling the plantation forestry on available marginal lands	EE.04	FORE	Knowledge about the carbon benefit and substitution effect of different afforestation scenarios	Suitability of plantation forestry using different suitable tree species for different land area scenarios for the entire country of Estonia

4. Slovenian Pilot

4.1. Pilot area description

The Slovenian pilot area comprises two sites (*Figure 12*). The first is the Biomass Centre Nazarje in an industrial zone, focused on processing wood waste into woody biomass for power, heat, and wood fuel production. Its fully automated process includes the preparation, transport, and feeding of materials into wood gasifiers. The plant uses pyrolysis, combining a wood gasifier and a Combined Heat and Power (CHP) system to generate heat and power. It produces wood gas from chips and pellets, powering 12 modular CHP units with 550 kWe and 1,200 kWth capacity. Furthermore, they operate two biomass boilers (1,5 MW_{th} and 4,0 MW_{th}). Annual output includes 150,000 nm^3 of dried wood chips, 15,000 tons of pellets, and 6.5 GWh of electricity. Planned upgrades include new CHP units (300 kW_e/600 kW_{th} and 500 kW_e/900 kW_{th}), EV charging point (300 kW), PV power plants (1,0 MW and 0,7 MW), and battery energy storage system (2,5 MW/ 5,0 MWh). In the scope of the project, the optimal schedules for individual energy assets will be calculated with the goal of maximizing market opportunities, operational efficiency, security of supply and enhance grid stability through ancillary services.

Furthermore, a modular woody biomass power plant prototype, offering tailored solutions for small-scale users like sawmills or farms will be developed in the Biomass centre. Flexibility management of slow pyrolysis will also be tested – investigation of the correlation between slow pyrolysis operating temperature and biochar output, which could be used as a biofertilizer.

The second site is IC Jablje, owned by the Agricultural Institute of Slovenia (KIS), featuring a modular micro biogas plant. This plant includes an anaerobic digester, a biogas holder, and a 7 kWe/16 kWth cogeneration unit. Planned upgrades will add biomethane production, storage, and a refuelling station for biomethane-powered tractors. Furthermore, the biochar quality (side product of pyrolysis from CHP of Biomass centre) will be analysed and assessed for potential agricultural applications.

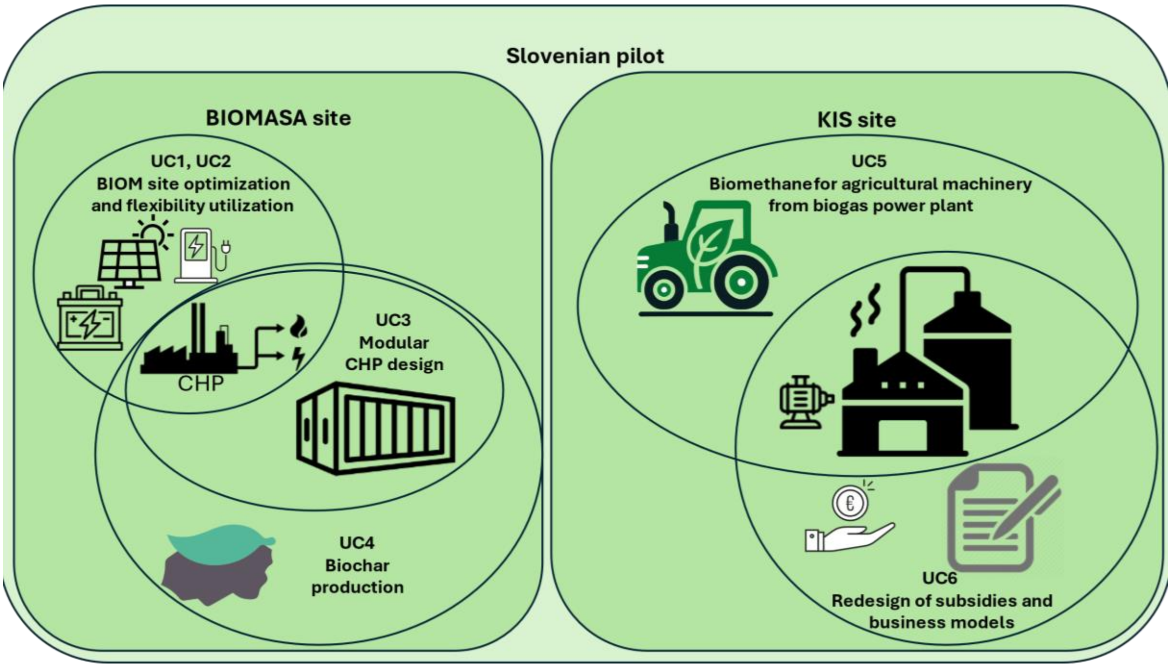

Figure 12. Slovenian Pilot Area infographic

4.2. Use Cases overview

UC SI.01 - Optimize the operation and improve the security of supply of biomass centre Nazarje

The UC aims to optimize Biomass Centre Nazarje's energy system by integrating existing and new infrastructure like CHP units, wood chip boilers, EV charging, PV, and battery storage, to maximize market opportunities, operational efficiency, and security of supply. Additionally, it explores distributing excess heat to industrial zone end-users for environmental and social benefits.

UC SI.02 - Utilization of flexibility of the biomass centre Nazarje

The UC leverages biomass centre Nazarje's flexibility assets to provide ancillary services, enhancing grid stability and enabling passive monetization. Through the Kolektor sETup aggregation platform, historical data guides strategic bidding in ancillary services markets, unlocking the integration of more renewables.

UC SI.03 - Design of a modular biomass slow pyrolysis system solution

The UC designs a modular woody biomass power plant prototype, offering tailored solutions for small-scale users like sawmills or farms. The outcome will be a container-based CHP unit with basic specifications, showcasing the potential for scaling up to meet various energy needs.

UC SI.04 - Biochar maximum utilization

The UC explores biochar production in CHP operations, examining temperature's impact on power output and byproduct yield. The analysis will assess biochar quality for potential agricultural applications, integrating its value into CHP profitability evaluation.

UC SI.05 - Biomethane from biogas power plant utilization for agricultural machinery

KIS operates a collaborative micro biogas plant, converting organic wastes into biogas to reduce emissions and support energy needs. UC will progress in biomethane production, employing a two-phase purification process to obtain high-purity methane for use as fuel, alongside generating organic matter for fertilizing as a byproduct.

UC SI.06 - Redesign of subsidies and business models for biogas

The UC aims to improve the agricultural sector's energy landscape through innovative BMs and subsidies for biogas and biomethane production, aligning with sustainable development goals. The project targets carbon footprint reduction, energy self-sufficiency, and rural economic growth, utilizing innovative financial support and policy changes for biogas plants to create a scalable framework for widespread adoption.

4.3. Pilot area activities

The following Table 11 represents the planned activities and their short description of the Slovenian Pilot.

Table 11. Planned activities of the Slovenian Pilot.

Activity	Description	Related tasks	Related Use Cases
1. Data collection	Data needed for optimization and ancillary services analysis will be reviewed twice between SETUP (receiver) and BIOM (sender) to ensure relevance, availability, timely transmission, and quality.	T4.1 T3.2 T3.3	SI.01 SI.02
2. Optimization model development	Modelling energy assets for optimization, including market connections and constraints. Calculating and optimizing baseline costs using historical data. Expanding with new assets and defining additional scenarios with BIOM.	T4.1 T3.2 T3.3	SI.01
3. Optimization model results analysis	Evaluating baseline optimization, new asset inclusion, and additional scenario optimizations.	T4.1 T3.2 T3.3	SI.01
4. Ancillary services feasibility analysis	Modelling advanced baseline and flexibility forecasts for ancillary services. Evaluating with BIOM and finalizing based on feedback.	T4.1 T3.2	SI.02
5. Integration of the optimization model with Biomasa and demonstration	Integrating the optimization model into Biomasa's IT system, testing functionalities, data exchange, and refining based on results. The final phase includes demonstration and impact evaluation on Biomasa's energy assets.	T4.1 T3.2 T3.3 T5.1	SI.01
6. Demonstration of ancillary services bidding	Integrating control devices into energy assets for ancillary services. Preparing registration documentation, testing activation signals, and demonstrating bidding.	T4.1 T3.2	SI.02
7. Modular CHP system concept and design	Analysing market demand, regulations, and environmental factors, followed by developing modular and containerized design concepts. A feasibility study assesses technical and economic viability, including resource availability and costs. Detailed design specifications define performance criteria, operational parameters, and layout. Key components such as the biomass burner, heat exchangers, generator, and control systems are selected. Engineering blueprints are drafted to ensure modular integration and a risk assessment is conducted to identify potential challenges and mitigation strategies.	T3.2	SI.03 SI.04
8. Modular CHP system development and testing	The procurement phase involves acquiring necessary components and materials for the prototype. In the prototyping phase, the modular CHP system is assembled in a controlled environment according to design specifications. Instrumentation setup includes	T3.2	SI.03 SI.04

	installing sensors and monitoring equipment to collect performance data. Initial functional testing verifies basic operation and identifies any assembly or design issues.		
9. Modular CHP system deployment and testing	Performance testing evaluates efficiency, emissions, and reliability. Stress testing ensures durability and safety under extreme conditions. Data collection analyses heat, power, biomass consumption, and costs. Refinements address issues found, adjusting design and components. Validation testing confirms improvements. Final documentation includes design, testing outcomes, and insights. The prototype is then deployed at the pilot site for real-world operation. Pilot testing monitors performance and showcases the system to stakeholders. Finally, a report compiles all findings.	T3.2	SI.03 SI.04
10. Single CHP system operation planning and testing	Define testing objectives to evaluate flexibility in CHP operation, including efficiency, power-to-heat ratios, and side-product generation, as well as operational boundaries and modes. Experimental design involves developing testing scenarios with varying burner temperatures. Resource allocation secures biomass feedstock and arranges facilities for biochar and ash analysis.	T3.2	SI.03 SI.04
11. Biochar production monitoring	Instrumentation setup installs sensors to monitor temperature, efficiency, and output. Testing protocol development creates procedures for flexibility tests, including safety measures. Operational variability tests evaluate impacts of different burner temperatures on power, heat, and by-products. Efficiency analysis measures energy conversion across temperature ranges. By-products like biochar and ash are collected for further analysis.	T3.2	SI.03 SI.04
12. Biochar analysis and certification	Chemical analysis evaluates the nutrient content, pH, and structure of biochar for potential biofertilizer use. Ash characterization analyses composition for disposal or reuse options. Certification preparation involves documenting biochar for EU biofertilizer certification. Data analysis compiles results to identify optimal operating conditions for flexibility. System adjustments propose performance improvements based on testing outcomes. Final reporting documents findings for stakeholders and regulatory bodies.	T3.2	SI.03 SI.04
13. Activation and optimization of the biomethane PSA filter	Conduct a diagnostic analysis of the PSA unit to identify faults and inefficiencies in the biomethane production system. Repair and optimize critical components to meet performance standards for methane purity, efficiency, and energy consumption. Perform operational testing to validate PSA unit performance under different load conditions and ensure compliance with regulatory standards.	T4.1 T3.3	SI.05
14. Biomethane production and dispensing system installation	Complete the installation of biomethane dispensing infrastructure, including storage tanks, pipelines, and safety systems. Integrate the PSA unit into the dispensing system for seamless operation. Perform trial runs to validate readiness, focusing on gas flow, energy	T4.1 T3.3	SI.05

	efficiency, and methane concentration. Address any technical or operational issues.		
15. Upgrading agricultural machinery for biomethane compatibility	Design and modify agricultural machinery, like tractors, to run efficiently on biomethane. Adapt engine components, including fuel injection systems, tanks, and exhausts, for biomethane compatibility. Conduct testing to evaluate performance, durability, and emissions. Analyse data to assess environmental impacts and optimize machinery for long-term use.	T4.1 T5.2	SI.05
16. Feasibility and impact analysis of biomethane use in agriculture	Collect and analyse data on the operational, economic, and environmental feasibility of using biomethane in agriculture. Assess economic viability through cost-benefit analysis and ROI for farmers. Conduct stakeholder consultations and integrate findings into a report. Include environmental impact evaluations, such as GHG emission reductions, to highlight the sustainability of biomethane adoption.	T5.2	SI.05
17. Development of strategic action plan for biomethane integration	Draft a strategic action plan for integrating biomethane into agriculture, including technical guidelines for biogas plant upgrades, machinery retrofitting, and infrastructure development. Engage stakeholders to gather feedback on the draft plan. Finalize the action plan, incorporating stakeholder insights and lessons learned, ensuring alignment with EU sustainability goals and local regulations.	T6.1	SI.05 SI.06
18. Review of existing subsidy frameworks	Conduct a review of Slovenian subsidy programs and financial support for biomethane production and use. Analyse existing frameworks to identify gaps, such as limited accessibility, insufficient funding, or outdated regulations. Develop a report summarizing key findings and providing actionable recommendations to improve policy support for biomethane adoption.	T3.1	SI.06
19. Workshop for agricultural stakeholders on biomethane technology	Organize workshops with agricultural stakeholders, including farmers, cooperatives, and industry representatives, to present the technical and economic potential of biomethane. Address challenges, financial barriers, and regulatory requirements. Collect feedback on real-world constraints and stakeholder needs to refine business models and policy recommendations.	T6.4	SI.05 SI.06
20. Development of business models and policy recommendations for biomethane adoption	Design innovative business models for the Slovenian biomethane sector, focusing on financial sustainability, operational feasibility, and scalability, while considering farm sizes and energy production capacities. Draft evidence-based policy recommendations aligned with EU directives and local needs, emphasizing improved subsidies, reduced administrative barriers, and incentivizing private investments. Present these models and recommendations to policymakers, industry leaders, and stakeholders for feedback and validation.	T4.2 T6.4 T3.1	SI.05 SI.06

21. Monitoring and evaluation of redesigned models	Develop a monitoring framework to track the implementation of business models and policy recommendations. Evaluate performance using indicators like stakeholder adoption, economic benefits, environmental impact reductions (e.g., GHG emissions), and operational challenges. Conduct periodic evaluations, incorporating feedback and field data to refine models. Prepare detailed reports summarizing findings and scaling guidelines. Ensure compliance with EU reporting standards and provide actionable insights for future policymaking.	T6.4	SI.05 SI.06

4.4. General Gantt diagram of Pilot activities

General Gantt diagram of the Pilot activities is represented here (Table 12). The timeline is represented in quarters of the ECOLOOP project years. A more detailed version with step-by-step breakdown of each activity and a timeline in months can be found in the internal repository.

Table 12. General Gantt diagram of the Slovenian Pilot Area activities.

Activity	LEAD	FROM	TO	Year 1				Year 2				Year 3				Year 4			
				Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16
				M3	**M6**	**M9**	**M12**	**M15**	**M18**	**M21**	**M24**	**M27**	**M30**	**M33**	**M36**	**M39**	**M42**	**M45**	**M48**
1. Data collection	SETUP	M13	M20																
2. Optimization model development	SETUP	M18	M30																
3. Optimization model results analysis	SETUP	M25	M32																
4. Ancillary services feasibility analysis	SETUP	M18	M30																
5. Integration of the optimization model with Biomasa and demonstration	SETUP	M33	M48																
6. Demonstration of ancillary services bidding ancillary services bidding	SETUP	M33	M48																

7. Modular CHP system concept and design	BIOMASA	M20	M30																
8. Modular CHP system development and testing	BIOMASA	M30	M36																
9. Modular CHP system deployment and testing	BIOMASA	M36	M48																
10. Single CHP system operation planning and testing	BIOMASA	M20	M30																
11. Biochar production monitoring	BIOMASA	M30	M44																
12. Biochar analysis and certification	BIOMASA	M36	M48																
13. Activation and optimization of the biomethane PSA filter	KIS	M7	M22																
14. Biomethane production and dispensing system installation	KIS	M18	M27																
15. Upgrading agricultural machinery for biomethane compatibility	KIS	M16	M36																
16. Feasibility and impact analysis of biomethane use in agriculture	KIS	M27	M36																
17. Development of strategic action plan for biomethane integration	KIS	M36	M48																

18. Review of existing subsidy frameworks	IRI UL, KIS	M7	M20																
19. Workshop for agricultural stakeholders on biomethane technology	IRI UL, KIS	M23	M27																
20. Development of business models and policy recommendations for biomethane adoption	IRI UL, KIS	M16	M30																
21. Monitoring and evaluation of redesigned models	IRI UL, KIS	M30	M48																

4.5. Deployment and demonstration phases

The prerequisites, activities during and the outcome of both deployment phases of the Slovenian Pilot Area are represented in Table 13.

Table 13. Phase 1 and 2 of the deployment activities of the Slovenian Pilot Area.

Phase	Prerequisites	Activities during	Result
1st phase of demonstration (launches M30 – Milestone 6)	• Data from Biomasa defined, collected, reviewed and confirmed. • Optimization model developed. • Models for ancillary services feasibility developed. • Review and select components for modular CHP system, prepare detailed blueprints • Define tests for biochar production • PSA unit reactivated and optimized • Dispensing infrastructure finalized and integrated with PSA Initial biomethane production validated. Existing legislation and subsidy schemes for biomethane power plants and machinery • KIS to set internet connection in the biogas plant for the DSS to obtain biogas production data	• Optimization model results analysis. • Ancillary services feasibility analysis. • Integration of the optimization model with Biomasa. • Integration of control devices with chosen energy assets for ancillary services. • Assembly and initial testing of modular CHP unit • Feasibility analysis of biomethane use in agriculture. • Preliminary testing of biomethane-compatible machinery. • Review of existing documentation and identification of best practises • Connection between KIS biogas analyser, computer and the DSS tool	• Optimization model functionality evaluated and approved. • Feasibility of energy assets for ancillary services evaluated and approved. • Optimisation model integrated and ready for testing. • Control devices of chosen energy assets integrated and ready for testing. • Performance reports for modular CHP unit, feasibility study and unit's blueprints • Functional biomethane production system. • Feasibility report and initial testing results. • Prepare recommendations for novelties on the subsidies for biomethane sector • Biogas production data to be presented in the DSS dashboard.
2nd phase of demonstration	• Optimisation model integrated. • Control devices of chosen energy assets integrated.	• Testing of optimisation model functionalities. • Testing of ancillary services activations. • Testing of the modular CHP unit	• Go live for optimisation model demonstration, • Go live for ancillary services bidding.

(launches M36 – Milestone 8)	• Operational modular CHP unit • Definition of variable temperature setpoint range for biochar side production • Field testing of biomethane-compatible machinery completed	• Testing of variable temperature setpoint and monitoring of biochar production • Final machinery testing and emissions evaluation. • Stakeholder workshop and demonstration. • Development of strategic action plan.	• Biochar analysis and CHP operation analysis • Verified machinery performance and emissions. • Final action plan for biomethane integration.

4.6. Risk management plan

Risk table of the Slovenian Pilot is represented here (Table 14). A more detailed risk identification matrix can be found in the internal repository.

Table 14. Slovenian Pilot risk identification and mitigation plan.

Nº Risk	Risk responsible	Risk description	Milestone or deliverable affected	Probability 4/3/2/1	Risk Assessment	Global Risk Indicator 0=Minimum, 4=Maximum	Contingency Plan
SI.01	SETUP	Data quality for development of optimization model	D3.1 D4.1	1	LOW	0.5	SETUP is in regular contact with BIOMASA. SETUP will organize regular meetings to ensure collecting all relevant data for development of optimization model.
SI.02	SETUP	Difficulties with obtaining documentation and other relevant paperwork for registration for ancillary services with TSO	D6.2	2	MODERATE	0.875	When the energy assets relevant for ancillary services are determined, KOL will in collaboration with BIOM immediately start with the documentation workflow.
SI.03	SETUP	Technical challenges in activating and optimizing the existing biomethane PSA filter.	T4.1	2	MODERATE	1.0	Collaborate with PSA provider to conduct diagnostics and resolve issues.
SI.04	SETUP	Testing delays for biomethane use on agricultural machinery due to compatibility issues.	T4.1	2	MODERATE	1	Conduct pre-testing with machinery to identify compatibility issues early.

SI.05	SETUP	Unforeseen costs related to upgrading existing biomethane infrastructure for agricultural machinery.	T4.1	2	MODERATE	1	Create a step-by-step integration plan and test components separately.
SI.06	BIOMASA	Modular unit component compatibility issues	T3.2	1	LOW	0.5	BIOM will prepare a potential component list, based on the experiences from existing CHP systems and installations
SI.07	BIOMASA/KIS	Delays in equipment delivery	T6.4	2	MODERATE	0.875	Potential components will be ordered as soon as possible to avoid long delivery dates or potential compatibility issues

4.7. Assets to be tested

A preliminary mapping of assets going to be tested during the Pilot's activities and the expected outcome is presented in the following Table 15.

Table 15. Preliminary mapping of assets going to be tested on the Slovenian Pilot.

Asset	Related UCs	Lead	Gained info	Outcome
Optimisation model	SI.01	SETUP	Communication flow (reliability of communication), data/information flow (confirmation of measurement and scheduling data), and potential bugs of the information exchanged.	The improved optimisation model.
Baseline and flexibility forecast algorithms	SI.02	SETUP	Accuracy of the baseline and forecast algorithms.	The improved model for bidding in the ancillary services market.
Modular CHP unit	SI.03	BIOMASA	Interoperability and scalability potential of the modular CHP system	The CHP system component will be tested and evaluated for the modular integration into tailored CHP system
Single CHP wood burner	SI.03 SI.04	BIOMASA	Operational limits of the CHP system as a flexibility source	The operational temperature setpoints will be evaluated in regard to the Biochar/ash production in addition to the power/heat output of the unit
Biochar	SI.03 SI.04	BIOMASA	The biochar, which will be created will be analysed for its chemical structure and fertilising potential	Biochar certificate

Biogas power plant	SI.05 SI.06	KIS	Biogas power plant will serve as a biomethane and digestate production unit. Biogas to biomethane conversion efficiency. Stability and reliability of operations.	Validated biomethane and digestate production processes.
Biomethane powered tractor	SI.05 SI.06	KIS	Tractor will showcase the use of biomethane for use in agricultural setting. Emission reduction compared to conventional fuel	Demonstration of using biomethane as alternative fuel

5. Bulgarian Pilot

5.1. Pilot Area description

The Bulgarian pilot site, located in the Momchil area near Balchik, is part of the Dobrich district, Bulgaria's leading agricultural region. Covering 4,720 km², with 81% of its land dedicated to agriculture, the district plays a crucial role in the country's food production. Major crops grown in the region include wheat, barley, sunflower, rapeseed, and corn.

The pilot site is managed by subsidiaries of Albena JSCo, a leader in sustainable tourism, agriculture, and renewable energy integration. This project is part of a broader initiative to develop a circular economy model that enhances resource efficiency, renewable energy adoption, and sustainable rural development (Figure 13).

Figure 13. Aerial view of the Bulgarian pilot site, showing the biogas facility, greenhouses and surrounding farmland.

The Bulgarian pilot site spans 12.8 hectares (128,000 m²) and demonstrates the integration of renewable energy and sustainable agriculture through several key infrastructures. A biogas facility converts organic waste into energy and biofertilizers, contributing to a circular economy model. The site also features greenhouses equipped with photovoltaic (PV) panels, which produce renewable electricity while enhancing crop growth conditions. In addition, pastures are included to support agricultural and livestock activities. Storage halls are currently used for agricultural production storage, with plans underway for future conversion into mushroom farms, cattle sheds, and other production facilities (Figure 13).

The surrounding agricultural lands can support complementary activities within the pilot framework, such as agronomic trials, monitoring of crop performance under integrated energy systems, regenerative practices to improve soil fertility and demonstration of innovative agricultural practices.

The site consists of two closely integrated systems in the Momchil area, forming the foundation of its circular economy model. A smart agricultural photovoltaic (Agri-PV) system supports the energy needs of the pilot site through multiple installations. Photovoltaic panels with a capacity of 29.7 kWp are installed on the rooftop of one greenhouse, contributing to the renewable energy supply and partially shading the structure, which helps regulate internal temperatures, reduce water consumption, and improve crop growth conditions. In addition, larger PV systems are installed on the rooftops of two storage halls, with capacities of 204.6 kWp and 194.7 kWp respectively. Together, these installations provide renewable electricity to power the greenhouse, administrative buildings, and other operational infrastructure, significantly enhancing the site's overall energy self-sufficiency.

Complementing this system is a biogas facility (Figure 14) that processes agricultural waste, food residues, and manure sourced from surrounding farms. The facility produces biogas, which is utilized for both electricity generation and heat production, significantly reducing the site's reliance on fossil fuels. Waste heat from the biogas process is transferred via a pipeline network to the greenhouses, enabling optimal growing conditions throughout the year. The digestate by-product from the biogas process is further valorised into biofertilizers, which are used both in the greenhouses and on agricultural fields to enhance soil quality and reduce dependence on chemical fertilizers.

Figure 14. Close-up view of a part of the biogas facility.

5.1.1. Circular Economy Model in Action

The Bulgarian pilot site applies an integrated circular economy approach where waste, energy, and agricultural systems operate synergistically to optimize resource efficiency and environmental sustainability. Biogas production relies on a combination of agricultural residues, food waste, and manure as input materials, resulting in renewable energy generation and the production of biofertilizers that support soil health. Thermal energy generated during the biogas process is distributed to greenhouses through a pipeline system, contributing to a stable climate and improved productivity.

Electricity generated by the photovoltaic panels is used to power the full scope of site activities, including biogas plant operations, greenhouse systems, and administrative functions. Additionally, the shading from PV panels supports greenhouse climate control by mitigating excessive heat, which in turn reduces energy use and enhances crop resilience. The biofertilizers produced from digestate are intended for application in agricultural use, potentially including both greenhouse environments and open fields, to enhance soil fertility and support crop productivity.

Altogether, the pilot site represents a scalable model for circular agriculture and integrated energy systems. It serves as a demonstration platform for regional stakeholders and agricultural enterprises, highlighting the practical benefits of combining renewable energy technologies with sustainable resource management practices.

5.2. Use Cases overview

UC BG.01 - Smart agricultural PV implementation in greenhouses and scale-up in combination with biogas energy for sustainable processes.

This UC focuses on integrating photovoltaic (PV) systems into existing greenhouses to create smart, energy-efficient agricultural facilities. By utilizing energy produced by PV systems and thermal energy from the biogas facility, the greenhouses will achieve optimal temperature regulation, enabling increased yield cycles and reduced carbon emissions. This smart energy integration will showcase the potential of combining renewable energy sources to enhance agricultural productivity while minimizing environmental impact.

UC BG.02 - Regional agricultural and other waste analysis and potential biogas production.

This UC emphasizes the assessment and utilization of agricultural and organic waste for biogas production. A detailed analysis of waste streams will be conducted to identify their biogas production potential. The findings will optimize the biogas facility's feedstock mix, reducing reliance on corn silage and increasing the use of sustainable, locally available waste. Additionally, this UC will evaluate the impact of biogas bioproducts, such as digestate, as biofertilizers to improve soil quality and crop yield.

UC BG.03 - National and regional regulation and business model implementation to foster rural development.

This UC aims to address regulatory and economic challenges associated with the adoption of renewable energy technologies in rural areas. By developing business models and analysing existing policies, the pilot seeks to create favourable conditions for the establishment of energy cooperatives and decentralized energy systems. Collaboration with policymakers and stakeholders will help align these initiatives with national strategies, empowering local communities to achieve energy self-sufficiency, reduce greenhouse gas emissions, and enhance socioeconomic resilience.

5.3. Pilot area activities

The following Table 16 represents the planned activities and their short description of the Bulgarian Pilot.

Table 16. Planned activities of the Bulgarian Pilot Area.

Activity	Detailed description	Related tasks	Related Use Cases
1. Integration of PV systems in existing greenhouses	Site preparation, installation of PV panels, connection to the energy distribution system, and integration with greenhouse operations to achieve complete energy self-sufficiency while reducing operational costs and environmental impact.	T6.5 T3.3	BG.01
2. Thermal regulation of greenhouses using biogas-derived energy	Integrating thermal energy distribution through pipelines to monitor greenhouse temperature stability to improve crop yields.	T6.5 T3.3	BG.01
3. Implementation of Automated Monitoring and Regulation System	Integration of automated monitoring and control systems in greenhouses with Agri-PV, ensuring optimal growing conditions and efficient energy management.	T6.5 T3.3 T.4.1 T4.4	BG.01
4. Agricultural and organic waste analysis	Waste sampling, laboratory analysis, and developing a database of waste characteristics to optimize feedstock for the biogas facility.	T6.5 T3.1 T3.4	BG.02
5. Optimization of biogas production processes	Testing different feedstock combinations, improving digestion processes, and implementing real-time monitoring and control systems.	T6.5 T3.1 T3.4	BG.02
6. Development of business models and regulatory recommendations	Stakeholder engagement, financial analysis, and drafting policy recommendations to facilitate the establishment of energy cooperatives and decentralized energy systems.	T6.5 T5.1 T5.2 T5.3 T5.4	BG.03

5.4. General Gannt diagram of Pilot activities

General Gantt diagram of the Pilot activities is represented here (Table 17). The timeline is represented in quarters of the ECOLOOP project years. A more detailed version with step-by-step breakdown of each activity and a timeline in months can be found in the internal repository.

Table 17. General Gantt diagram of the Bulgarian Pilot Area activities.

No.	Activity	LEAD	FROM	TO	Year 1				Year 2				Year 3				Year 4			
					Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16
					M3	**M6**	**M9**	**M12**	**M15**	**M18**	**M21**	**M24**	**M27**	**M30**	**M33**	**M36**	**M39**	**M42**	**M45**	**M48**
1	Integration of PV systems in existing greenhouses	ALBENA	M13	M16																
2	Sowing and harvesting from Greenhouses	ALBENA	M16	M48																
3	Thermal regulation of greenhouses using biogas-derived energy	ALBENA	M16	M48																
4	Implementation of automated monitoring and regulation system	ALBENA	M18	M30																
5	Agricultural and organic waste analysis	TRU	M17	M25																

6	Implementation of lab analysis and scientific research for optimization of biogas production	ALBENA	M21	M48																
7	Testing of biofertilizers on local crops	ALBENA	M21	M48																
8	Development of business models and regulatory recommendations	TRU	M18	M39																
9	Knowledge Transfer sharing knowledge with local stakeholders. Workshops and training programs.	TRU	M39	M48																

5.5. Deployment and demonstration phases

The prerequisites, activities during and the outcome of both deployment phases of the Bulgarian Pilot Area are represented in Table 18.

Table 18. Phase 1 and 2 of the deployment activities of the Bulgarian Pilot.

Phase	Prerequisites	Activities during	Result
1st phase of demonstration (launches M30 – Milestone 6)	• Completion of site preparation for PV systems and biogas facility integration. • Definition of test cases and protocols for greenhouse energy efficiency and biogas optimization. • Installation and commissioning of PV systems and thermal regulation setups.	• Initial testing of PV-powered greenhouses and biogas facility. • Collection of baseline data on energy consumption, waste input, and greenhouse yields. • Stakeholder engagement to gather feedback on initial system performance. • Connection of PV systems and biogas facility with DSS tool.	• Operational smart greenhouses with integrated PV and biogas energy systems. • Preliminary insights into energy efficiency and biogas production efficiency. • Identification of areas for improvement before full-scale deployment. • First consumption/production results to be presented in the DSS tool dashboard.
2nd phase of demonstration (launches M36 – Milestone 8)	• Completion of adjustments and improvements identified during Phase 1. • Deployment of DSS and monitoring systems.	• Full-scale operation of smart greenhouses and biogas facilities. • Application of optimized biofertilizers derived from biogas digestate. • Demonstration of economic and environmental benefits to stakeholders. • Comprehensive data collection for evaluating system performance and impacts.	• Fully operational and optimized renewable energy systems. • Significant reduction in greenhouse energy costs and carbon footprint. • Detailed reports on environmental, social, and economic impacts for dissemination.

5.6. Risk management plan

Risk table of the Bulgarian Pilot is represented here (Table 19). A more detailed risk identification matrix can be found in the internal repository.

Table 19. Bulgarian Pilot risk identification and mitigation plan.

№ Risk	Risk manager	Risk description	Milestone or deliverable affected	Probability 4/3/2/1	Risk Assessment	Global Risk Indicator 0=Minimum, 4=Maximum	Contingency Plan
BG.01	ALBENA	Failure to comply with legal requirements/permits for installing a photovoltaic system.	D6.1 MS6	1	LOW	0.5	Employ legal experts to review all applications and documentation to ensure compliance with regulations and expedite the approval process.
BG.02	ALBENA	Insufficient waste streams for biogas production	D6.2 MS8	2	LOW	0.875	Collaborate with nearby industries to secure additional waste streams. Explore alternative high-yield feedstock crops.
BG.03	ALBENA	Technical challenges in greenhouse thermal regulation	D6.2 MS8	2	MODERATE	1.25	Conduct thorough testing and implement advanced climate control systems, such as automated sensors and thermal pumps. Use real-time monitoring to ensure temperature stability.
BG.04	TRU	Economic unviability of proposed business models	D6.2 MS8	1	LOW	0.5625	Develop flexible business models based on stakeholder feedback, lab analysis of tested feedstock, and market analysis. Explore additional funding sources.
BG.05	ALBENA	Unfavourable <<weather conditions affecting PV systems	D6.2 MS8	2	LOW	0.75	Design systems with weather-resilient components such as durable materials and energy storage solutions to handle fluctuations.

BG.06	TRU	Stakeholder disengagement or lack of community support	D6.2 MS8	2	MODERATE	0.875	Engage stakeholders through regular communication and workshops, highlighting project benefits. Provide incentives for participation and involve key community leaders to build trust and support.
BG.07	ALBENA	Substrate seperating in different layers	D6.2 MS8	2	MODERATE	0.875	Taking a probe, getting it analyzed and order necessary enzymes; change mixing regime;
BG.08	ALBENA	Low quality methane	D6.2 MS8	2	MODERATE	1	Operator needs to: Raise temperature, add more raw material/silage/and raise the mixer working frequency
BG.09	ALBENA	Risk of a failure in the biogas plant, which could disrupt the supply of thermal energy to the greenhouses.	D6.2 MS8	2	HIGH	1.375	Create backup systems (auxiliary heating or energy buffering) and failsafe mechanisms by usage of an electrical water-heater/boiler to use the electricity from the Agri PV System; reduce thermal energy usage for other consumers.

5.7. Assets to be tested

A preliminary mapping of assets going to be tested during the Pilot's activities and the expected outcome is presented in the following Table 20.

Table 20. Preliminary mapping of assets going to be tested on the Bulgarian Pilot.

Asset	Related UCs	Lead	Gained info	Outcome
Smart PV system for greenhouses	BG 2.1	ALBENA	Performance metrics for energy efficiency and crop yield	Energy efficiency and optimized crop yield
Biogas facility with enhanced waste processing	BG 2.2	ALBENA	Data on waste processing efficiency and biogas yield	Increased biogas yield and improved waste management
Biofertilizers derived from biogas digestate	BG 2.1 BG 2.2	ALBENA	Impact on soil quality and crop productivity	Improved soil quality
Decision support tool for energy and resource optimization	BG 2.1 BG 2.2	ALBENA	Insights for optimizing renewable energy operations	Data-driven decisions for sustainable operations
Monitoring systems for greenhouse and biogas facility	BG 2.1 BG 2.2	ALBENA	Real-time data on operational performance and environmental conditions	Enhanced operational reliability and efficiency

6. CONCLUSIONS

This report provides an overview of each Pilot Area's activities, their timeline and the risks identified per pilot site. The work was performed within the *Task 6.1: Overall coordination of Pilot Sites and Living Lab activities [M13-M18]* which ran for a duration of 6 months (from October 2024 until the end of March 2025). The activity identification for this document is strongly built upon the previously defined UCs per Pilot Area. For this document all the ECOLOOP Pilot Areas have identified the necessary activities on different Pilot's sites, the necessary timeline of the activities, definition of the 1st and 2nd phases for deployment, the risks related to all the activities. At the end of each Pilot's chapter, a preliminary mapping of assets to be tested was completed. The Pilot Areas of project ECOLOOP are varying, thus covering a large area of agricultural, sustainable energy and forestry activities in different regions of Europe.

Spanish Pilot Area encompasses incorporation of Agri-PV and geothermal systems into the production of agricultural crops, the utilization of agricultural waste to produce biogas and the use of the left-over digestate in improving the agricultural soils. The planned project activities help to move towards circular bioeconomy with the aim of producing biogas, improving soil health and the productivity of the agricultural sector by the reduction of waste and usage of green energy.

The Estonian Pilot project aims to develop comprehensive knowledge of a novel silvicultural method in Northern Europe, focusing on the cultivation of fast-growing hardwoods in short-rotation forestry plantations for future biorefining and assessing its environmental impact. The primary objective is to map the growth and yield dynamics using various afforestation strategies for suitable hardwoods and analyse their potential for future biorefineries. All results will be integrated into the CC Tool. These findings will provide an overview of the feasibility of using low-quality timber from plantation forestry for green products, rather than utilizing low-grade timber assortments and timber industry waste for energy.

The Slovenian Pilot project aims to optimize the operational efficiency, supply security, and grid stability of heat and power production in a CHP system using wood waste. The suitability of leftover biochar for agricultural applications will be analysed. Additionally, modular micro biogas plants will be tested to develop fuel-grade biomethane production, storage, and refuelling stations. This approach maximizes the use of waste from forestry, timber, and agricultural sectors, reduces the carbon footprint, and promotes energy self-sufficiency.

The activities of the Bulgarian Pilot Area follow a circular bioeconomy model by utilizing green energy, thereby enhancing sustainability in the sector. Thermal energy and a smart agri-PV system are integrated into agricultural crop production, optimizing output and minimizing emissions. Agricultural waste is converted into biogas, further reducing the area's dependence on fossil fuels. The leftover digestate will be used to produce biofertilizers, improving soil fertility and health.

It is worth mentioning that while each pilot site faces unique challenges, the risk mitigation strategies in place ensure that potential issues are identified early and addressed effectively, ultimately supporting the successful integration of sustainable technologies into energy and agricultural systems.

With the commencement of the actual deployment and demonstration activities starting in M19 (April 2025) across all Pilots (Tasks 6.2, 6.3, 6.4 and 6.5), this document serves as a comprehensive handbook detailing the schedule and procedures for each activity within the pilot areas. Over the coming months, a standardised testing template will be developed for all Pilot Areas to facilitate the monitoring of asset testing during the deployment phases.

7. ACRONYMS

Acronym	Description
ALBENA	Albena AD
AVA-ASAJA	Asociacion Valenciana de Agricultores
BG	Bulgaria
BIOMASA	Biomasa družba za trgovino, servis in montažo kotlov na biomaso d.o.o.
CC TOOL	Carbon Calculator Tool
CHP	Combined heat and power
DSS	Decision Support System
EE	Estonia
ES	Spain
ETRA	Etra Investigacion y Desarrollo, S. A
EULS	Estonian University of Life Sciences, Eesti Maaülikool
FERTINAGRO	Fertinagro Biotech, S.L.
FIBE	Fibenol OÜ
FORE	Foreko OÜ
GPC	Gel permeation chromatography
HSQC NMR	Heteronuclear single quantum coherence nuclear magnetic resonance
ICP-MS	Inductively Coupled Plasma Mass Spectrometry
INDEREN	Ingenieria y desarrollos renovables, S.L.
IRI UL	Inovacijsko-razvojni institut Univerze v Ljubljani

KIS	Kmetijski inštitut Slovenije - Agricultural Institute of Slovenia
LL	Soil Living Lab
M	Month
MCC	Micro-crystalline cellulose
MS	Milestone
PV	Photovoltaic
R&D	Research and development
SETUP	Kolektor seETup, storitve energetskega upravljanja, d.o.o
SI	Slovenia
T	Task
TRU	Trakiyski universitet
UC	Use Case
UPV	Universitat Politécnica de Valencia
WP	Work package
XRD	X-ray diffraction

8. REFERENCES

[1] "D1.1", Deliverable D1.1 – Project Management plan v1. Project ECOLOOP deliverable related to tasks T1.1 and T1.2.

[2] "D2.1", Deliverable D2.1 – Pilot site analyses and use cases, requirements and KPIs definition. Project ECOLOOP deliverable related to tasks T2.1, T2.2, T2.3.

[3] "D2.2", Deliverable D2.2 – ECOLOOP SOIL Living laboratory description. Project ECOLOOP deliverable related to task T2.4.