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<b>Main Author(s), partner in charge:</b>	Roberta Curiazzi (AFIL)
<b>Contributing Author(s):</b>	Golboo Pourabdollahian (CNR-STIIMA)
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## Revision History

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0.1	Draft	20.03.2020	Roberta Curiazzi	first draft created
1.0	Final draft for review	30.03.2020	Roberta Curiazzi	Document updated and final draft for review created

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## List of abbreviations

RP: Reporting period

LL: Living Lab

RES : Renewable Energy Sources

ACMM: Associazione Cluster Marche Manufacturing

TPLj: Technology Park Ljubljana

PTP: Pomurje Technology Park

RCM: Region Central Macedonia

CIE: Cluster Intelligent Energia

CCE: Croatian Chamber of Economy

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## 1 Executive Summary

The aim of Activity 2.2, related to this deliverable, is to create and manage the community of the project. The community is composed by all stakeholders to which the project is relevant encompassing manufacturing companies, universities, research centres, intermediaries and Living Labs. This Community has the objective of creating a stable network of regional stakeholders' groups (Platforms), involved in Green Manufacturing Innovation, and developing at least 3 Living Labs within such network. Living Labs needs to be created, managed, and organized in a way that assures effective usage of such a form of innovation environment. A part of Activity 2.2 is therefore the design of the model for the Living Labs within the community, and the planning of actions to have them up and running by the end of the project.

As stated in the previous reports, the focus of this deliverable is the Living Labs within the Project Community. The objective is therefore to provide an update on the activities ongoing and in particular on the progresses achieved in the Sixth Reporting Period, which was targeted to the formalisation of GREENOMED Living Lab by all the partner regions.

The underlying idea is that the establishment of Living Labs will drive the implementation of the cooperation methodology as well, being one of the tangible outputs stemming from the successful implementation of it. In particular, Living Labs can constitute physical environment where research and innovation actions are promoted and realised by the companies in the community. Moreover, establishing cooperation with Living Labs in the other region can promote the creation of a network of connected facilities where it is possible to find up to date technologies and test them for the upscale. Last but not least, Living Lab can be considered assets for the Pilot Plants projects in the framework of Green Manufacturing, targeted by GREENOMED project.

The following report is divided in two parts. In the first one, an overview of the activities planned at project level for Living Lab establishment and development is presented. Then the second part includes the actions implemented during the sixth reporting period by all the GREENOMED partners and their match with the original plan. Then, in the appendixes, the descriptions of Living Labs identified in the different regions are presented according to a common scheme.

## 2 Description of the activities planned

The activities related to Living Labs within A2.2 started in RP1 with the planning of the different phases to be carried out in throughout the duration of the project to achieve the target results. The planning, represented in **Figure 1**, has been implemented since the beginning of the project and it is proceeding with no major changes with respect to the original scheduling. The extension of the project allowed partners to have more time for the development and formalisation of those strategic assets.

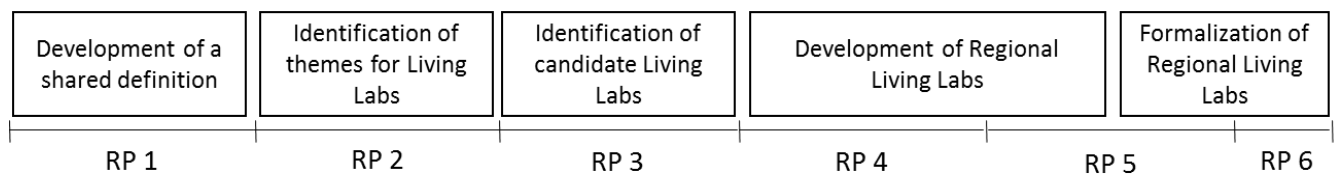


Figure 1. Activities planning for D2.2.2: Living Labs

The first and the second reports, provided at the end of RP1 and RP2, illustrated the actions and the results of the initial phases. Indeed, after a first analysis on the concept of living labs and the creation of a common understating on the topic and the activities to be carried out, partners worked on the identification of target topics to be addressed, matching the objectives and the focus of the project with regional priorities and already existing infrastructures. Then during RP3, besides continuing the analysis of the topics of interest to be addressed, activities were mainly directed to the identification of candidate living labs active in the field(s) of interest. This task was easier for partners experienced in Vanguard Initiative (STIIMA-CNR, AFIL and EURECAT), while the process required more time for the other partners. Indeed, while in Lombardy and Catalonia a consolidated network of facilities and infrastructures supporting the implementation of regional pilot plant nodes were already identified within the Vanguard context, in the other regions partners had to start the process from scratch with the support of the stakeholders map tool provided by GREENOMED and with the support of experienced partners who guided the identification of candidate living labs, meeting the features and the requirements previously outlined and, at the same time, matching the regional priorities and the key topics identified in the context of testing activities for the development of a regional pilot plant. Then, during RP4, partners continued the analysis of candidate Living Labs and started the selection of the most promising and interested to GREENOMED activities and committed toward the inclusion in an interregional open innovation networks of Living Labs. At the end of RP4 and during RP5, partners organised Living Lab dedicated events with the intent to connect the Living Labs to the stakeholders active in the regional working groups. Some of these events had an interregional scope and were aimed at connecting the infrastructures in different regions according to their focus not limiting the collaboration to the regional working group. During RP6, Living Lab were clearly identified and committed in all the regions involved, representing strategic stakeholders for the

orchestration and consolidation of regional Working Groups, in which Living Labs were involved too.

Summarizing all this, the actions implemented in the sixth Reporting Period were:

- Lombardy and Catalonia continued their coaching actions supporting other partners in the formalisation of Living Labs and in the organisation of the dedicated meeting.
- Description of the Living Labs are constantly updated according to the progresses achieved
- Additional regional Living Lab events have been organised by testing partners mobilising the stakeholders participating in regional working groups. Coaching partners supported physically or virtually the development of these meetings to present GREENOMED methodology and/or the context of Vanguard Initiative
- An interregional Living Lab event was organised again by EURECAT at the premises of Cerdanyola Pilot Plant, involving GREENOMED partners interested in the “Functional polymers products” demo-case connecting them with the Vanguard network.

## ***2.1 Progress of activity according to the original plan***

The actions programmed within the GREENOMED consortium for the development of Living Labs are taking place in 5 main phases (**Figure 1**) : i) development of a shared definition; ii) identification of themes for living labs; iii) identification of candidate living labs; iv) development of regional living labs; v) formalization of regional living labs. As already mentioned in the previous reports, the activities related to GREENOMED Living Labs started earlier than what was planned in the Application Form due to the need of a shared definition of living labs, agreed by all partners and aligned with the concept of living labs at horizontal and programme levels. Thanks to the project extension, in RP6 it was possible to dedicate more time in reinforcing connection at regional level among stakeholders and Living Lab within working group actions but there was also the opportunity to work more on the capitalisation of the collaborations established.

In the following paragraphs, a summary of the activities previously reported is provided and complemented with an overview of the actions carried out in the third reporting period.

### **2.1.1 Reporting Period 1**

The preliminary activities to define “Living Labs” in GREENOMED was initiated at the beginning of the project through initial discussions among partners on the role of living labs in the context of GREENOMED. Upon collecting comments during the Kick-Off Meeting about their definition, a literature review started to identify different explanations within state-of-the art. Based on the results of literature review, a first draft for the definition of living labs was prepared by adapting the existing definitions with characteristics and requirements of GREENOMED project. The first draft was mainly developed by the partners involved in Vanguard initiative due to their experience of pilot plants and living



labs. This draft was shared and presented among all partners during the second communication meeting on 15<sup>th</sup> May 2017. Partners studied the document and provided the task leader with their comments. Based on received comments, a second draft was prepared focusing on definition of living labs and clarifying the difference between living labs and pilot plants. The final version was then elaborated and included in the first progress report of this deliverable.

### 2.1.2 Reporting Period 2

During the second reporting period, activities were mainly directed toward: 1) final consolidation of the concept of living labs 2) Identification of preliminary topics for living labs.

Regarding the first point, partners consolidated the definition of Living Lab included in the first report of D2.2.2. In particular, during the third communication meeting, a presentation was held and all agreed on the proposed definition. During the same meeting, discussions were raised regarding the potential topics of the living labs and the approach toward the identification of the potential living labs in regions was introduced. It was agreed that in the initial phase the topics should be quite wide-ranged (however always in the context of green manufacturing) in order to enable partners to map all relevant living labs. Thereafter, in the following phases filters are used to provide more detailed topics and thus prepare a shortlist of candidate living labs. At this stage partners considered the alignment of potential living labs with green manufacturing context and some sub-areas such as remanufacturing and recycling, advanced surfacing materials and energy efficiency.

### 2.1.3 Reporting Period 3

Reporting period 3 has been characterized by the fine tuning of the themes and the topics proposed in the previous period, since activities were carried out in parallel with testing activities. Each region initiated the activity of identification of potential living labs aligned with the themes and sub-topics that they were focusing on in testing activities. Accordingly, the initial list of potential living lab was turned into a short list of candidates for GREENOMED Living Labs dealing with “key topics for pilot plants” defined during the implementation of the cooperation methodology in A3.3. These targeted Living Labs will be the focus of the activities in the following reporting periods, which aim at developing the regional infrastructure and formalizing the integration of the living labs in the regional context with a possible evolution or upgrade toward a pilot plant.

### 2.1.4 Reporting Period 4

Considering their initial status and their different experience in the framework of Vanguard Initiative, partners are implementing activities related to Living Labs in a different way and in different timeframe. Accordingly, also in RP4 partners implemented slightly different activities.

- **Lombardy and Catalonia**, due to their experience in the framework of Vanguard Initiative, had already defined topics aligned with their regional S3 and accordingly they had identified local laboratories and infrastructures focusing on the interests

topics and capable of supporting the development of a pilot plant. These regions (and their partners), on the basis of the interest topics will be the reference for the other partners developing regional innovation ecosystem acting as a model as well as a contact to foster and stimulate interregional collaboration among the stakeholders involved. In particular, in RP4 Lombardy organised an interregional Living Lab events on the 28<sup>th</sup> June 2018 at “De-Manufacturing of Mechatronics” plant venue. GREENOMED partners and some of their stakeholders participated to the event taking the opportunity of receiving a concrete example of Living Labs structure and activities, as well as an overview of the collaborations established with different types of stakeholder at regional and interregional level.

### **“De-Manufacturing of Mechatronics” Pilot Plant of CNR-STIIMA**

*It was inaugurated in June 2013 and was developed in the framework of the Vanguard Initiative – New Growth Through Smart Specialisation. Within the Pilot, research activity is addressed to the development of modular low cost technological solutions, exploiting optimal human-machine cooperation, capable of processing heterogeneous products with a limited hardware and software reconfiguration effort, while self-adapting to the context variations. Furthermore, new Design for De-Manufacturing paradigms and new De-Manufacturing business models are also tackled.*

*Within the De-Manufacturing Pilot Plant, new technologies have been developed and integrated for repair, remanufacturing/upgrade, component re-use and materials recycling purpose. Specifically, the De-Manufacturing Pilot Plant represents a fully automated, modular and reconfigurable solution involving integrated PCB analysis, rework, testing, disassembly, shredding and mechanical separation technologies. A further key aspect of the pilot plant is the integration of testing and de-welding, as important pre-treatment for effective subsequent shredding and separation stages.*

*The De-Manufacturing Pilot Plant is structured in three main cells: PCB sorting and disassembly cell, PCB analysis repair and testing cell, PCB material recycling cell. Besides demonstration and research activities, the overall pilot plant has been conceived to support also training activities, representing an ideal framework for advanced factory technologies learning. The pilot plant will be a unique example in Europe of a fully integrated automated plant for EOL PCBs management. It will support the training of new high-skilled workers with advanced competences in a disciplinary area that, beyond being fundamental for future sustainability, can potentially represent a distinctive success factor for national and European industry. The de-manufacturing pilot plant of STIIMA is considered as one of the central hubs of living labs in GREENOMED project for efficient and sustainable manufacturing. Partners who target industrial waste de and re-manufacturing as a potential topic for the living lab in their region, can start the first steps of integration their regional living lab to the network of GREENOMED living labs by setting up links with STIIMA pilot plant. In particular joint visits can be organized, the regional stakeholders in Lombardy dealing with the pilot plant can have joint meetings with other regions’ stakeholders who are working or are interested in the similar topic and thus the new living lab can be integrated to GREENOMED network of living labs.*

- **Auvergne Rhone Alpes** leveraging on a consolidated regional ecosystem and a previous approach to Vanguard Initiative, it had already clearly identified the topic of interest and the framework in which to develop the activities related to GREENOMED project. Indeed, while focusing testing activities on smart materials, in particular on Smart Plastics, Plastipolis identified a list of potential living labs in that context succeeding in the selection of the candidate GREENOMED Living Lab by the end of the RP3. During RP4, a regional event was organised by Plastipolis at Ampere Living Lab and they are planning an interregional LL event that will be organised in Lyon during RP5 at the end of January 2019. In this events, all GREENOMED partners will invite the identified Living Labs to start fostering the interregional collaboration among them.
- **Croatia:** CIE and CEE made relevant progresses in the identification of Living Labs selecting among the candidates two organisations that ensured their commitment toward the project activities and their engagement in the GREENOMED Living Labs network. In particular, as it will be extensively reported in the Annex, the Living Labs identified respectively by CIE and CEE are Veski and the Faculty of Geotechnical Engineering of Zagreb University working on the topics of energy efficiency and circular economy. It is also important to highlight that CIE supported the organisation of a regional Living Lab event at Veski on the 21<sup>st</sup> December 2018 during which regional stakeholders participated and also the coaching partners STIIMA-CNR and AFIL supported the event virtually introducing the concept and activities related to Living Labs. In addition, Veski representatives participated to the First Political Event organised in Brussels in December presenting their activities and services and remarking the interest in being involved in GREENOMED network.

For the upcoming period, CIE and CCE will continue the collaboration with these two Living Labs involving them in the relevant projects' events (i.e. Testing Seminar planned in January 2019 in Lyon and Second GREENOMED conference planned in April 2019 in Barcelona). Moreover, CEE promoted the organisation of a regional Living Lab event that will be held on the 8<sup>th</sup> April 2019 at Faculty of Geotechnical Engineering.

- **Marche,** after having identified the list of potential Living Labs in the region, started the process of regional Living Lab definition focusing on one of the candid VC ate identified during the previous reporting periods: MECCANO. Besides the update of Meccano description, reported in the annex, the collaboration has been intensified and ACMM is going to involve MECCANO representatives in relevant interregional events that will be organised by the consortium in RP5. In addition, at regional level ACMM will support the organisation of a regional Living Lab events at MECCANO premises with the involvement of the regional stakeholders active in working groups.

- **Slovenia:** PTP and TPLj continued their effort toward the identified LLs to increase their commitment toward the project activities and involve them in the Living Lab network. In particular, during RP5 TPLj will organise a regional event for the opening of their Living Lab that will be held on the 21<sup>st</sup> March 2019. In parallel, to increase the participation of this stakeholders at interregional level and support them in establishing collaborations with the stakeholders of other regions, they will be invited to participate at Lyon Testing Event in January 2019 and to the Second Conference in Barcelona in April 2019.
- **Central Macedonia** is still working on the identification of candidate Living Labs and to strengthen the relationships with them as well as their involvement in GREENOMED Living Lab network. In particular, they are focusing on the topic of BIOMASS-Residuals (connected to testing activities) with the related LL hosted by i-BEC and exploiting connections with the University.

### 2.1.5 Reporting Period 5

During RP5 all the partners continued the interaction with their Living Lab with the aim to formalise the relationship established. Moreover, with the intent to enlarge the scope of the collaboration, Living Labs meetings were organised at interregional level with the aim to favour connection among facilities located in other regions.

- **Auvergne Rhone-Alpes** having already consolidated the collaboration with its Living Lab and formalised its connection with the regional working group, focused all the effort on internationalisation effort to establish relationship with the Living Labs operating in other Regions. Accordingly, the first interregional Living Lab meeting was organised in parallel with the Testing Seminar held in Lyon on the 29<sup>th</sup>-30<sup>th</sup> January 2019. The session dedicated to Living Lab gave the opportunity to discuss about the creation of the Living Lab, their technological expertise, their interactions with regional companies and public authorities. Moreover, Ampere Lab has opened its door to GREENOMED partners and their stakeholders, among which there were also representatives of other Living Labs. In addition, in April, a representative of Ampere Lab was invited to attend the Second GREENOMED Conference. This was the occasion to exchange ideas and competences on the topic of “Smart Plastics” with stakeholders from other regions during the dedicated thematic session, as well as to visit the Catalan Living Lab located in Cerdanyola.
- **Croatia:** CIE and CEE continued their actions toward the formalisation of their Living Labs organising a series of events at regional an interregional level aimed at increasing awareness on laboratories activities and thus favouring the interactions among the Living Labs and the stakeholders.

On 8<sup>th</sup> of April 2019, CEE supported the organisation of the Living Lab Open Day, held in Varaždin during which the university laboratory was presented to business and academic community. On that occasion the long term cooperation agreement in professional, scientific, research, development and educational projects between the Croatian Chamber of Economy –Varaždin and the Geotechnical Faculty in Varaždin was signed by Dragutin Gložinić, President of the CCE – Varaždin and

prof. dr. Ranko Biondić, Dean of the Geotechnical Faculty. A 2<sup>nd</sup> event was organised on the 13<sup>th</sup> of April 2019 with an interregional scope, where the Geotechnical Faculty Lab was presented during the conference “Smart solutions for Growth and Jobs”.

CIE worked on the inclusion of an additional Living Lab in its network and successfully involved FER LARES in GREENOMED activities. During the last month of RP5, CIE started the planning of the 2<sup>nd</sup> Living Lab event that will be targeted to the presentation of FER LARES lab to the group of stakeholders. The event will be organised in July 2019 and it will be opened also to partners and stakeholders from other regions.

- **Marche:** ACMM selected, during this reporting period, laboratory of Università Politecnica delle Marche as Living Lab, since their activities are completely aligned with the topics developed within the framework of GREENOMED project and it showed the willingness to cooperate with the companies involved in the working group. On the 10<sup>th</sup> of May, a regional event dedicated to the Living Lab was organised, inviting companies from the working group and other local SMEs to visit the University's laboratory dealing with composite materials. On this occasion, companies had the opportunity to understand which technologies are applied to realize testing activities and no- destructive checks on composite materials. Moreover, some internationalisation actions have been promoted in the framework of Living Lab, since representatives from Marche Living Lab was invited to attend the Testing Seminar in Lyon and the 2<sup>nd</sup> GREENOMED Conference in Barcelona, where they have the opportunity both to visit other facilities connected to the network of GREENOMED Living Lab and to meet other Living Lab representatives to share ideas and establish synergic relationships. Indeed, leveraging on the
- **Slovenia:** TPLj and PTP worked on the consolidation and reinforcement of the relationships established with the Living Lab selected. As anticipated in the previous report, TPLj organised a regional Living Lab event on the 21<sup>st</sup> of March 2019 at “Look Around 360” TPLj lab, discussing the use of green technologies in manufacturing have been presented to a wide audience (focus on VR and AR technologies). For what concern the internationalisation activities, TPLj invited a representative of TECOS to attend both Testing Seminar in Lyon and the 2<sup>nd</sup> GREENOMED Conference in Barcelona. These events were the occasion for TECOS to meet and exchange with Living Labs from other regions.
- **Central Macedonia** relevant progresses have been achieved in RP5 by iBEC, who identified its Living Lab and started to connect it with the regional working groups. Green living is actually a symbiotic network of different labs of the Region conducting research in the field of exploitation of agro-residues. Green living lab aspires to become a specialized local point of applied research in the domain of exploitation of secondary agro-residues, which is one of the most demanding fields of activities in the Region of Central Macedonia. On 28<sup>th</sup> of June, i-BEC organized at its premises the first GREENOMED living lab event in the Region of Central Macedonia, which was dedicated to the SMEs involved in the regional Working Groups, who had the opportunity to visit the Living Lab dealing with chemical



analyses of biomass as well as with microalgae cultivation in different polluted growth mediums.

### 2.1.6 Reporting Period 6

During RP6, GREENOMED partners consolidated the relationship with the identified Living Labs during meeting and events. Thanks to the project extension it was also possible to work on interregional collaborations among Living Labs establishing fruitful connection that will continue beyond the project. Considering that not all the partners had the opportunity to go through all the steps of the methodology during the project lifetime, actions targeted that may involve Living Labs, such as Pilot Plant design and Pilot Plant business planning, will be realised beyond the project duration.

- **Auvergne Rhone-Alpes:** Plastipolis established a fruitful collaboration with Ampere Lab since the beginning of Living Lab activities in the framework of GREENOMED. Accordingly, the laboratory has been well integrated in the regional working group activities exploiting mutual benefits and it was also involved in interregional collaboration organising targeted events. Thanks to the progresses achieved by Plastipolis in the implementation of the GREENOMED methodology, the Ampere Lab is also participating to the elaboration of business plan for the use case identified by the WG. This business plan will also be defined in an interregional dimension in the framework of Vanguard activities and in order to achieve this goal Plastipolis continued to attend dedicated meetings. The last one was held at the premises of EURECAT Pilot Plant in Cerdanyola, which is also a GREENOMED Living Lab.
- **Croatia:** CIE and CEE continued their actions toward the formalisation of their Living Labs organising a series of events at regional and interregional level aimed at increasing awareness on laboratories activities and thus favouring the interactions among the Living Labs and the stakeholders.

CCE- Varaždin County Chamber organized the 2<sup>nd</sup> Living Lab event "Smart Solutions for Growth and Jobs" on June 13<sup>th</sup> for the representatives of business sector, support entrepreneurial institutions and universities. The aim of the conference was to encourage innovative entrepreneurs to integrate into the European value chain networks through infrastructure investment and capacity building, technology transfer, R&D, to improve existing and create new products and services, to make profit and create new jobs with high added value within the sectors related to the priorities of the Smart Specialization Strategy. In particular, the Greenomed Living Lab established at the Faculty of Geotechnical Engineering in Varaždin was introduced as a place where entrepreneurs can address the real technological needs and problems and try to find solutions in collaboration with other companies and research organizations in partners regions. Although this event was formally held in RP5, costs and activities have been reported in RP6.

CIE organized the 2<sup>nd</sup> Living lab event in Zagreb on July 11<sup>th</sup> at Laboratory for Renewable Energy Systems (LARES) of University of Zagreb, Faculty of Electrical Engineering and Computing. Participants were taken on a tour of laboratory included in the network of GREENOMED Living Lab. The visit was followed by a

round table discussion at CCE premises, discussing about the Croatian possibilities and business climate in the topic of energy efficiency.

- **Marche:** After the formalisation of laboratory of Università Politecnica delle Marche as GREENOMED Living Lab, ACMM continued the collaboration with the laboratory involving its representatives in strategic events both at regional and interregional level. In particular, reflecting on potential partnerships that could be established beyond GREENOMED project, Lombardy “De and Remanufacturing Plant” and Croatian laboratory at University of Varaždin have been identified as the most synergic for Circular Economy applications.
- **Slovenia:** TPLj focused its activities on the development of Living Labs “AR/VR/XR” Living Lab owned by Technology park Ljubljana as well as TECOS (Slovenian tool cluster company) living lab. While TPLJ Lab, named Look Around 360, started operating in March 2019 and is considered the largest state of the art AR/VR/XR Laboratory in Slovenia, the latter laboratory is targeting remanufacturing of plastics.

PTP continued its action toward IOS Living Lab, capitalising its involvement and role within SRIP Circular economy and its demo-plant. In line with the focus of testing activities, PTP also started the identification of key actors in the framework of Food Manufacturing and Biogas production through algae. Although interest and opportunities in these topics emerged at the end of the project, activities will continue beyond GREENOMED lifetime thanks to the collaborations established with Greek partners, in the area of Bioeconomy, and Catalonia, Lombardy and Auvergne Rhone Alpes in the framework of Food Manufacturing.

- **Central Macedonia** after the formalisation of GREEN Living Lab during RP5, a Living Lab event opened also to interregional stakeholders was organised on the 16<sup>th</sup> of October. In particular, i-BEC organized a visit to one of the cooperating lab of the GREEN Living lab, the Lab of General & Inorganic Chemical Technology of School of Chemistry of Aristotle University of Thessaloniki (Nanomaterials and Chemical Processes Group) during which representatives of regional SMEs had the opportunity to get informed about the activities of the lab linked with the analysis and exploitation of agro-based residuals.

Summarising the results and progresses achieved during these RPs, it emerged that partners implemented activities proposed in different ways mainly due to the background context in which partners and Living Lab are operating. To cope with punctual barriers and challenges, partners have been supported bilaterally by Lombardy and Catalonia on the basis of their previous experience, succeeding in completing the plan envisaged for the creation of Living Lab network and aligning Living Lab activities with actions carried out in Testing Activities.

A complete overview of potential Living Labs identified is reported in Annex I, with the complete list of infrastructures in each region. Then, on the basis of the detailed descriptions of these infrastructures and related activities provided in the previous report, partners updated the information on the basis of the scheme summarized in Table 1.

Table 1. Structure of the Living Lab template

<b>Idea of Living Lab</b>	Briefly describe the context in which the living lab candidate operates and the field/thematic domain addressed
<b>Relevance</b>	Motivate why the living lab candidate is relevant in the framework of GREENOMED project and how it can be linked to the topic of Green Manufacturing
<b>Level of infrastructure</b>	Describe the level of infrastructure in the lab. If there is no infrastructure or there is partially some infrastructure
<b>Technologies and TRL</b>	In case of existence of infrastructure, describe the set of technologies addressed by the living lab and their TRL.
<b>Services</b>	Describe the services provided by the candidate living lab and the activities implemented (i.e. R&I, product development, testing, etc. for labs with infrastructure) and (i.e. community building, training, etc. for labs without technological infrastructure).
<b>Stakeholders</b>	Please describe the stakeholder/s who own and operate the lab. Please also refer to the regional stakeholders who have access the facilities (companies, Research Organisations, Universities, ...).
<b>Possible development linked with Greenomed activities</b>	<p>Describe the possible development foreseen for the living lab with the support of Greenomed community and related activities. In case the technological infrastructure of the lab provides an opportunity of further improvement, explain why and how the status quo of the living lab can be improved, or even how it can be supported in the evolution toward a pilot plant.</p> <p>In case, a technological infrastructure doesn't exist, please describe how the lab could be used as a meeting point for different regional stakeholders and to build regional community to boost innovation for green manufacturing.</p> <p>Please clearly indicate the activities related to Greenomed project (i.e. events, matchmaking useful for learning from other example) as well as other funding sources (regional, national or European) that can serve for the improvement of the infrastructure.</p>

It is also important to highlight that partners from the same region are not always focusing on shared topics and so they are implementing testing activities independently, focusing on the needs and priorities of their stakeholders. Accordingly, the list of Living Labs and the candidates selected by Slovenia and Croatia are in the field of green manufacturing, but they are focusing on the different sub-topics selected by the partners. Finally, the complete description of the selected GREENOMED Living Lab is reported in **Annex II**.



## Annex I – Complete list of candidate Living Labs

REGION	Name of the Facility	Owner of the facility	Type of owner	Status of the Contact	Actual Use / Functionality	Type of Governance
Auvergne-Rhône-Alpes	IPC	IPC	Research Centre	Stakeholder contacted, and interested	Testing and qualification of products/processes	Public-Private-Partnership
	Ampere Laboratory	University of Lyon	University	Stakeholder is active in a group	Testing and qualification of products/processes	Public-Private-Partnership
Marche	No-destructive checks on composite material testing laboratory	Università Politecnica delle Marche	University	Stakeholder contacted, and interested	Testing and qualification of products/processes	Public
	COSMOB	Research Centre	Research Centre	Stakeholder has been only identified	Testing and qualification of products/processes	Public-Private-Partnership
	MECCANO	Research Centre	Research Centre	Stakeholder has been only identified	Testing and qualification of products/processes	Public-Private-Partnership
	DIH	Confartigianato	Consultancy	Stakeholder has been only identified	Training	Public
	DIH: Innovation Box	CNA	Consultancy	Stakeholder has been only identified	Training	Public
	DIH	Confindustria	Consultancy	Stakeholder has been only identified	Training	Public
	Green Future Academy	Diasen	Consultancy	Stakeholder has been only identified	Technology Development and demonstration	Private
Croatia	FESB - Fakultet elektrotehnike, strojarstva i brodogradnje Split	University of Zagreb	University	Stakeholder contacted, and interested	Technology Development and demonstration	Public
	FER - Fakultet elektrotehnike i računarstva Zagreb	University of Zagreb	University	Stakeholder contacted, and interested	Technology Development and demonstration	Public
	VESKI d.o.o.	SME	SMEs	Stakeholder is active in a group	Technology Development and demonstration	Private

	<b>Faculty of Geotechnical Engineering</b>	University	University	Stakeholder is active in a group	Identification of new technologies	Public
Slovenia	<b>Look Around 360</b>	TP LJ (Technology Park Ljubljana)	System Integrator	Stakeholder is active in a group	Technology Development and demonstration	Public-Private-Partnership
	-	TECOS (Applied Industrial R&D)	Research Centre	Stakeholder is active in a group	Technology Development and demonstration	Private
	<b>LASIM Laboratory</b>	Faculty of mechanical engineering, University of Ljubljana	University	Stakeholder is active in a group	Technology Development and demonstration	Public
	-	IJS (Institute Joze Stefan Ljubljana)	Research Centre	Stakeholder is active in a group	Technology Development and demonstration	Public
	-	FE UNI LJ (Faculty of Electrical Engineering)	University	Stakeholder has been only identified	Technology Development and demonstration	Public
	-	PTP (Technology Park Pomurje)	System Integrator	Stakeholder is active in a group	Identification of new technologies	Public-Private-Partnership
	-	FERI UMB	University	Stakeholder has been only identified	Technology Development and demonstration	Public
	-	UNIMB	University	Stakeholder has been only identified	Technology Development and demonstration	Public
	<b>AlgEn</b>	KO-TO	SME	Stakeholder has been only identified	Technology Development and demonstration	Private
	<b>IOS</b>	IOS	SME	Stakeholder is active in a group	Technology Development and demonstration	Private
	<b>Laboratory for Oliveculture</b>	Science and Research Centre Koper	Research Center	Stakeholder has been only identified		Public
Region Central Macedonia	<b>Nanomaterials and Chemical process</b>	School of Chemistry, AUTH University	University	Stakeholder is active in a group	Technology Development and demonstration	Public
	<b>Environmental Studies</b>	i-BEC	University	Stakeholder is active in a group	Environmental studies- Chemical analyses	Public

## **Annex II - GREENOMED Living Labs descriptions**

### **Partner: Plastipolis – Auvergne Rhone Alpes**

#### **Living Lab: The Ampere Lab - Plastronics**

##### **Idea of living lab**

The Ampere Lab is part of Lyon University (UMR 5005 – CNRS, INSA, UCBL, ECL) and its domains are: electrical energy, bioengineering, methods for engineering systems and bioelectromagnetism and microsystems. It gathers 180 people. One of its research platform concerns electric engineering for 3D plastronics, interface with plastics industry, global methodology of design, practical approach and innovative applications. Plastipolis has defined this platform as a potential living lab for GREENOMED. The Ampere Lab goals relies on connection between academic and economic stakeholders to develop training programs, industrial projects, scientific collaboration, products design, manufacturing and characterization. Different methods are used by the Ampere Lab: bi-injection, in-mould labelling, hot embossing, laser or plasma removal, spray or ink spurt printing and micro-stamping..

##### **Relevance**

Plastronics is the link between plastics industry and electronics. The technology relies on electronics engraving on a plastics substratum. The advantages of plastronics are to produce more compact and less sizeable products, and to reduce the number of integrated components in order to produce lighter items. Consequently, plastronics is related to green manufacturing by using less electronics components and also producing more flexible, thinner and lighter products.

##### **Level of infrastructure**

During summer 2018, the Ampere Lab installed all tools which are available for testing and training from September 2018. Infrastructure is located at INSA Lyon, 100% public institution. INSA Lyon is the owner of the infrastructure but some equipments are owned by other public institutions like the Fondation pour l'Université de Lyon (FUdL), Université Claude Bernard Lyon 1 and CNRS.

Some partner companies are supporting indirectly the infrastructure through the specific cursus on plastronics. The Fondation pour l'Université de Lyon (FUdL) collects money from industry partners, as sponsoring to the specific cursus and the largest part of this budget is invested in the infrastructure.

Industry partners (sponsors of FUdL) do not decide about the infrastructure development but they are invited to give opinions and advices. Direct investment in the infrastructure is possible but industry partners generally prefer supporting or participating to a project program that carries a budget for investment (local, regional, national, EU).

### ***Technologies and TRL***

- Prototyping of plastronics devices : metallization of 3D printed parts, soldering of Surface Mount Devices...
- Design and test of plastronics devices with scalable technology in cooperation with industrial partners (Laser Direct Structuring, In Mold Electronics, Ink Jet Printing, Pad Printing...)
- Access to innovative manufacturing technologies (ex : 3D Microcontact Printing, 3D Laser Micromachining...)

As a research lab, Ampere is meant to investigate advanced processes and techniques. TRL is generally low: i.e. TRL2-TRL3 with validated demonstrators.

Some processes and techniques are available with TRL over 6 but these are not the subject of research actions: they participate to the engineering of demonstrators.

### ***Services***

The Ampere Lab goals relies on connection between academic and economic stakeholders to develop training programs, industrial projects, scientific collaboration, products design, manufacturing and characterization.

Targeted users:

- Companies directly involved in Plastronics : S2P, Sintex, Faurecia, Schneider... (we can help as the technology is not mature)
- Companies and end users interested but not (yet) competent in the field : automotive, aerospace, electrical household appliances, medical applications (including start up companies), medium size companies in polymer processing...
- Suppliers : polymers, conductive inks, 3D printing business (machines and materials)
- Research Labs : IMP(Polymers), CREATIS (IRM Applications...)

### **Higher Level Education :**

- **Master 2 at INSA and CPE** (with industrial projects) at the Living Lab cofinanced by the French State and private fundings (Fondation Dassault Systèmes, Plastic Omnium, SEB/CALOR, Sintex, Cirly, etc.)
- Multidisciplinary courses (material science, electronics, polymer processing, mechanics)for students with different backgrounds
- Practical work, including 2 months industrial project during Semester 1
- 4-6 months internship during Semester 2

- **PhD at European Level** : SIMEC project submitted (DTU, KUL, INSA...)

### **Stakeholders**

The Living Lab is owned by Supervisory authorities ( mainly CNRS, INSA Lyon, UCBL) with public fundings.

Some equipment for teaching are owned by the Fondation pour l'Université de Lyon (mix of private and and public fundings) but there is a contract with the Living Lab.

The Ampere Lab provides technologies to students, scientific doctors for their research programs, universities which own administrative supervision, other universities and companies. The team associated to the living-lab is the interlocutor for any stakeholder or user of the living-lab. Interactions are supposed to be direct, reactive and dedicated to the projects at hand.

The living-lab as the overall platform is under the supervision of Philippe Lombard. P. Lombard will be in charge of coordinating the activities in the living-lab and regulate the access of users, according to the availability of the equipments or the coherence of equipment usage among projects.

Access to the living-lab infrastructure is open but submitted to an approval. The approval is mainly technical and scientific: an access is related to a project and the project enables the analysis of the pertinence of a direct access. The approval is related to security and competence in a second step: a practical user of the equipments must prove his abilities and a security clearance applies.

### **Possible development linked with Greenomed activities**

As a provider of advanced technologies, the Ampere Lab, part of Lyon University, is one of its research platforms concerning electric engineering for 3D plastronics. Hosting a plastronics master degree diplom, the Ampere lab provides training for students, but also development for companies projects. The Greenomed community may have different impacts on the lab:

- Increasing technological collaboration between the Ampere lab and Greenomed community activities
- Developing communication within the Greenomed community
- Recruiting students or companies to make them involved in collaborative innovation projects
- Welcoming Greenomed community delegation

Further technological improvement may make more companies involved in the Ampere Lab, for example design or recycling processes related to 3D plastronics. According to plasturgy strategy to decrease or to add value to industry waste, the Ampere Lab may expand their activities to circular economy which requires other skills from Greenomed

partners. The development of new activities may be associated to “The City of Plastronics” project in Oyonnax, as an innovation technology platform. Consequently, Greenomed community is able to support the living lab progression, through welcoming foreign delegation and face to face business meetings. It can also be interesting to visit Greenomed partners living lab to exchange about their future strategies and to set up advanced technology partnerships.

On January 30<sup>th</sup> 2019, Plastipolis organised a visit of the living lab in connection with the testing seminar in Lyon. It was the first transregional event regarding living lab projects. The visit gave the opportunity for Greenomed community members and some external partners to discuss about the creation of the living lab, their technological expertise, their interactions with regional companies and public authorities, and development objectives. During the visit, discussions between partners and living labs started which may open to transregional collaboration.

Additional funding sources are required to develop the living lab tools and human resources. European, national and regional funding may be necessary to increase the technological machines stock and regional funding is required to hire an employee to organise the laboratory visit, technology and business meetings and communication strategy.

Additional equipment of the living lab are taken into account in the writing of the business plan and the sector analysis which will be finalised by mid of February 2020. These equipment are analysed and planned in order to answer to regional stakeholders needs in the next 5 years.

## **Partner: Croatian Chamber of Economy - Croatia**

### **Living Lab –RES IN FOOD PRODUCTION (Varaždin)**

#### **Idea of living lab**

##### ***Low energy greenhouses***

The idea is to create, on the same agrarian surface, a dual-purpose plant in which vegetable enjoys lightly shaded space, as well as the production of solar energy at the same time. Dual purpose plant use natural sun energy for the growth and production of plant varieties which planting can partially be limited in those areas where a possibility of damage exists (affray, frost). Produced energy of solar plant exceeds the needs of energy for irrigation and ecological cultivation and cooling.

Conversion of electrical into thermal energy is possible in multiple ways. The goal is to choose the most effective one. The challenge which is being faced is how to do this in an efficient manner and to store energy while doing so.

##### ***Automatic sun stations for irrigation***

Rational irrigation of plants has a positive effect on their growth and increase in yield. Sun emission can be used for the production of electrical energy sufficient for the drive of a highly-efficient, programmed and controlled pump irrigation system. The energy has to be ecological and sustainable, safe and adjusted to irrigation needs. According to the size of the irrigation area and the type of crops the necessary amount of water can be calculated (m<sup>3</sup>/hour), type of pump can be identified and concept of automatic, programmed irrigation, on-line control and data management implemented. The concept is based on the premises of no connection to communal infrastructure and public network, maximum energy and investment cost reduction with general contribution to the lowering of CO<sub>2</sub> emission and with the possibility of irrigation during summer for a period longer than 16 hours.

#### ***Relevance***

Production of healthy and fresh food for growing population is becoming a global issue. Constant climate changes require production of food under controlled and protected conditions. This type of production is however complex and very expensive.

Production of food in closed conditions and greenhouses requires the use of all available scientific and technical attainments which can be commercially used to build a plant functional to create climate and energy conditions for production of energy and food.

Other problem in agricultural production which can be solved with usage of RES is uncontrolled irrigation. Very often motor pumps are used without possibility of calibration according to the needs of specific crops. The consequences are multiple, ranging from



excessive use of oil derivate to negative effects due to abluton of nutriments, soil erosion, oil and gas pollution etc. The basic problem of irrigation is the lack of water and energy on the cultivation area. Communal infrastructure is limited and getting all the infrastructure to the cultivation grounds is very expensive and non-profitable.

### ***Level of infrastructure***

One pilot plant for joint production of food and energy was realized within the concept of solar power plant (SE) 500kW in Medinci, Croatia. The purpose of the plant is to serve as a pilot project/practicum for students attending Slatina high school, while agro-technical conditions of production would be tested by Agricultural Faculty in Osijek.

Further energy-related research and experience in obtaining sufficient solar energy applicable in production of food and energy was carried on in location in Varaždin ( Working Ltd) with the purpose to create future low-energy greenhouses.

### ***Technologies and TRL***

By coordinating energy needs throughout the whole period of programmed production of plants, optimal construction solution with use of new materials and technologies with photovoltaic production of electrical energy can be created. Further research should be carried out on behalf of specialists, while the implementation of scientific and technological achievements should be directed towards the sustainability of the entire project.

The first enhancement alternative is to cut down the duration of shade and to increase luminance. The width of surfaces used for the cultivation of plants can be increased. This can be achieved with the usage of f-clean foil, both unilateral and bilateral. This type of material has good mechanic characteristics and a longer period of duration (up to 30 years) compared to standard foils and it also has excellent light technology characteristics and UV radiation transmission. Thin-film PV panels can also be placed on the foil which could serve to convert solar irradiance into electrical power. By doing so, roof load will be reduced as well as adjusted to additional snow weight and wind blasts, all according to EU procedures.

The shortages of Mednici plant was noticed during first natural irrigation period. The entire surface was not irrigated equally which would have damaging effects in plant production. However, by collecting rainwater and by programmed irrigation, the shortage can be corrected. The development of the idea as to how to correct the afore-mentioned offers work to different system integrators. Available resource of the plant is electrical energy which is universal in conversion in different forms with greater or lesser energy-efficiency. The biggest contribution is the energy produced ecologically and which is self-sustainable.

Investment and maintenance costs in the phase of building the plant however present a great challenge. Conversion of electrical into thermal energy is possible in multiple ways. The goal is to choose the most effective one. The challenge which is being faced is how to do this in an efficient manner.



### **Services**

- energy related issues for green production
- design of RES optimal models for agricultural production
- cooperation and achievement of synergy with other living labs

### **Stakeholders**

- In initial phase – focus on coordination of interests of different types of stakeholders (SMEs, cluster, R&D institutions, local authorities,..) and setting up of organizational structure

### **Possible development linked with Greenomed activities**

Development of technology in function of raising life standard, demands the production of goods during which large amounts of different fossil fuels are being used the consequences of which are visible with regards to both nature and climate. The necessity to obtain healthy food leads to production in closed environment with a requisite to obtain energy in the most natural way possible.

## **Partner: Croatian Chamber of Economy - Croatia**

### **Living Lab – Circular economy for Green Manufacturing in Varaždin**

#### **Idea of living lab**

The Faculty of Geotechnical Engineering conducts scientific research in the field of technical sciences: environmental engineering, geotechnics and hydrotechnics, mining, petroleum and geological engineering and in the field of natural sciences.

The Faculty wants to be recognized at national level as one of the leading research institutes in the field of environmental engineering, especially those of its segments that are aimed at the identification, design, construction and management of systems for solving problems of air, soil, water and nature pollution, solving the sectorial pressures of noise, light pollution, traffic and providing answers to cross-sectorial challenges.

The Living Lab would be a place where theoretical knowledge, scientific research and practical experience in the field of interdisciplinary technical sciences could be provided by staff of the Faculty that would help the economy, especially the economic subjects in Varaždin County.

The Faculty is also a member of two KIC consortiums – KIC Raw Materials and KIC Climate.

#### ***Relevance***

Circular economy is a concept aligned with concept of adoption of green practices in manufacturing which is in focus of Greenomed project. New circular economy package, presented by European Commission contains an action plan for coming years and we have to take over responsibility on time for potential opportunities and challenges. Joining the concept “Closing the loop” and enabling the realization of regional innovative entrepreneurial projects which aim to improve product design by promoting the reparability, durability and possibilities for upgrading and recycling of products, we will enable systematic transition to the circular economy.

#### ***Level of infrastructure***

There are three laboratories at the Faculty:

- Laboratory for Environmental Engineering,
- Laboratory of environmental geochemistry and
- Geotechnical Laboratory.

From the major capital equipment the Faculty has the luminescence spectrometer Perkin Elmer LS55; analyzer of total organic carbon; atomic absorption spectrometer Perkin Elmer AAnalyst 800 and FIAS 100 for mercury (Hg); ball mill and UV-VIS spectrophotometer, static sCPT Penetrometer, vacuum pyrolysis furnace.

The good equipment of the existing laboratories on the Faculty and equipment for field researches result in scientific projects and teaching, good cooperation with the economy,

which is reflected in a series of studies, elaborations and projects in the field of soil and water protection, water management, waste management, geotechnics and geodesy.

In the recent years, the Laboratory for Environmental Engineering has been developing pilot project for solar photocatalysis for air and wastewater treatment which won two gold medals on international Innovation Fair ARCA 2018 and AgroARCA 2018, held in Zagreb (Croatia).

### ***Technologies and TRL***

In the Living lab the set of technologies that would be addressed are:

- “Closing the Loop” in the recycling process of waste to contribute the circular economy and environmental protection, where waste from one industry becomes raw material in the other industry
  - very good existing cooperation with regional construction company Zagorje Tehnobeton Ltd., authorized entities for waste collection and treatment (Spectra Media Ltd, Flora-VTC Ltd, Čistoća Varaždin, C.I.O.S. MBO, regional centers for waste management (Kaštijun, Biljane Donje), and waste tire recycling facility Gumiimpex GRP Ltd
  - future cooperation with Boxmark Ltd (leather industry), Varteks Ltd (textile industry)
- eco-innovations
- environmental product declarations
- testing and application of new and alternative methods of water and air purification in the semi-industrial scale, including photocatalytic engineering, recognized as the alternative best available technique – cooperation with waste tire recycling facility Gumiimpex GRP Ltd, Varaždin
- research and development of chemical sensors and biosensors for use in the environment, industry and biomedicine, particularly fast and cheap point-of-care for agriculture and agronomy, food industry

### ***Services***

Stakeholders who would work in the living lab are researchers within the faculty, undergraduate and graduate students in scientific work through their thesis, PhD students through their scientific work on gaining the PhD diploma.

Living lab will be open to interested regional business companies, non-governmental organizations and researches from other institutions.

### ***Stakeholders***

The Geotechnical Faculty Varaždin owns and operates the Living Lab and as already stated the research community and business sector are the main potential user of this Living Lab with close cooperation with CCE Varaždin.

### ***Possible development linked with Greenomed activities***

De-and Remanufacturing pilot with its main objective to integrate a multidisciplinary set of advanced and innovative enabling technologies and digital innovations (Technology

Readiness Level -7-8) is adequate frame for realization our aspirations of adoption of the new concept of circular economy in regional ecosystem. Our ultimate goal is to develop and offer services to business community as innovation hub for circular economy and include our producer through Vanguard initiative into international network of competence and technology centers and support innovation to the highest level of production readiness.

## **Partner: Cluster Intelligent Energia – Croatia**

### **Living Lab: VESKI – CoDiS-Lab**

#### **Idea of living lab**

Veski Lab purpose is to introduce the potential interested parties (engineers, students, customers and university professors) with hydro power plant condition monitoring with highlight on plant efficiency.

Live lab consists of several components interlinked together on common platform, our monitoring and diagnostic software CoDiS (Computerized Diagnostic system). CoDiS is a product developed and deployed on over 50 hydro plants (over 100 machines monitored on-line) used for on-line machine condition monitoring (mainly installed on hydro stations). The system continuously monitors and protects hydro machines ensuring increase in *reliability and efficiency*.

CoDiS-Lab (Living lab) has an on-line demo case at our facility consisting of small model of a generator with installed sensors, also consists of centralized CoDiS Server on which all the data is stored permanently. That server also contains all the data from real CoDiS installations all over the world, enabling remote access to all interested parties.

The software also has a capability connecting remotely to live data in those power plants that allowed remote access. This gives our customer direct link to data diagnostics and ensures that machines are monitored by our experts at any given time.

#### **Relevance**

Our Concept allows the same user to be linked to all their monitored assets at one location.

That way, the localized systems in each plant at each generator will perform their reliability function, protecting the asset from failure on individual level. At the same time, all the monitored data can be stored to centralized database, enabling easy access, data analysis and correlation between different plants in order to achieve maximum efficiency in terms of operation and maintenance.

At the same time, our live demo at our facility enables simulation of different faults and machine operation, analysing that data and training the customers on how to use and interpret the data., without interfering with real data from real power plants.

The final goal is to implement prediction analytics, using big data analysis and machine learning (ML).

In last 10 years we have collected the relevant data in large amounts and have actual records of various faults that occurred, which can help us in testing the ML algorithms and fine tune them to recognize similar faults from our database.

### ***Level of infrastructure***

The infrastructure in our lab consists of:

- Demo model of a generator (the Rotor Kit), equipped with various sensors
- Demo CoDiS monitoring hardware – controller with acquisition and relay modules - acquiring, collecting, and analysing the data from the Rotor kit model. This is used to demonstrate the reliability part of our monitoring platform. Also used for internal training of our personnel, as well as our end users
- Centralized CoDiS Server with CoDiS application for data storage, analysis and diagnostics

This server has a backup of databases from real installations, that are being updated remotely on a regular basis (when available and applicable due to cyber-safety regulations). Here we collect and archive all the data that is available to us. The purpose is to provide remote diagnostics to our customers, improving their machine efficiency and reliability of operation.

- Various simulation devices where real faults, recorded on real machines, are being used as inputs to our demo CoDiS system, for training purposes – (HIL – Hardware in the loop).

### ***Technologies and TRL***

- Technologies are implemented and already functioning
- Only technology that is not yet being implemented is the use of machine learning algorithms to predict machine faults and behaviour. This implies big data analysis as well.
- The rest of the lab's infrastructure, described in previous section, is functional.

### ***Services***

Services consist of following:

- Machine real condition monitoring
- Maintenance planning
- Fault prediction
- Increasing Machine/Plant efficiency
- Increase in knowledge about machine behaviour
- Increase in knowledge about machine diagnostics and condition estimate

### ***Stakeholders***

This lab is private, funded by internal Veski resources owned by Veski. However, Veski collaborates with universities and public institutions, some of which are a part of Inteligentna Energija Cluster. All cluster members and members of academic community

(students, professors, researchers etc.) can have the access to our lab and we often exchange our experiences and share our data (with consent of the end user) for research and development purposes. Some of our products are a result of collaboration projects with universities and therefor all the data and knowledge gained through this collaboration is automatically public (papers, presentations, workshops etc.).

### ***Possible development linked with Greenomed activities***

Currently we have sensors, acquisition and real time analysis developed and implemented across numerous plants worldwide. The data is stored and collected and Veski has a lot of valuable information available for machine learning algorithms to be tested and implemented using the same.

Our current technology is tested and proven. Next step is to improve the existing product with big data analysis, machine learning algorithms and common communication platform that enables fast data exchange between different plant parts.

If described technology we have in mind would be applied and used for predictive purposes, a continuous efficiency improvement can be expected, bringing enormous cost savings for plant owners.

That way we can divide the infrastructure in two layers:

1. Plant installed on-line monitoring, analysis and data collection with specialized diagnostic service. IIoT (Industrial Internet of Things) network with multiple measurements - already implemented at the certain level with our CoDiS monitoring platform
2. (Cloud based) Machine learning and big data analysis platform with automated algorithms for behaviour prediction and consequently increased efficiency.

We see following possible improvement of our Living Lab/CoDiS-Lab with support of Greenomed community:

- Application of machine learning and big data analysis on our collected data with the purpose of automating machine fault prediction and improve of machine/plant/fleet operability and efficiency.
- Development of cloud based platform with centralized “brain” that would contain all relevant information, extracted from our current CoDiS platform and filtered using big data analytics.

## **Partner: Cluster Intelligent Energia – Croatia**

### **Living Lab: University of Zagreb Faculty of Electrical Engineering and Computing**

#### **Idea of living lab**

The available living lab consists of renewable energy production, electrical storages and controllable energy consumption to accommodate the resource management and energy flows balancing for various conditions of electricity market prices to achieve the maximum energy efficiency and the minimum cost of operation. The living lab is established with the aim of implementation of various estimation and control algorithms. Research group's knowledge and area of application is comprehensive and range from building thermal behaviour, over electricity market conditions to high understanding of individual system components.

#### ***Relevance***

The living lab at University of Zagreb Faculty of Electrical Engineering and Computing (UNIZGFER) has a sophisticated microgrid with renewable sources, electrical storages and fully automated heating/cooling system. The technologies are all integrated into a single database, open for custom (advanced and predictive) real-time control algorithms for production-consumption balancing with the common goal of cost minimisation. Listed components are placed under a continuous influence of building users in 248 rooms and offices on 13 floors.

The topic of Green Manufacturing of the envisioned GREENOMED project is mainly encompassed through the energy efficiency of production and consumption balancing in the variable and stochastic environment. Since the covered area is very wide, particular applications can be on a high level of resource management, all the way to the low level of particular component observation: e.g. life cycle of electrical machine as a wind turbine generator or different types of power converters.

#### ***Level of infrastructure***

The UNIZGFER skyscraper building comprises the basement, 13 floors (+ the ground floor), and a roof. It is equipped with a two-pipe central heating/cooling system that uses fan coils.

The building utilizes a new advanced central control unit for heating/cooling, which enables data acquisition at the level of the building zones and transfer of the measurements to a central database. Based on these measurements, the control commands for individual fan coils are computed and transferred back through the existing communication network. The key feature is a simple software-based switch, through which one can easily switch



between the old, decentralized, zone-by-zone control and the new advanced control.

Laboratory for Renewable Energy Systems is located on the 13<sup>th</sup> floor and on the building rooftop. It contains a 22.5 kWp photovoltaic system, a 10 kWh VRLA battery setup, an ultracapacitor, and a 2 kW in / 0.5 kW out hydrogen-based storage system, all connected to a 48 V DC bus, tied to a 230 V grid through a 5.5 kW power converter. In addition, there is a 32 kWh Li-Ion battery bank connected to a 230 V bus.

The laboratory setup also includes state-of-the-art equipment for measuring direct, diffuse, global horizontal and reflected solar irradiance, as well as seven different tilted surface solar irradiances relevant for the building and its surroundings. There is also a weather station located on the rooftop for the standard meteorological measurements: temperature, pressure, wind, and relative humidity. Weather data are relevant for zone level (offices) heating/cooling control, central heating/cooling medium preparation (chiller unit efficiency) and microgrid level (renewables production). All weather, weather forecast and energy production data are continuously logged in the laboratory database since 2014, and thus a huge database is at our disposal for different data-based prediction models development and tuning.

Enabled collection of all data from all systems is collected to a single database, which forms a SCADA system, but also enables a real-time central management for energy efficient operation and minimization of costs in the various market conditions. The sampling time of all the variables in the database is 1 min.

All the components are installed and networked, and the database is being filled with values. The advanced energy management approach is currently being implemented and will be fully commissioned and operational by the end of September 2018.

Microgrid components can be found at [http://www.lares.fer.hr/lares/about\\_lares/equipment](http://www.lares.fer.hr/lares/about_lares/equipment) and the overall system described in more details in the additional PDF file attached.

### ***Technologies and TRL***

The renewable sources, storages and power converters are commercial components with additional custom modifications for enabling the scientific approach to the low levels of component management. The rest of the components are regular commercial products. The SCADA system (networked components) and advanced resource management strategy will reach the TRL 6 by the end of September 2018. The technology is currently being replicated to 8 other pilots in of the Danube region through the existing project “3Smart – Smart Building – Smart Grid – Smart City” financed by the Interreg Danube call (where UNIZGFER is the coordinator). Therefore, all the 8 living labs of different configurations will be thoroughly tested, including also the technology replication tests.

### ***Services***

1. Optimal resource management with energy efficiency and cost reduction goals.  
The core technology that distinguish the living lab is an advanced optimisation

algorithm based on model predictive control, added on the established SCADA system. The concept of the building-side energy management system consists of three levels to keep the technological independence and easier implementation. Those are: zone level, central heating, ventilation and air conditioning (HVAC) level and microgrid level. Each of the level is optimally controlled individually as an independent and modular approach, with its own criteria of energy efficiency. Finally, all the levels are coordinated by hierarchical control approach with the common goal of electricity cost reduction. Uncertainty in the system comes from the stochastic weather conditions and arbitrary user behaviour.

Each of the three levels is susceptible to application of various feedback control approaches and for testing of different resource management strategies: individually, in combination of levels or the complete coordination of the system. In addition, each of the components can be considered individually (e.g. optimal charging of batteries or photovoltaics tilt angle).

2. Autonomous adjustment to variable and stochastic living lab conditions.  
Zones are controller individually to accommodate high comfort level for individual users, who can freely adjust their temperature setpoints and the system finds an optimal solution and balances energy flows accordingly. Weather forecast on the other hand dictates the renewable energy production capabilities. Robustness of the optimal control is ensured by: feedback control based on models and sensors measurements, and modelling and estimation of uncertain variables based on their past behaviours on the other side.

Due to the modular approach, the system can be extended to additional zones, microgrid components or the whole new control levels. Therefore, different scenarios and/or configurations can be considered

3. Monitoring and diagnostics method of the various components of the living lab.  
The building incorporates a mesh of temperature sensors placed on fan coils and pipes, power meters on electrical lines, currents and voltage measurements in the microgrid components, weather measurements etc. All of this is archived in the database and serves as a basis for identification of individual components, user behaviour, but also overall system performance in various conditions.

Finally, the information can be exploited for advanced monitoring techniques for predictive maintenance and resource management, and consequently to additional increase of system efficiency. Finally, this is a basis for the green manufacturing.

## **Stakeholders**

Owner of the laboratory and the equipment is Laboratory for Renewable Energy Systems consisted of researchers from Department of Control and Computer Engineering as part of the UNIZGFER. Results of the research performed under the project “3Smart” will be published publically.

## **Possible development linked with Greenomed activities**

The possible further development of the living lab are the following:

- Development of monitoring techniques for individual components such as electrical machines, power converters and batteries status as critical components to ensure a stable and reliable green manufacturing process for the whole system to identify energy leaks due to a malfunctioned equipment or a negligent users behaviour.
- Additionally increase resilience to the commonly present uncertain conditions of the living lab by further development of the optimal resource management in the direction of stochastic or distributed control approaches.
- Advanced control techniques of living lab components that have beneficial effect on their life cycle such as optimal charging current profiles for electrical storages or vibration minimisation and eccentricity compensation of electrical machines, aimed to prolong the durability of green manufacturing components.
- Extension of the living lab to incorporate other systems (in simulations or physically): e.g. charging stations for electric cars, water systems, building aggregators for participation in the energy exchange and power market etc. to extend the green manufacturing coverage.

## **Partner: Associazione Cluster Marche Manufacturing – Marche**

## **Living Lab: Università Politecnica delle Marche - No-destructive checks on composite material testing laboratory**

### **Idea of living lab**

The laboratory belongs to Università Politecnica delle Marche (UNIVPM). The laboratory is dealing with composite materials; its main aim is to apply the most used technologies to realize testing activities and no-destructive checks on these materials. The creation of a living lab inside the university is related to the necessity of link the academic world with the industrial one. The living lab offers a good variety of testing activities for different types of polymers; it also focused on different techniques of measurement of chemical-physical-mechanical features of both traditional and technologically advanced materials. Some of the measurement techniques dealt with air-coupled ultrasonic measurement techniques; thermographic measurement techniques; shearographic measurement techniques; laser ultrasonic measurement techniques.

### **Relevance**

According with the new European programme 2021-2027, green economy will be one of the main pillars for a sustainable growth. Green economy aims for sustainable development without degrading the environment; the reuse and recycle of composite material is one of the hot topics. At the moment, composite material represents a cost for companies. The idea is to find technologies or solutions to transform those costs and re-design value chains in a logic of circular economy.

The living lab is relevant in the framework of Greenomed Project since could allow companies involved in the working group on de and re-manufacturing for composite materials to understand which are the most applied technologies for testing activities on those materials. The laboratory will allow the development of future synergies and collaboration among the actors involved and will offer a common infrastructure for testing technologies.

### **Level of infrastructure**

The laboratory is furnished with several instruments as equipment: ultrasonic generation and acquisition system; electrocapacitive probes; cartesian robot; application system for thermal, mechanical and vibration load; laser vibrometer with high frequency decoder; ultrasonic probes.

The LL is equipped with the most technologically advanced equipment, including a wide range of ultrasound transducers (electro-capacitive and piezoelectric), covering a frequency range from 100 kHz to 1000 kHz.

The development of a Cartesian robot which moves the sensors along the object to be inspected makes it possible to plot a detailed map of the whole object, giving information on the size and position of the defect.

The possibility of having a coupling between the probe and the object to be inspected simply through air has allowed the application of these techniques to materials, particularly porous materials, for which contact with oil or water as a coupling means was unthinkable.

The living lab is also involved in the development of a full-field optical technique called shearography which measures without contact the deformation gradient of a surface over extended regions in short time and using equipment which can be taken to the field. It fully expresses its potential on composite materials when searching for sub-surface defects of different kinds (delaminations, fractures, inclusions, impact damages). Defect, in fact, are highlighted when the surface is subjected to strains. The living lab is doing a research activity aimed at optimising loading procedures and developing algorithms to process the data acquired, so as to promote greater dissemination of the technique in different fields.

The living lab has acquired considerable experience in ceramic materials for tile production, chipboard for the furniture industry and composite materials for aeronautic structures. These techniques are continuously developed and optimized so as to be able to use them for the quality control of items whose only prerogative to be competitive on the market is overall production quality.

The living lab is also engaged in the development of measurement procedures and application methods related to thermography, not only in non-destructive testing, but also in the environmental control field, the energy sector and production processes.

The development of new processing algorithms for thermographic images becomes fundamental for the optimization of the technique in relation to single specific application cases.

The laboratory is one of the most modern in Marche Region; in 2018 it received the label of “excellent laboratory” by MIUR (Ministry of Research and Education). Thanks to this label the laboratory will receive funds during the period 2018-2022 to buy new technologies and hire people for the use and implementation of them.

## **Technologies and TRL**

The main technologies addressed by the living lab are the following:

- Laser ultrasonic technologies based on the generation of thermal wave;
- Shearographic measurement technologies, ex. thermal, mechanical and vacuum loading system, shearography system, Dantec Q-800 shearography system ...;
- Thermographic measurements technologies that develop processing algorithms for the optimization of the technique in relation to single specific application cases, ex. FLIR S40 Thermal infrared camera (range between 7,5 and 13  $\mu\text{m}$ , FPA 320x240 pixels),

active thermography test bench with halogen lamps...;

- Air coupled ultrasonic measurement technologies, ex. Ultrasound generation and acquisition system (The Ultran Group), ultrasound generation and acquisition system (Metalscan), ultrasound generation and acquisition system (JSR).

The identified TRL for the laboratory is 4: “functionalities verified in protected environment”. It will also investigate advanced processes and techniques with a low TRL (TRL 2 or 3) to validate demonstrators.

## Services

The living lab aims to connect the academic world with the entrepreneurial one; the idea is to develop together solutions to improve productivity or reduce costs of companies, industrial projects, scientific collaborations and so on. The living lab intended at measuring features of materials which are being studied or which are being developed at taking specific measurements, both normalised and developed in accordance with specific requirements on marketed materials.

The services provided consist of testing and research activities realized by

acquiring innovative and technologically advanced technologies, such as: measurement techniques with ultrasound coupled in air, thermographic measurement techniques, shearographic measurement techniques, measurement techniques and ultrasound laser.

The living lab also offered multidisciplinary courses to students already enrolled at Università Politecnica delle Marche; they have the possibility to use technologies and equipment of the living lab under the assistance of qualified and skilled staff.

## Stakeholders

The main stakeholder who has access to the facility is the Università Politecnica delle Marche, in particular the staff operating and working in the laboratory. It also provides technologies to students, scientific doctors, researchers that, under the supervision of qualified staff, should use the facilities of the living lab.

The laboratory also cooperates with foreign universities and private companies; the main users of the facility are companies of automotive and electronic sectors; in the last years also maritime, wind and aerospace sectors are approaching the lab. The whole living lab is under the supervision of the professor Gian Marco Revel and the technician assistant Giuseppe Pandarese. The professor coordinates all activities of the living lab, supporting also the purchase of new equipment and materials; the assistant takes care of access of users, use of facilities, safety and security inside the living lab.

Possible development linked with Greenomed activities

The regional living lab can be related to de and re-manufacturing pilot already

implemented. The idea is to link the regional living lab with the one already set up at CNR of Milan, offering a wide range of services and rising their quality. The living lab will not offer services at TRL 4, but also at TRL 7-8, scaling up solutions and launch products into the market. In this way the living lab will enter in contact with the Greenomed community, developing a standard communication and fostering a strong collaboration between the actors already involved in circular economy and especially de-re manufacturing topic.

For example, the living lab can exploit possible projects with Lombardy Region or with Croatia who are working in the same field. It could be really interesting to organise a matchmaking event with the Lombardy cluster AFIL, in particular with its thematic working group on de-re manufacturing. The participants could exploit together the facilities available and how to use it in their processes. In this framework, regional companies involved in our working group have already visit the living lab set up in Milan to explore possible synergies and opportunities of cooperation.



## **Partner: Pomurje Technology Park - Slovenia**

### **Living Labs: Resyntex, IOS\_ Institute for Environmental Protection and Sensors**

#### **Idea of living lab**

IOS, Institute for Environmental protection and Sensors is an SME, private research organization, funded in 2006 and located in Maribor, Slovenia.

IOS is a research and development organisation that deals with the measurement, research, education and supply of scientific and professional information concerning environmental protection, sensors and new (nano)materials. There are 20 employees, 8 of them PhDs. IOS's strategy is to continually acquire new expertise and apply it to the economic and research area, both home and international.

The institute's mission is to employ highly educated personnel in laboratories with the most advanced equipment possible in order to bring state-of-the-art technology into the economic environment.

Our core business is research and development (R&D) in the fields of sensors, environmental protection, nanomaterials & nanotechnologies and sources of renewable energy. Based on own R&D results we develop custom-made technological solutions and product ready for market.

#### **Relevance**

In the area of environmental protection IOS Ltd. Is connecting the acquired knowledge and expertise in ecology and engineering with emphasis on (waste)water treatment. We provide lab and semi-industrial pilot-scale treatment experiments and relevant analytical support to evaluate the efficiency of treatment, in addition to development of advanced treatment procedures.

We own and operate different pilot-plants for (an)aerobic treatment, membrane filtration (ultra, nano and RO), membrane biological reactor (MBR), gas injection treatment, adsorption, oxidation processes (ozonation, H<sub>2</sub>O<sub>2</sub>/O<sub>3</sub>, H<sub>2</sub>O<sub>2</sub>/UV and ultrasound) appropriate for the treatment of municipal, industrial wastewater and swimming or drinking water.

We consult in the field of (waste)water treatment and water analysis. We implement both conventional and innovative procedures for wastewater treatment. We developed a new concept of a modular-mobile membrane biological reactor for recycling of municipal wastewaters.

Beside extensive list of active direct industrial projects IOS is currently involved as a co-coordinator in the EU H<sub>2</sub>O<sub>2</sub>O project "RESYNTEX – A new circular economy concept: from textile waste towards chemical and textile industries feedstock"

RESYNTEX is a research project which aims to create a new circular economy concept for the textile and chemical industries. Through industrial symbiosis, it aims to produce secondary raw materials from textile waste. IOS's role refers to the development and implementation of treatment technology, including pilot plants for solid and liquid waste treatment.



## Level of infrastructure

Available research equipment, property of IOS, Institute for environmental protection and sensors, Ltd (Beloruska ulica 7, 2000 Maribor):

- UV/VIS Spectrophotometer, Lambda 35 (Perkin Elmer),
- Luminescent/Flourescent Spectrophotometer, LS-55 (Perkin Elmer),
- Spectrophotometer AvaSpec TF 51118650, (Avantes),
- Spectrophotometer DR2800, (Hach lange) Bx s4,
- Fiber optic oxygen transmitter, S TLA 0002 000152 (Presens),
- Fiber optic pH transmitter, pH-1-mini-AOT-08-267 (Presens),
- Differential Scanning Calorimeter DSC Star Systems (Mettler Toledo),
- Laboratory oven,
- Incubator KB 53 (Binder),
- Microbiology safety cabinet Cytostar TS11224 (TelStar),
- SBR Recactor,
- Automatic Methane Potential Test System – AMPTS II,
- Centrifuge Universal 320 R (Hettich)
- OXI TOP C IS 12 208-133 (WTW),
- Microscope DM 1000, camera DFC 295 (Leica)
- Module for converting an optical, analog signal,
- Analytical Balance XP 205 (Mettler Toledo),
- Spin coater model WS-650MZ-23NPP/LITE (Laurell),
- UV disinfection plant, Model UV-201, 2GPM (PurePro®),
- MBR mobile (waste)water treatment plant (10 PE)
- 4-channel mixing chamber for gas mixture preparation (Echo Instruments),
- Dryer FED 115 (Binder).

Patents-membrane functionalization for the filtration process of wastewater

- Surface functionalization process of thin film composite (TFC) membranes with tetra alkoxysilanes for retention of heavy metal ions for the filtration process of wastewater; Patent no. SI 23535 A, 2012;
- Surface functionalization process of thin film composite (TFC) nano-filtration membranes with functional alkoxysilanes for the removal of heavy metal ions for the filtration process of wastewater; Patent no. SI 23534 A, 2012;

## Technologies and TRL

The Lab carries out research and analysis of different types of water, related to research projects or are intended for the design of cleaning concepts and devices. We consult in the field of water, wastewater treatment and water analysis.

We provide consultancy of the preparation of technological water as a heating or cooling medium. We work with water supply companies in accordance with internal control within the HACCP system, we perform analytics (microbiological and physic-chemical parameters) and carry out education in this field.

Under our own brand Wate(R)euse, we developed a mobile-modular membrane biological reactor

(MBR), which enables the cleaning and reuse of municipal waste water.

The Water4future water purification concept allows the combination of various technological procedures for the preparation and treatment of industrial and industrial wastewater.

We initiate action In the Care of Clean Drinking Water in which end users can individually order drinking water analysis, it is intended for end-users and for checking the quality of water from their own well or other sources.

Work on the EU (H2020) in RESYNTEx (<http://resyntex.eu>), launched in June 2015, is in closing phase The most important goal of the four years project is to create a new concept of a circular economy that includes two industrial sectors, textile and chemical. The introduction of the proposed concept of industrial symbiosis will enable recycling of valuable secondary raw materials from textile waste and reduce the negative impact of the processes on the environment. IOS is a co-coordinator of the project, among other things, it is also responsible for operating the developed pilot line for the demonstration of all chemical and bio-chemical processes within the Resyntex project as well as the final processing of all liquid and solid waste streams from the Resyntex process line.

The demonstration pilot line with maximum capacity 30 tons of input waste per year consists of:

- Three closed reactor vessels: one HTP, one HT and bio reactor
- Extruder
- Automated closed system for dosing chemicals
- Closed filtration system
- Industrial wastewater treatment plant (based on membrane filtration unit)

## Services

IOS Ltd is specialized in:

- Preparation and treatment of water: drinking, surface, swimming and various types of waste water (municipal, industrial, leached...);
- Water monitoring;
- Consultancy in the field of water/waste water treatment and analysis;
- Implementation of both, established and innovative procedures for the preparation of drinking, surface, technological, swimming water as well as for the wastewater treatment;
- Pilot/industrial plants for renewing special pollutants (heavy metals, endocrine inhibitors, antibiotics, other pharmaceutical components, pesticides, etc.);
- Providing water monitoring, analytical support in pilot/industrial scale water treatment experiments;
- Wate@use Modular-Mobile concept is dealing with Membrane Biological Reactor (MBR) for recycling of municipal wastewaters;
- Water4Future concept is dealing with combination of various water treatment possibilities from the adsorption, anaerobic treatment, membrane filtration (RO, nano, ultra, micro), gas injection treatment, thermochemical conversion to the chemical oxidation processes (such as ozonation, H<sub>2</sub>O<sub>2</sub>/O<sub>3</sub>, TiO<sub>2</sub>/O<sub>3</sub>, H<sub>2</sub>O<sub>2</sub>/UV and ultrasound), disinfection processes for the preparation of drinking, surface, technological, swimming waters as well as waste waters such as municipal, industrial, leached, with the goal to ensure the quality of the water needed/wanted.,

## Stakeholders

Among stakeholders, it can be mentioned: Chemistry Lab at Faculty of Mechanical Engineering of University of Maribor, Competence center for Circular Economy – part of SRIP Circular Economy, which has various projects with concrete companies such as ROTO Pavlinjek for MultiNano Optic-chemical sensors for water monitoring, also Ministry of Economic Development and Technologies who sponsors a lot of applicative projects for the industrial use (case of ROTO for example), and through similar applicative projects reach industry partners like Em.tronic d.o.o, Piktronik d.o.o., Teletech d.o.o., IEI d.o.o.(WaterCleanBox). Through the Resyntex demo plant also European Community financed the H2020 value chain from waste collection to raw materials for industrial needs.

## Possible development linked with Greenomed activities

IOS with its capacity (private) and link to university of Maribor (Faculty of Mechanical Engineering and its chemistry lab) alone are interesting public-private partnership, which merges 2 different but complementary approaches, where both partners widen their knowledge and lab capacities, which based on experience are upgraded and meant for scale-up potentials with international partners, considering IPR and other, more open possibilities of knowledge exchange (joint R&D projects and later commercialization). Currently majority of IOS operations are funded from H2020, ERDF, national funds by Ministry of Economic development and Technology and quite some % also from commercial operations with industry related to wastewater treatments and sensors (food industry applications).

Infrastructure of IOS consist of lab and offices (private ownership), demo-plant Resyntex (capacity of recycling the 100 tons of waste textile annually-IOs is already looking for commercial partners to use this capacity – among identified partners there are Adidas and Decathlon and thus testing of business model) with potential to widen the plant towards pilot de/re-manufacturing of plastics (successful testing done in lab environment e.g. in small scale) and same for food wastes. For that capacity building IOS is interested in funding opportunities within Vanguard initiative e.g. calls for investments.

## **Partner: Pomurje Technology Park - Slovenia**

### **Living Labs: ABG, Algen**

#### **Idea of living lab**

AlgEn is committed to be an active participant in the blooming area of algal technologies. Internal research and development activities are being complemented by components and know-how of partners (typical Living Lab facility) into effective solutions.

Algal technologies have the potential to change the world:

- production of biofuels from algae,
- bio-sequestration of greenhouse gaseous emissions,
- extraction of precious organic materials, exceptional nutritional qualities of algal biomass, production of vitamins, antioxidants and unsaturated fatty acids,
- extremely efficient wastewater treatment

Some of these applications are being introduced into practical and economic deployment, others are still lacking some pieces of the technological (and economical) puzzle. And these pieces of technology are being developed at many places around the world. Due to complexity of the technology a single breakthrough solution is not to be expected as many different innovations will still have to be integrated into the world-changing technology first.

AlgEn is committed to provide its own innovative contributions integrated with the best available technologies developed elsewhere into state-of-the-future-art solutions.

Research & development of biotechnologies connected to algae dates back for at least 50 years. While the scientific area of phycology has been progressing steadily, the biotechnology aspects is gaining and loosing popularity in waves. This is another evidence that the technological problems are far from being simple, but their solution has a high potential in many application areas.

Algal treatment of biogas digestate with significant economic and environmental benefits for biogas plants operators is the title of the project that resulted in a concrete demo plant in cooperation with KO-TO Ltd factory in Slovenia. So we have proven concept and in-field working example for which we feel it is worth spreading, especially due to the fact there is high tech knowledge in the background that might be interesting for transfer to other regions (Living Lab approach).

#### **Relevance**

AlgEn lab is a best practice in Slovenia and considering its focus and ongoing activities it can be connected to the Bioeconomy Pilot of the Vanguard Initiative.

Concrete applications refer to at least two topics within Bioeconomy projects, however it is still necessary to better analyse the solution and its appropriateness in comparison to already available knowledge and technologies in the framework of Bioeconomy Pilot, focusing in particular on:

- Biogas Beyond Energy Production
- Food & Feed Ingredients from Agrofood Waste
- Food & Feed Ingredients from Algae

## ***Level of infrastructure***

Basically the initiative has been developed on the basis of an applicative case of KO-TO Ltd, where bio wastes from whole Slovenia are collected and where these remains of plants and animals at certain percentage are used as raw materials for biogas production and on the other side not all residuals can be burned and thus with some treatment could be recycled for some either raw materials or re-used as fertilizers, or animal feed products, in some cases even as food.

Concrete project where forces are joined is the one of AlgEn with process knowledge and KO-TO with some industrial infrastructure existing and raw materials available represent a winning combination for testing some solutions that can be applied by real company, with a little bit infrastructure adapted to new technology processes and ready to be tested or for later commercial use, but definitely it worked for the testing period within project duration.

A joint project with KO-TO industrial partner shows AlgEn orientation towards applicative solutions, based on high-tech innovations which resulted in demo plant for bio-gas production and at the same time optimization of biogas and power production, they are always in search of affordable highly energetic substrates (feedstock), effective use of the heat produced, and disposal or even monetization of the resulting digestate.



## ***Technologies and TRL***

Specific AlageBioGas demo-plant corresponds to TRL 8 technologies, tested/applied at KO-TO industrial premises, where certain section serves as testing capacity.

Different technologies and different substrates are used but all of them have some common challenges. Beside optimization of biogas and power production, they are always in search of affordable highly energetic substrates (feedstock), effective use of the heat produced, and disposal or even monetization of the resulting digestate. Digestate can be directly applied after production to the nearby agricultural land, however, an accumulation of biogas plants in certain regions and their increasing number leads to an oversupply of digestate. Digestate specific intense smell also negatively influences the quality of life of nearby population.

By algal treatment of biogas digestate, quality of digestate liquid fraction (liquor) can be

improved, produce algae which can be used as an energetic substrate or processed in bio refinery, recycle CO<sub>2</sub> emissions, effectively use excess heat and reduce odour of digestate. Nutrients can be recovered and cycled on-site. Algae hold great potential for energy use because of their growth rate, easy production and better utilization of sunlight compared to conventional plants, shorter lifecycles and independence from fertile agricultural land. Biogas plants are rich sources of mineral nutrients, CO<sub>2</sub> and heat.

## **Services**

Living lab of AlgEn, aside of available infrastructure, offers services that are based on AlgEn understanding of the processes, gained experience and acquired expertise. Some of the services are performed in-house; others are performed by respectful external organizations (KIS-chemical institute of Slovenia; Biotechnical Faculty, Limnos Institute,) and in some funded projects also under AlgEn supervision. The role of AlgEn expertise is in the knowledge of what to test and how to interpret the results.

In particular, the laboratory is providing R&I and testing services. A possible further development to be evaluated with the owner is to turn this facility into an open pilot plant, if it doesn't interfere too much with regular production of KO-TO.

AlgEn is currently involved in diverse activities including:

- AlgaeCan LIFE+ project
- Water2REturn project
- Saltgae project
- AlgaeBioGas project
- wastewater treatment
- biogas digestate preliminary testing as an algae nutrient
- photobioreactor control system development
- AlgaDisk project
- Algal Bank maintainance
- Dronic project

## **Stakeholders**

The demonstration center has been developed by KO-TO and it has been exploited for project purposed in collaboration with AlgEn. Among other stakeholders there are KIS - National institute of Chemistry, next National institute of Biotechnology and University of Ljubljana/ Biotechnical Faculty where lab capacities as well as human resources (experts are available).

## **Possible development linked with Greenomed activities**

Although this Living Lab has been identified too late, possible further development beyond GREENOMED project are still possible in the framework of Vanguard Initiative. Leveraging on the tools and the services offered by the methodology, PTP will follow up with the Living Lab stakeholders with the aim to get them involved in Bioeconomy Pilot.



## Partner: Technology Park Ljubiana - Slovenia

### Living Lab: Technology Park Ljubljana Ltd.

#### Idea of living lab

**Technology Park Ljubljana** opened the augmented reality/virtual reality/extended reality laboratory called **Look Around 360** in March 2019. The newly established laboratory is equipped with state-of-the-art equipment and is unique in the way it operates in the Slovenian testing “landscape”. The grand opening of the Look Around 360 Laboratory was accompanied by the largest **Virtual reality conference** in Slovenia where Greenomed project was promoted. Within the Greenomed project the TPLJ lab is also used with the aim of testing technologies that can **contribute to the progress of green/sustainable technologies in the scope of Efficient and sustainable manufacturing**.

The Lab has been set up with the collaboration of different experts in the field of innovation technology, for example various Faculties: Faculty of electrical engineering, University of Ljubljana, Faculty of mechanics, University of Ljubljana; research facilities like Institute Jozef Stefan and companies like Multimedia Lab (Laboratorij za multimedijo), Zavod 404, Infomedia, Art Rebel 9 and many others. TPLJ encourages the involvement of the member companies of the TPLJ community in order to build a strong recognition among local stakeholder. In the scope of the Greenomed project, the lab activities will focus on the green and sustainable technologies – especially with the involvement of the Faculty of mechanics, University of Ljubljana, whose focus is on the **efficiency aspect of manufacturing**. The Faculty of mechanics is active in the field of digital twins for factories and production lines. With other involved companies and stakeholders, we will try to encourage **innovation in sustainability and green manufacturing** (opposed to energy efficiency endeavors).

In the first month after opening two collaborations on cases in the field of green technologies took place in the Look Around 360 Laboratory – with companies Synech and Logon. The Slovenian company Logon, which core business is the development of advanced software solutions adapted to the specific requirements of customers, presented its product (case) in the Look Around 360 Lab to a high-level delegation of experts (The Surveying and Mapping Authority of the Republic of Slovenia, Ministry of the environment and spatial planning) and hydro power plant representatives (Šoča river hydro power plant, Sava river hydro power plant). The product deals with renewable energy sources and the placement of new water plants on the lower Sava River.

The company Syntech presented the detailed composition and operation of their new patented evaporator using AR/VR technology to investors and future business partners, with which synthetic gases are derived from the garbage.



## ***Relevance***

Technology Park Ljubljana Ltd (TPLJ) is a leading entity and key national stakeholder in the development of innovative and knowledge-based entrepreneurship in Slovenia. TPLJ focuses on facilitating knowledge and technology transfer from research institutes, academia to national and international markets and therefore acts as a System Integrator. The Living lab candidate operates as a Smart city for 300+ member companies, innovative teams and individuals. TPLJ is active in the following main clusters and fields of focus: ICT, green technologies, health, smart and creative. TPLJ's type of governance is a Public-Private-Partnership.

Technology Park Ljubljana Ltd (TPLJ) acts like a System Integrator for various stakeholders. TPLJ has gained a wide range of experience in participating and managing European projects. TPLJ is a project partner in the Greenomed project and has therefore in-depth knowledge about the project and a wide network of possible stakeholders. Technology park Ljubljana is also member of several national initiatives, ambassador of Slovenian Smart specialization strategy and member of 4 Strategic Research and Innovation partnerships as well as closely connected to other SRIPs. As a member of Slovenian Digital Innovation Hub (DIH), FAB Lab Network and ICT horizontal network, TPLJ has a large network and means for promoting the lab in the Slovene ecosystem.

## ***Level of infrastructure***

The Living Lab is equipped with state-of-the-art equipment and is unique in the way it operates in the Slovenian testing "landscape". The AR/VR lab at Technology park Ljubljana represents a start of the art innovation area supporting providers of technological solutions to embed them in the manufacturing sector, understanding the processes efficiency and risks

## ***Technologies and TRL***

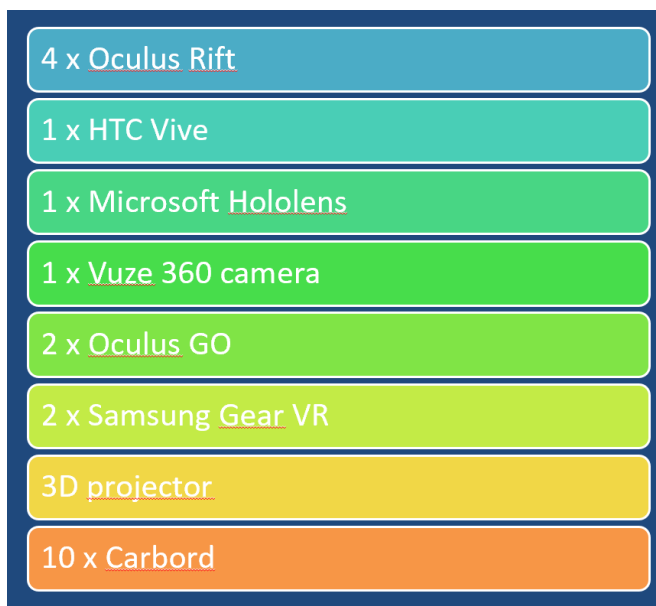
The level of infrastructure in the lab is quite extensive (208 parts) and consists of:

- Laser cutter + ventilation
- Bigger CNC Milling Machine
- Cutter for vinyl
- Laser Printer
- 3D scanner
- 3D printer
- Replacement materials for the machines
- Various tools for the machines
- Electronics equipment
- Development platforms for electronics
- 3D projector
- Adequate computers
- 3D camera
- FULL HD camera
- VR equipment Oculus Rift CV1 with touch controllers or HTC Vive with controllers
- AR / MR solution HoloLense or MS compatible AR helmet
- Mobile VR Samsung Gear or Google Daydream with a suitable phone
- Mobile AR iPhone / iPad with ARKit support Google mobile AR with ARCore support

- Smart TV

The main use and functionality of the Living lab is the Identification of new technologies. The TRL (Technology readiness level) of the technologies that are going to be used in the Living lab is 6 (prototype delivered) and above.

Short technology overview:



## Services

The Living Lab operates as an open Laboratory and is accessible to a wide range of stakeholders: faculties, students, research organizations, companies and enthusiasts in this field. The Lab especially targets companies that are members of the Technology park Ljubljana ecosystem, but also other companies in Slovenia. All stakeholders are supported by highly qualified mentors from LASIM Lab (Faculty of electronics, University of Ljubljana) and Zavod 404.

## Stakeholders

The Living Lab is owned by Technology Park Ljubljana Ltd. The Stakeholders have access to the Living Lab Facilities: The Faculty of Mechanical Engineering- University of Ljubljana, The Faculty of Electrical Engineering- University of Ljubljana, Institute Jozef Stefan and various Companies (Multimedia Lab (Laboratorij za multimedijo), Zavod 404, Infomedia, Art Rebel 9), SRIPs (clusters) as well as researchers.

## Possible development linked with Greenomed activities

The Lab Look Around 360 is definitely in line with the Vanguard philosophy of “Living Labs”, also by securing economic growth and employment through regional cooperation in the field of industry, co-creation and co-investment. In this regard, the opening of the Lab is also aimed at education and raising awareness about importance of green technologies, especially from the point of view of digitization and visualization of processes, the

development of new ecological products, and the visualization of possible solutions, which also means saving resources in the phase of developing a product.

The greatest emphasis is and will be on **education**, because if you can plan, present and understand the processes, then you have made a big step towards the users, the customer and the understanding of investors.

## **Partner: iBEC – Region Central Macedonia**

### **Living Lab: GREEN LIVING LAB IN THE REGION OF CENTRAL MACEDONIA**

#### **Idea of living lab**

The GREEN Living lab, which is currently hosting in the premises of i-BEC, is an attempt to develop a thematic living lab in the Region focusing on the exploitation of biomass residuals coming from agro-based industries which are settled in the Region of Central Macedonia. The motivation idea behind the creation of the GREEN living lab was the absent of any living lab in the Region accessible to industries and SMEs active in the research field of the exploitation of biomass residuals coming from agro-based industries. Having as a matrix the accredited laboratory of I-BEC, GREEN living lab aspires to create a network of labs that are active in the Region in order to be able to provide a great variety of testing activities in the field of agro-based biomass. Currently, GREEN Living lab is consistent from the following labs established in the Region of Central Macedonia.

- Lab of environmental studies of i-BEC
- Lab. of General & Inorganic Chemical Technology of School of Chemistry of Aristotle University of Thessaloniki (Nanomaterials and Chemical Processes Group) & Hybrid Inorganic-Organic and Nanocomposite Materials Group of the Center for Interdisciplinary Research and Innovation of AUTH

#### ***Relevance***

The relevance degree of the GREEN Living lab is high since GREEN Living lab has infrastructure relative with the testing activities of the regional working groups that have been created in the frame of implementation of GREENOMED project in the Region of Central Macedonia.

#### ***Level of infrastructure***

i-BEC's Lab is one of the most modern and fully equipped in Greece. The existing laboratory infrastructure and facilities are fully utilized by experienced scientists ensuring reliable services and analyses. The laboratory is responsible for the in-situ, telemetric and airborne, Earth Observation data validation for i-BEC's EO related research activities. All analyses are done according to the National Standards and the Laboratory is accredited by the National Council of Accreditation [E.S.Y.D] based on the EL0T EN ISO/IEC 17025:2005 [Certificate of Accreditation with No.720] standard. Moreover, i-BEC act as a smart specialization training centre for Recycle Economy & Greening Agriculture invests to:

- Produce, process and certify products of minimal ecological footprint (water, energy & CO2 emission reduction)

- Recycle, treat and reuse agricultural waste
- Develop new products from coastal biomass and microalgae
- Combine crop cultivations and algae cultures to maximise system exergy
- Parameterize products and processes for specific conditions
- Support all these activities with spectral analyses

#### Infrastructure of i-BECs Lab:

- Fully equipped water, soil and biomass laboratory
- Innovative Hybrid Solar & Geothermal Systems
- Microalgal Photobioreactor
- Hydroponic Cultivation Systems
- Growth Chamber
- Composting infrastructures
- Greenhouse and Field Diagnostic toolboxes
- Mobile Soil Device System

#### Lab of General & Inorganic Chemical Technology of School of Chemistry of Aristotle University of Thessaloniki (Nanomaterials and Chemical Processes Group)

The Lab of General & Inorganic Chemical Technology of School of Chemistry of Aristotle University of Thessaloniki is one of the most equipped in Greece, especially for conducting research in the field of nanomaterials and chemical process.

#### Infrastructure of General & Inorganic Chemical Technology of School of Chemistry of Aristotle University of Thessaloniki:

- Fully equipped biomass laboratory
- Bioreactors
- HPLC
- GC-MS-MS
- *Powder X-ray Diffractometer-PANalytical*
- Thermo Gravimetric Analyzer
- Electrochemical Analyzer
- Electrochemical work station-Bio Logic SP-300

- Potentiostat-galvanostat

### ***Technologies and TRL***

The main technologies addressed by the Living Lab and its collaborators are the following:

- Heterotrophic cultivation of microalgae (using non-purified glycerol from biodiesel plants as carbon source)
- Wastewater treatment through autotrophic cultivation of microalgae
- Hybrid organic-inorganic nanostructured materials. Polymer nanocomposites with nanostructured clay, silica and carbon materials
- Heterogeneous - Environmental Catalysis
- Biomass thermochemical and enzymatic conversion to fuels and chemicals
- Synthesis, Modification and Characterization of Inorganic Materials (zeolites, mesoporous materials, clays, LDH's, etc.)
- Adsorption/separation processes (environmental applications)

The TRL for each one of the abovementioned technology ranges from 4 to 7.

### ***Services***

GREEN Living lab's provided services to the end users are classified as:

- Low input sustainable agriculture (LISA) in harmonization with the United Nations SDGs water quality certification
- Electronic registry of water users
- Validating agricultural practices regarding Codes of Good Agricultural Practices, updating the Codes of Good Agricultural Practices
- Wastewater and bio-waste treatment and recycling efficiency
- Development of integrated innovative closed systems for reduction of water consumption in primary production

### **Primary production through practices of minimal carbon footprint**

- Innovative hybrid solar – geothermal systems for heating and cooling of greenhouses
- Small and large scale photobioreactors for algae cultivation, which is characterized by increased CO<sub>2</sub> absorption and algae biomass can be used for producing biofuel
- Development of combined crops
- Best management practices

### **Production processes in agriculture and food manufacturing**

- Remotely controlled spatiotemporal variable application of irrigation
- Spatiotemporal variable application offertilizers
- Food product certification
- Recording and uploading agro-environmental incidents and mobilizing adecision support system
- Networking for small and medium agrifood enterprises

### **Risk assessment and early warning mechanisms**

- Flood risk assessment
- Fire risk assessment
- Early warning information for critical pollution incidents for each water user
- Predicting soil erosion and degradation
- Predicting algal biomass blooms

### ***Stakeholders***

The GREEN Living lab is a property of i-BEC providing access to its facilities in SMEs and public bodies of GREECE.