Mastering Participatory Living Labs

Effective Interaction with Participants, Illustrated by the Electromobility Project unIT-e²

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Abstract. This paper presents the concept and implementation of participatory living labs in the context of the unIT-e² project, which aims to integrate electromobility into the energy system efficiently. The article focuses on two field trials involving private and corporate users of electric vehicles and charging infrastructure. The paper describes the theoretical foundations of participatory aspects in living labs and proposes a participation pyramid model to structure the different levels and methods of participation. The paper also reports on the practical experiences and lessons from applying the participation pyramid model in the context unIT-e². The paper offers general recommendations for future participatory living labs in the energy and mobility transition context, such as developing an interaction strategy before participant acquisition, ensuring early onboarding and continuous information provision, balancing online and offline events, and gathering and listening to participant feedback. The paper concludes that professional, proactive, and regular interaction with the participants is crucial for the success of living labs and the knowledge gained for civil society and science.

Keywords: Electromobility, Living Labs, Participation

1. Motivation and initial situation

Field trials are essential for testing innovative technologies in practice. So-called "living labs" (German: "Reallabor") have become established in research for this purpose. According to the German Federal Ministry for Economic Affairs and Climate Actions (BMWK) definition, living labs are test rooms limited in time and space in which innovative technologies or business models are tested under real-world conditions. [1] They often involve private individuals as participants. Since many living lab participants are tech-savvy early adopters, catering to their understanding and interests is essential [2], as their insights can be another valuable data source for developers and operators of novice technical systems. However, the successful implementation of a living lab goes beyond the technical implementation. The active involvement and interaction with the participants are relevant to the project's success. Recognizing the participants as partners and not just passive data providers enables a deep understanding of the participants' needs.

Based on previous experiences with living labs, the intensity and form of participative interaction should be tailored to the available financial and human resources. [3] Efficient implementations require compelling participatory aspects that motivate the participant's active engagement in the research project. Traditional information channels such as newsletters or websites enable regular updates. [4] However, they often need help to achieve the goal of

retrieving valuable knowledge for the researchers. Furthermore, relevant literature suggests that such methods can only be classified as a preliminary participation stage. [5] Interacting with the target group through online and offline events is a proactive way of encouraging active participation. Implementing such events is also associated with potential risks. A poor implementation can negatively impact attitudes towards the project, the organization executing it, or the technology being tested. In the research project "unIT-e² Living Lab for Integrated E-Mobility" (funded by the BMWK, funding code: 01MV21UN01), several field trials investigating intelligent charging strategies were conducted. All of them relied heavily on the participation of end users. This article presents the lessons learned from the project and offers general recommendations for future participatory living labs in the energy and mobility transition context.

unIT-e² is a consortium of 31 companies and research institutes. The goal is to mobilize the digital energy transition by investigating solutions to efficiently integrate electromobility into the energy system. Field trials and laboratory experiments are conducted and scientifically monitored to ensure practical implementation. The project comprises four sub-projects called "clusters". Their structurally similar design and the parallel investigation of different but related research questions help accelerate knowledge acquisition. The subject of this article is the cluster called "Harmon-E". Its goal is to create harmonious user interactions within the overall energy and grid management system. Accordingly, the value chain, from the electricity and system service markets to the flexible charging and discharging of electric cars, is being developed and demonstrated in the cluster. Harmon-E's living lab consists of two field trials.

The first field trial targets private homeowners with single-family homes, optionally equipped with a photovoltaic system, a battery-electric storage unit, or a heat pump. The trial will take place over nine months (April to December 2023) in two local grid areas of the project partner EWE Netz in Oldenburg and Rastede. Nineteen participants' homes will be upgraded with the necessary technology - an electric car, charging station, home energy management system (HEMS), and intelligent metering system (iMSys) and connected to the relevant backend services.

The second field trial focuses on charging electric vehicles at the workplace. Ten employees of Wernsing Feinkost AG in Essen (Oldenburg) participate in the living lab. The project partners are setting up the necessary infrastructure at Wernsing's production site: ten charging stations, an energy management system (EMS), and an intelligent metering system. In addition, ten electric vehicles are provided for the duration of the field trial.

Details on the technical setup of the two field trials have already been published [6].

Professional interaction with the participants is essential for the living labs' success and the functional and technical connection of the experimental setups. Before delving into details on implementing the participatory aspect within the unIT-e² project, it is vital to establish the theoretical foundations of participatory elements in living labs.

2. Participation concepts for living labs

2.1 The participation pyramid for living labs

Living labs are an essential component of inter- and transdisciplinary research. Through cooperation between civil society and science, they offer the unique opportunity for mutual learning in an experimental yet realistic and application-oriented environment. [7] The essential feature of a living lab, the participation or active involvement of civil society, is, at the same time, one of the central challenges researchers have to master. Living labs can only be successful if civil society participates. With their participation pyramid, Straßburger and Rieger have developed a framework that provides a structured description of civil society's participation in research

projects like unIT-e². [5] They differentiate between preliminary stages of participation (informing, asking for opinions, obtaining expertise on the living environment), stages of participation (allowing co-determination, partially handing over decision-making authority, transferring decision-making power), and independent civil society activities.

In living labs focusing on technical developments, users are generally not allowed co-determination. Participants can use the technology, such as an electric car, but have no decision-making power over its further development or adaptation. In contrast, higher stages of participation appear in living labs that follow a user-centered design approach. It allows them to influence the design and functionality of the technology and thus play a more critical role in the development process. However, they will likely never encounter independent civil society activities.

Therefore, a participation pyramid for living labs developed based on Straßburger and Rieger [5] is presented below.

The participation pyramid for living labs depicted in Figure 1 is divided into six levels (Information Stages I - III, Soliciting Opinions/Advising, and Co-determination). The individual stages are described in detail below.

2.2 Stages of the participation Pyramid for living labs

2.2.1 Information Stage I

Stage I of the participation pyramid for living labs represents the most fundamental way of communication. An impersonal, unidirectional flow of information characterizes it. In addition to the participants involved in the living lab, the target group of this communication is the civil society as a whole. The primary purpose of this stage is to transport information from the scientific sphere to the sphere of civil society. Both online, via websites and newsletters, and offline, using flyers and other communication channels, can be applied for this purpose.
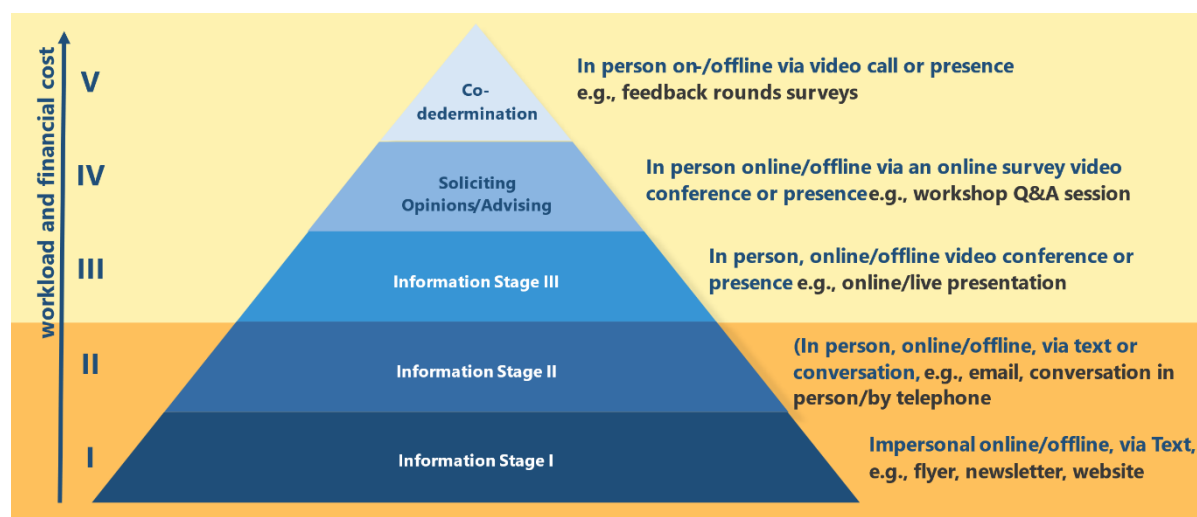

Figure 1. Participation pyramid for living labs.

Stage I methods can be used to acquire participants in the phases before the start of the trial period. During the trial, these methods provide participants with up-to-date information from the living lab without much additional work. After the end of the trial period, stage I techniques allow participants to stay informed about the project's progress and results. This continuous communication helps participants to see the results of their participation and experience a sense of appreciation. The expected workload and financial cost for this stage are expected to be low.

2.2.2 Information Stage II

In contrast to stage I, stage II is aimed personally and exclusively at the participants of the living lab. Communication occurs online, via e-mail or telephone, and offline during face-to-face meetings. Before the start of the trial period, prequalification and installation appointments are arranged using stage II methods. During the trial period, participants can submit personal concerns to the researchers via service e-mail or speak directly, for example, by telephone with their contact person at the support department. After the trial period ends, participants can receive personal notifications about further information offers or be invited to final events. The expected workload and financial cost are slightly higher than for stage I, but it is essential for successfully implementing a living lab.

2.2.3 Information Stage III

Stage III is the last stage of information. It serves to supplement and, at the same time, intensify information offered in stages I - II. The use of exchange formats, whether online through video conferencing or offline during face-to-face events, provides an excellent opportunity to share in-depth information with interested participants. This can include detailed explanations of how particular test objects work or contain time-critical information, such as the procedure for decommissioning the experimental setup at the participant's home or returning their vehicle. This stage requires significantly more human and financial resources to do well than the subordinate stages.

2.2.4 Soliciting Opinions/Advising

With stage IV, Soliciting Opinions/Advising, the flow of information is reversed from the pure transfer of information from science to civil society. It becomes a more information or data-focused flow towards the sphere of research. While stages I - III exclusively address the smooth execution of the trial phase at an organizational level, the focus in stages IV and V lies on gaining scientific and technical knowledge. In stage IV, user research methods such as workshops and surveys are used to gain valuable insights into both the behavior of the participants as well as the suitability and functionality of the technology under investigation. Depending on the scope of the chosen methodology, a high workload can be expected. In return, this additional effort can be rewarded with valuable insights for the further development of the technology.

2.2.4 Co-determination

Stage V co-determination allows participants to actively participate in the decision-making processes and the further technical development of the project. This showcases how scientific stakeholders can learn from civil society stakeholders in living labs. Science can directly address relevant issues with participants in living labs online and in person through active feedback and surveys, including video conferences.

3. Participation in the unIT-e² real-world laboratory

The "Harmon-E" cluster of the unIT-e² project implements the concept of the participation pyramid for living labs. The individual stages are applied with varying intensity over time (see Figure 2). Before the start of the trial period, stages I and II dominate. They are primarily used to prepare for the field trial and to onboard the participants. This process includes systematically introducing and integrating the participants into the project. During this phase, participants receive essential information, resources, and support to ensure effective participation. Stages I and II peak at the beginning of the trial period (the active phase during which the scientific research takes place) but are quickly followed by stages III to V. These higher stages are mainly used during the trial period and vary in intensity. Towards the end of the trial period,

stages III to V peak and decrease rapidly. Those stages are central for closely monitoring the participants during the trial period and contribute significantly to gaining scientific knowledge.

The application of stages III to V can be helpful even before the start of the trial period, for example, during a kick-off event. Here, they can be used to clarify urgent questions and manage expectations. After the end of the trial period, measures such as final surveys or final events represent this category.
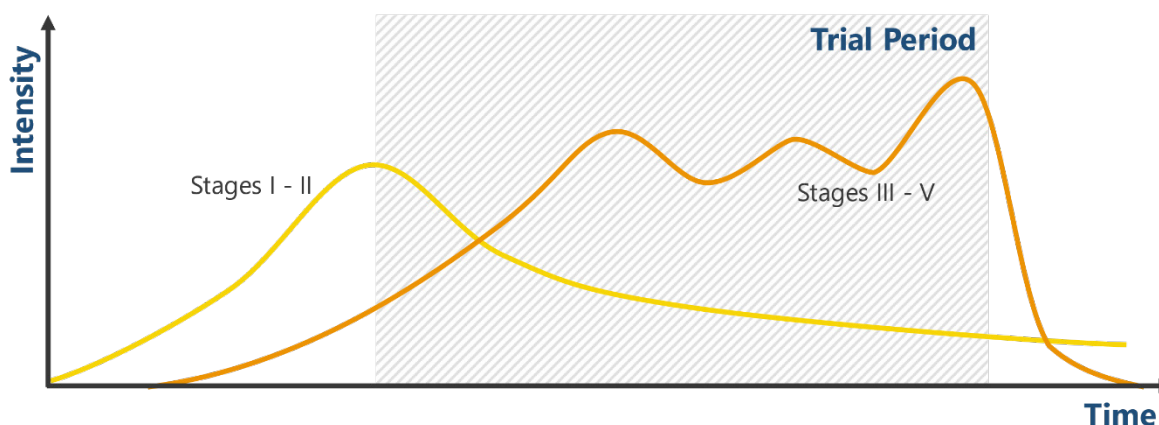

Figure 2. *Intensity of participation levels before, during, and after the trial period in the unIT-e² cluster Harmon-E.*

While stages III to IV have a deterministic end, stages I and II can remain relevant beyond the end of the trial period. Stage II can be available for any necessary support, and stage I can transmit research results to civil society, for example, via the project's website. This enables the dissemination of results even after the end of the trial period.

Figure 3 visualizes the phases and times the various measures are applied as a Gantt chart. The following sections provide a comprehensive explanation of the implementation of the participation measures, structured by six specific phases and points in time: "Before the start of participant acquisition," "During participant acquisition," "At the start of the trial period," "During the trial period," "At the end of the trial period" and "During the follow-up."

3.1 Participation methods before the start of participant acquisition

Even before the acquisition of participants begins, the focus is on informing civil society. A project website (stage I) is created for this purpose. This website (https://unit-e2.de/) mainly offers freely accessible information about the project, which remains available even after the project has ended. When designing the project website, particular attention should be paid to ensuring it is up-to-date and visually appealing. In the context of living labs, which focus on the participation of civil society, this is particularly relevant regarding the upcoming acquisition of participants. Appointing a staff member responsible for public relations has proven to be a good way of providing up-to-date information. Cooperating with a design agency is recommended to achieve a high-quality design.

3.2 Participation Methods During Participant Acquisition

During the participant acquisition phase, stages I and II become increasingly important. The living lab can be advertised via the project partners' existing sales channels. The advertising measures can be implemented by telephone, e-mail, or mail using flyers. As with the project website, a design concept tailored to the target group is also fundamental here. A professional approach and communication with potential participants are of utmost importance. Assigning

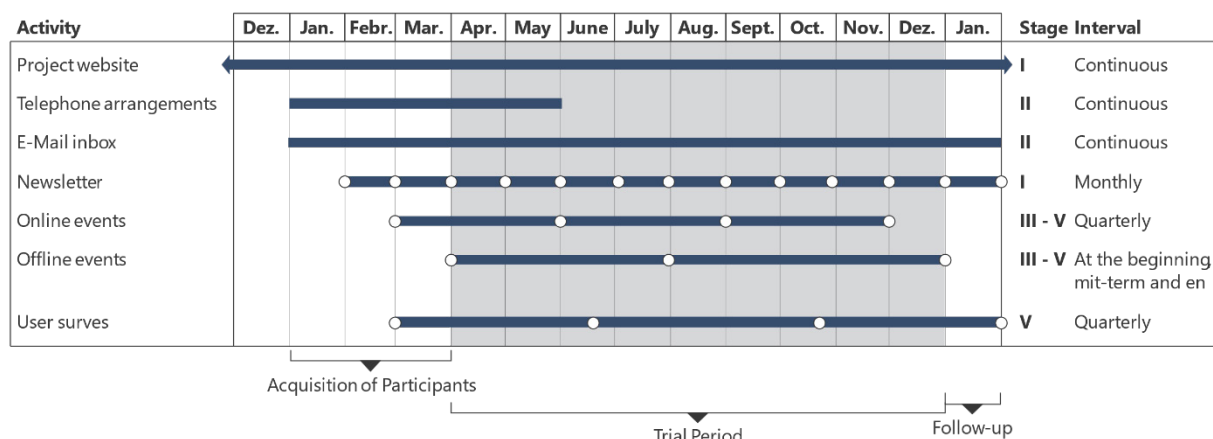this task to a project employee can significantly increase the quality and, thus, the acquisition's success.

Figure 3. Gantt chart presentation of participation methods in the unIT-e² Cluster Harmon-E over time.

3.1 Participation methods before the start of participant acquisition

Developing a well-rounded strategy to ensure a successful acquisition is crucial. Offering affordable vehicles and less strict selection criteria can broaden the pool of potential applicants. On the other hand, selection criteria that are too strict, such as residence in a particular local area or the presence of special technical equipment such as photovoltaic systems with storage and heat pumps, as well as being limited to a specific vehicle model, can make it considerably more challenging to recruit a high number of suitable participants.

Before the start of the trial period, it is advisable to organize an initial online meeting with all participants. This allows the project partners to inform the participants about the overall goals and purpose of the project (stage III). A preliminary timeline provides participants with an initial overview of the trial period. In addition, organizational details, such as the preparation of the house installation or the pick-up date and procedure of the test vehicles, can be discussed. Upcoming questions can immediately be answered, and misunderstandings can be avoided (stage IV). The meeting also allows the project partners to manage the participant's expectations. These actions lead to well-prepared and informed participants.

Stage II methods are used to handle specific details like scheduling installation appointments. Depending on the length of the acquisition period, participants can be informed about current developments in the project before the trial period's start by a monthly newsletter (stage I).

If user surveys are planned during and after the trial period, an initial survey (stage V) can serve as the basis for user research.

3.3 Participation methods at the start of the trial period

The trial period is officially launched with a kick-off event. This event has several goals: It informs the participants (see agenda items 4 to 6 in Table 1) about the project objectives and introduces them to the technology used. It also serves the purpose of getting to know each other (see agenda item 7 in Table 1). It supports public relations work through the presence of political and press representatives. The social media team allows project partners to report event updates online, in addition to the press's presence. Table 1 contains an example agenda of such an event.

Table 1. Example agenda for a kickoff event.

	Agenda item	Description
1	Welcoming the participants	The Consortium Leader of the living lab will greet the attendees, which will serve as an introduction to the event and ensure a personal connection with the attendees.
2	Welcoming by a political representative	A political figure, for example, the mayor or prime minister, gives a greeting. This underlines the political importance and support of the project.
3	Welcoming by a representative of the participants	A representative of the participants, such as a managing director if a company employs the participants, welcomes them. This promotes the presentation and integration of the participants` perspectives.
4	Presentation of the project and the project goals	The project partners present the specific project objectives to the participants and guests with a particular focus on the objectives of the field trial. This ensures clarity and understanding of the project vision and direction.
5	Introduction to the technology	The participants receive a detailed introduction to the technology used by the project partners. This is essential to ensure an in-depth understanding of the technical aspects of the project.
6	Demonstration / A look into the systems	A practical demonstration or insight into the systems makes it possible to demonstrate the functionality and practical application of the system. This gives participants a tangible idea of the technology.
7	Networking and exchange	This part of the agenda provides space for open questions and enables participants and project partners to make contacts. It serves to promote cooperation and the exchange of ideas.

Starting with the trial period, a monthly newsletter will be published to inform participants about the project's current developments. Contents that proved to be particularly suitable for such a newsletter can be found in Table 2.

The newsletter's content should always be tailored to the target group's specific needs, prior knowledge, and interests. With most participants interested in technology, providing detailed insights into technical and operational processes is logical. Additional interactive content, such as links to technical documents, can encourage engagement. In contrast, a target group with less technical background requires a higher-level approach. Visualizations and practical application examples make complex issues more accessible for non-expert participants. An extensive FAQ section that answers basic questions is also recommended. It is crucial to balance detailed information and feedback options.

Table 2. Possible contents of a monthly newsletter with target group: Participants.

	Content-Type	Description
1	Project news	A summary of current information from the project, accompanied by information on technical changes and any delays in implementation, as well as invitations to events. This ensures that all participants are kept updated with the latest project developments.
2	Schedule with milestones	A detailed presentation of the timetable, including the start and end dates of the trial phase, as well as planned online and face-to-face meetings. This enables participants to keep track of important dates and milestones during the project.
3	Answers to frequently asked questions (Q&A)	Answering frequently asked questions that were received via various stage II channels. This point clarifies uncertainties and addresses any of the participant's concerns.

4	Statistics	Presentation of relevant data, such as the amount of energy charged or the total kilometers driven. This provides quantitative insights into the progress of the project.
5	Functionality of the tested use cases	A detailed explanation of how the use cases as part of the project work. This contributes to a better understanding of the practical applications and technological aspects.
6	First preliminary project results	If available, an overview of the first preliminary results of the project will be presented. This enables participants to gain an insight into the successes and challenges.
7	QR-Code for submitting questions and comments	Provision of a QR-Code that participants can use to submit their questions and comments, for example, in the form of a questionnaire that can be used multiple times. These questions can be answered in person at one of the quarterly online meetings or in writing in the subsequent newsletter. This encourages interactive participation and commitment by the participants.

3.4 Participation methods during the trial period

Various communication and interaction measures characterize the trial period. The monthly newsletter is crucial, continuously informing participants about current developments and events. An essential advantage of the newsletter is that the information can be accessed anytime or night without the risk of scheduling conflicts.

In addition to the newsletters, quarterly online meetings are scheduled. These meetings primarily explain the information conveyed in the newsletter in more detail and deepen the background (stage III). Here, interested participants also have the opportunity to gain deeper insights into the technical systems. An essential part of these meetings is a question-and-answer session (Q&A), where participants can target their questions directly to the project partners (stage IV). For a successful Q&A session, the presence of competent project partners to answer technical and operational questions is essential. Via a QR code in the newsletter, participants can submit their questions in advance via a linked questionnaire. Table 3 shows a possible agenda for such meetings. When planning and conducting the quarterly meetings, a balance between information provided by the project partners and the opportunity for the participants to ask questions is essential. This ensures that the events are both informative and interactive. When scheduling the quarterly online meetings, care should be taken to schedule them outside of the participant's working hours and not during school holidays to ensure the highest possible participation rates. A meeting duration of one to one and a half hours provides the project partners sufficient time to report critical information and gives the participants enough room to ask questions. After each quarterly meeting, all participants are provided with documentation, including the presentation, a transcript of the questions, and their corresponding answers. This follow-up ensures that the information conveyed is documented and made available to those participants who could not attend the session.

The last session can have a different structure. Instead of providing detailed information, this session intensely addresses stages IV and V. An interactive discussion, for example, in breakout rooms and the participant's feedback, allows for an intensive examination of specific topics and concerns. Through dialogue between participants and project partners, problems can be identified, and solutions developed that are important for civil society and science. This allows participants to participate actively in the decision-making process. Table 4 shows possible agenda items for a quarterly meeting focusing on soliciting opinions/advice and participation of the participants.

Table 3. Example agenda for a regular quarterly online meeting.

	Agenda item	Description
1	Welcoming the participants	All participants are welcomed at the beginning of the event. This creates an inviting and open atmosphere for the rest of the meeting.
2	Schedule	This section provides an overview of the current situation of the project. It answers questions such as: "Where do we currently stand?" "What has happened since the last meeting?" and "What is planned for the next few weeks?". This point comprehensively informs the participants about the project's progress and outlines a roadmap for the upcoming weeks.
3	Content	Specific aspects of the project are covered here, for example, by explaining the various use cases or demonstrating technical systems. This part of the agenda enables participants to better understand the project's practical implementation and technical details.
4	Q&A	In the final section of the event, there is space for a Q&A session. In addition to questions submitted in advance by the participants via the linked questionnaire in the newsletter, spontaneous questions are also answered. This interactive session promotes a direct dialog between the project partners and the participant. It also enables detailed clarification of specific concerns or uncertainties and accelerates knowledge gain for the project partners.

Besides the quarterly online meetings, a face-to-face meeting is planned halfway through the trial period. This live meeting is intended to intensify the participation of the parties. Unlike online events, the focus here is on bilateral exchange between the project partners and the participants and among the participants themselves. This allows the project partners to learn directly from the participants' experiences in dealing with the system that's being tested. Obstacles that can arise when speaking to a larger online group are eliminated in this case. In addition, confidential conversations provide a framework for addressing sensitive issues. The live event can be supplemented by workshops in which the participants, based on their experience with the use of the infrastructure, work with the project partners to develop solutions to problems that have arisen. Appropriate catering should be provided to create a pleasant atmosphere and increase the presence and duration of the participants' stay at the event.

Table 4. Example agenda for a quarterly online meeting focusing on stages IV – V.

	Agenda item	Description
1	Welcoming the participants	Comp. Table 3
2	Impressions of the participants	Two to four participants can share their experiences during the trial period with the other participants in an extensive plenary session. This point makes exchanging personal impressions and experiences possible and offers valuable insights into individual perceptions of the project. The active involvement of participants in this part of the program should be agreed upon in advance.
3	Feedback and discussions	Depending on the number of participants present, several breakout sessions will be organized to discuss the participants' experiences. In their smaller groups, it is possible to gather detailed feedback and derive specific recommendations for action for the project partners. These sessions encourage interactive participation and enable a deeper examination of the participants' feedback.

Regular user surveys (Stage V) will be conducted during the trial period. These surveys serve to capture user experiences and attitudes based on scientific methods. The results of these

surveys can be used for technical development or to improve the system's user-friendliness. They complement the informal and personal exchange of experiences during online and live meetings. Significant scientific and technological insights can be gained with an entrance survey conducted at the beginning and a concluding survey conducted after the trial period. An appropriate amount of time should be in between each survey. A quarterly survey interval is the optimal balance between cost and benefit.

3.5 Participation methods at the end of the trial period

The trial period will end for the participants with a final event. This event is distinct from the official project ending. The primary goal is to express gratitude to the participants for their participation and inform them about the project's initial results. The final event can be held either online or in person. However, it should be noted that live events require significantly more preparation. The agenda for the closing event is provided in Table 5, outlining what the program might entail.

Table 5. Example agenda for the final event.

	Agenda item	Description
1	Welcome and thanks	The project partners express their appreciation and thanks for the participants' commitment.
2	Impressions of the participants	If requested (comp. table 4).
3	The first results from the trial period	The project partners present initial results, ideally in critical statements or theses.
4	Ending and networking	This point is particularly recommended for face-to-face events. It offers informal exchange and deepening networking among participants and project partners.

3.6 Participation methods during the follow-up

With the completion of a final survey, the scientific data collection of the project ends. From now on, the project partners can fully concentrate on evaluating the collected data. Another critical step is disassembling the installed test infrastructure and the return of the vehicles used in the project. These processes are handled according to the methods of Stage II.

After the official end of the trial period, continuous information from the participants and the civil society about the insights and evaluations gained from the project is of great importance. For this purpose, the participants are kept up to date via a newsletter that is now sent less frequently and other information channels, such as the project's website. This helps maintain the participants' interest even after the project's end and gives them insight into the importance of their participation and the resulting results.

4. Lessons Learned and Recommendations

Implementing the unIT-e² field trials has highlighted that professional, proactive, and regular interactions with the participants are crucial. Therefore, developing an interaction strategy should happen before the participants' acquisition. This allows for an efficient management of expectations and minimizes potential disappointments on the project partners' and the participants' sides.

Early onboarding of the participants is of utmost importance. It helps to avoid ignorance and uncertainties regarding the project's progress, especially in the preparatory phase. Early personal interactions and information dissemination are essential to promote the willingness

of the participants to implement the desired actions. In this context, personalized emails, phone calls, and online events for introducing the project and its procedure have proven particularly effective. They enable the active participation of the participants while maintaining a balanced cost-benefit ratio.

The improvement of knowledge gain - for example, through surveys or active feedback - can be achieved through designated, open communication channels between participants and project partners and active encouragement to participate in open exchange formats like quarterly online meetings or mid-term live events.

Furthermore, implementing live events has proven valuable despite the increased personnel and financial effort. These should be balanced with online events. Project partners have the unique opportunity to learn from the participants' experiences and improve the systems being tested through direct conversation.

Finally, the participants' feedback should be actively gathered and listened to. If the participants desire more intensive participation, consideration should be given to increasing the intensity of interactive exchange formats (Stages III to V). An agile approach can be supportive in this process.

The methods described in this article have proven particularly effective in implementing the unIT-e² living lab in the Harmon-E cluster. However, they can be applied to other living labs in this form. The suggestions presented in this article's figures and tables help ensure optimal participation between civil society and science and achieve the most significant possible knowledge gain. Insights from unIT-e²'s living labs can help optimize interactions and engagement in similar projects. These tools provide a valuable framework for maximizing participants' involvement and scientific depth, thus making a substantial contribution to research and practical implementation.

Data availability statement

The results presented in this article are based on qualitative observations and insights gained during the practical implementation of the unIT-e² research project. There are no quantitative data available that could be made accessible by third parties. The insights and conclusions were derived from direct experience and acquired knowledge, which precludes data sharing in the conventional sense. For further information and inquiries regarding the content, the authors are available.

Underlying and related material

While this paper stands on its own, those interested in a broader understanding of the unIT-e² research project are encouraged to consult additional publications. These works delve into various facets of the project, providing a comprehensive view of the research and its outcomes

Author contributions

The author contributions to this work are as follows: The primary author was responsible for the conceptualization, investigation, methodology, visualization, as well as the writing of the original draft and subsequent review and editing of the manuscript. The second author provided support for these activities, ensuring the robustness and integrity of the work. Collectively, these efforts have culminated in a comprehensive and rigorous exploration of the subject matter, with the primary author undertaking the majority of the work.

Competing interests

The authors declare that they have no competing interests.

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