Next Generation Living Labs

Comprehensive Report

Authors

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Acknowledgments

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Abstract

This report aims to expand on existing logic and knowledge of Living Labs and take into consideration the innovation ecosystems surrounding Living Labs.

Through literature review and the lessons learned from the initiation and implementation of two Living Lab infrastructures in the Building Technology Accelerator Flagship Program (BTA), perspectives are offered focusing on Open Innovation ecosystems, Open Innovation organizational elements, co-creation and data system tools.

The breakdown of the methods as well as the results derived have been synthesized and compiled in this report. Key lessons learned were summarized and categorized using the European Network of Living Labs (ENoLL) harmonization Cube. This was done to provide a more comprehensive set of suggestions for organizations connected to Living Labs transitioning towards Open Innovation and developing Next Generation Living Labs.

We hope This report is a start towards the development of a comprehensive methodology for Living Lab infrastructures within the BTA network and points to important elements for this development.

Foreword

EIT Climate-KIC is the EU's largest public private partnership addressing climate change through innovation to build a zero carbon economy. It consists of four priority themes: urban areas, land use, production systems, decision metrics and finance. Education is at the heart of these themes to inspire and empower the next generation of climate leaders. EIT Climate-KIC is supported by the European Institute of Innovation and Technology (EIT), a body of the European Union.

The Building Technologies Accelerator Flagship Program (BTA) is a flagship project under the Urban Areas Theme. The BTA hosts a network of Living Lab infrastructures aiming to support innovative building technologies and construction services to reduce CO2 emissions and create new businesses and jobs in the European building sector (bta.climate-kic.org, no date).

The Next Generation Living Lab (NGLL) project is a project funded by the EIT Climate-KIC Building Technologies Accelerator (BTA) Flagship Program. This report is a part of the NGLL project that explores and identifies important elements and concepts of Open Innovation (OI) and how they can be applied to Living lab infrastructures to support and catalyze innovation in the built environment. This has been done by selecting two case study living labs from the BTA network and mapping their organizational structures and surrounding ecosystems in order to understand how they can transition to true OI. Finally, tools for Living labs are described and throughout suggestions are made on how to create open innovation ecosystems and organizations that foster and support living lab innovation.

The aforementioned tools were subsequently gathered and categorized using the European Network of Living Labs (EnoLL) Harmonizations Cube. Summed together, these suggest important elements to consider when creating Innovation ecosystems or transitioning an organization towards OI. This is needed in order to foster and support OI in Living Lab infrastructures.

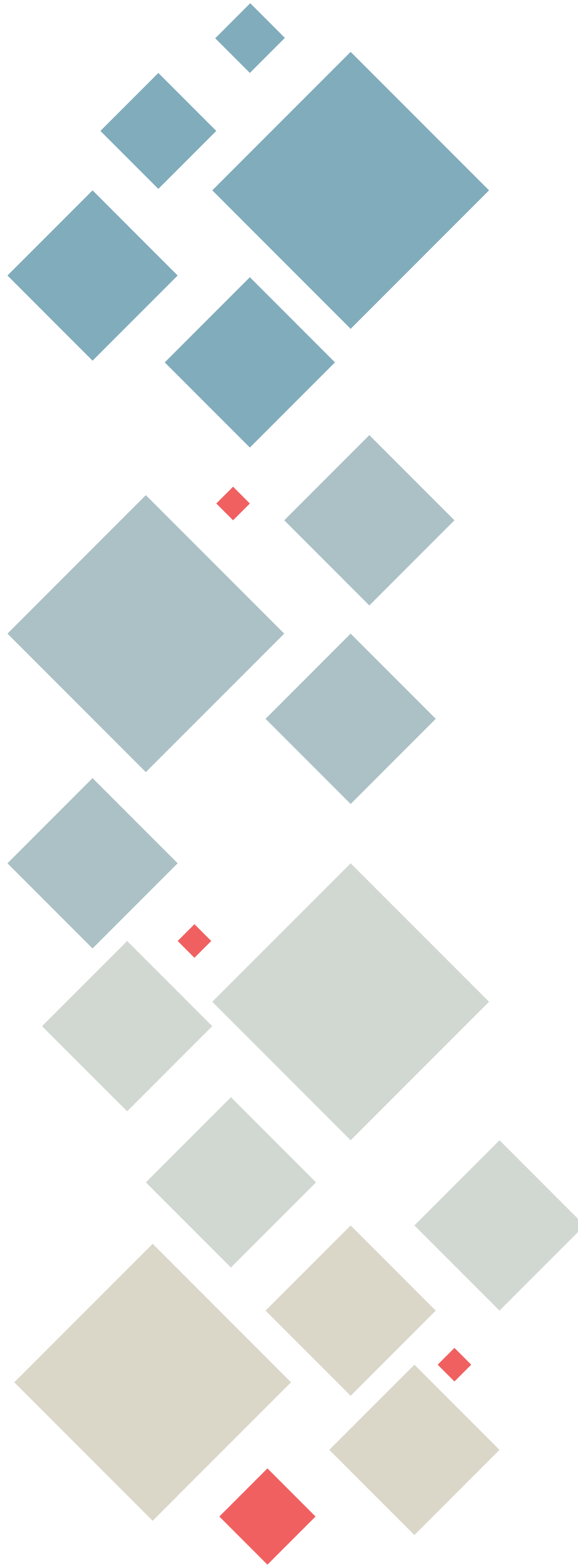


Table of Content

01_INTRODUCTION

Terminology

Living Lab - "A Living Lab aims to turn users into active co-creators of emerging ideas and innovative concepts. A Living Lab is an experimental environment, physical or virtual, where users are immersed in a creative social space for designing and experiencing their own future (McPhee, Westerlund and Leminen, 2012, cited in Hagy and Balaÿ, 2014, p.8)".

HSB Living Lab (HLL) - is a unique research and collaboration project of 12 partners in the built environment sector. The Living Lab is built as a residential building with 29 apartments for students and guest researchers on the campus of Chalmers University of Technology, Gothenburg, Sweden. The involved partners, the available sensor systems, and the established processes all aim to facilitate and develop sustainable solutions for the future of living.

Green Village (GV) - at TU Delft is a xx m2 site that is free from most building regulations, it focuses on systems and integrations testing in the built environment. It is a platform where knowledge institutions and companies will be able to jointly develop and valorise technologies and systems and consists of utility connections, flexible, robust paving, safe and secured site and a flexible layout with landscaping (campusdevelopment.tudelft.nl, no date).

Innovation Ecosystem -"An ecosystem in biological terms can be described as 'an interactive system established between living creatures and their environment in which they live" (Tansley, 1935, cited in Kraus et al., 2009, cited in Jucevicius and Grumadaite, 2014, p.127)" and innovation is the process designed to transform knowledge or ideas into commercial revenue streams. The result of the innovation process can range from new products, to companies, markets and even processes (Smith, 2006).

Innovation Management - Innovation management is a combination of the management of innovation processes, and change management. It refers both to product, business process, and organizational innovation.
Innovation management includes a set of tools that allow managers and engineers to cooperate with a common understanding of processes and goals. Innovation management allows the organization to respond to external or internal opportunities, and use its creativity to introduce new ideas, processes or products (Kelly and Kranzberg, 1978, cited in Simsit, Vayvay and Öztürk, 2014, p.691).

Co-Creation - methodology based on the fact that new knowledge and insights are generated when bringing together people from various relevant disciplines, and through creative and collaborative methods inspire them to discuss and come up with new ideas or concepts. (Hughes, 2014)

Building Technology Accelerator Flagship Program (BTA) - is a Climate KIC flagship that hosts Living Lab Network in Europe and supports innovative building technologies and construction services to reduce CO2e and create new businesses and jobs in the European building sector (bta.climate-kic.org, no date).

EIT Climate KIC (C-KIC) - Europe's largest public-private innovation partnership focused on climate change, consisting of dynamic companies, the best academic institutions and the public sector (climate-kic.org, no date).

Open Innovation (OI) - is a "paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology. Open innovation provides opportunities to both reach a previously unknown or unreachable market as well as create new markets"
(Chesbrough, Vanhaverbeke and West, 2006, cited in Hagy and Balaÿ, 2014, p.10).

Pop-up Living Lab - is a movable infrastructure that includes tools that support and foster the Living Lab methodology and open innovation. These tools could include; co-creation for active user engagement and stakeholder communication as well as data gathering systems for iterative processes needed to develop innovations.

The Innovation Challenge

On a global scale, buildings emit 36% of CO2 emissions, and energy consumption has been increasing in recent decades (Edenhofer et al, 2014). At the same time, the building industry accounts for approximately 8% of jobs and roughly 10% of global GDP. Thus, the building stock is often identified as one of the largest and most untapped potentials for energy efficiency improvement, greenhouse gas mitigation and economic development opportunities (Economidou et al, 2011).

Technical options to decrease energy demand are readily available, well understood and, in many cases, economically viable (Friege and Chappin, 2014), still, further innovation is needed to unwrap their full potential, including greater health, social and economic features.

Given that the building sector is one of the slowest in the adoption of innovation (Hagy and Balaÿ, 2014), further initiatives, tools and platforms are needed in order to enhance innovation. Living Labs provide Open-innovation environments, which in combination with established open innovation ecosystems and respective stakeholder organizations can serve as an effective platform to foster the development and uptake of innovation in the building sector.

NGLL Project Aim

"A Living Lab aims to turn users into active co-creators of emerging ideas and innovative concepts. A Living Lab is an experimental environment, physical or virtual, where users are immersed in a creative social space for designing and experiencing their own future"(Hagy and Balaÿ, 2014, p.8).

Living Labs recently emerged and have been identified as being key to innovate in the Built Environment through Open Innovation (OI) processes and are by nature open innovation environments. However, often the Innovation Ecosystems surrounding Living Labs, as well as the organizations in those ecosystems have not developed to a degree for true implementation of OI processes. Next Generation Living Labs are Living Labs that are embedded in strong OI ecosystems where all the respective organizations have systematically transitioned and reshaped their structure and culture to be able to foster OI. These could be larger more permanent infrastructures embedded in existing ecosystems such as those found at universities, but also smaller more mobile infrastructures such as a pop-up Living Labs.

Living Lab infrastructures should allow product and service development and testing in a real- world test-bed with users and other partners at eye level. Common interests and curiosity drive the assembly of Living Lab consortia and lead to defining processes for the Living Lab infrastructure orientation. The planning in this system starts with budgeting, a clarification of roles and responsibilities as well as setting up rules for enhanced cooperation between partners, who have not worked together so closely ever before. This is key for OI, but it is also a challenge to create a Living Lab infrastructure that includes all stakeholders involved to the highest possible level. To reach this, the main features are modularity, adaptability, co- creation, openness and societal integration. A comprehensive analysis and subsequent method for creating such Next Generation Living Lab infrastructures and supporting organizations are missing.

The 'Next Generation Living Lab' project (NGLL) complements the work done around ENoLL Harmonization Cube. The Harmonization Cube is a technique that enables a shared reference of methods and tools of Living Labs, includes their most important elements, and provides a tool for exchange of best practices (Mulder, Velthausz, and Kriens, 2008). The NGLL project focuses on the organizations and ecosystems that are involved in Living Lab infrastructures and how these organizations need to embrace and practice OI in order to be able to use the Harmonization Cube and effectively engage in Living Lab environments.

This report aims to expand on that logic and take into consideration the innovation ecosystems surrounding Living Labs. This offers a perspective on OI ecosystems, OI organizational elements, co-creation and data system tools through the lessons learned from the initiation and implementation of two Living Lab infrastructures in the Building Technology Accelerator Flagship Program (BTA) network. This report is a start towards the development of a comprehensive methodology for BTA Living Lab infrastructures and points to important elements for this development.

Methodology

The framework developed in the 'Next Generation Living Lab project' is based on the study of two case Living Lab Infrastructures within the EIT Climate-KIC Building Technology Accelerator Flagship Program. These are, the HSB Living Lab and the Green Village. These living labs were chosen out of the five BTA Living Labs. These two infrastructures were used as case studies to explore, identify and compare the components needed in successful Living Lab infrastructures.

For the purpose of this study, qualitative research methods were used in a three-step approach. First, a literature review was performed to identify state of the art knowledge on OI ecosystems and organizational structures. Second, stakeholder interviews were performed to acquire information and experiences related to the establishment of Living Lab infrastructures. The interviews were based on semi-structured method. Third, a workshop with the most relevant stakeholders was done, exploring specific technologies and how they may fit into an innovation pipeline and ecosystem at the HSB Living Lab.

The breakdown of the methods as well as the results derived from it, have been synthesized and compiled in this report. Each step of the process is defined in an individual section. Key lessons learned from each step have been located in the toolbox at the end of each section and were summarized at the end and categorized using the ENoLL harmonization Cube. This was done in order to provide a more comprehensive set of suggestions for potential future users of this report when transitioning towards OI and developing Next Generation Living Labs.

Case Studies

Name: -HSB Living Lab

Location: -Johanneberg Campus, Chalmers University of Technology Gothenburg, Sweden

Mission/Aim: -facilitation and development of sustainable solutions for the future of living

Form : -4 story apartment building

Size: -463 square meters (footprint)

Key Aspects: -29 apartments that can accommodate up to 40 students and researches
-prototyping/co-creation lab available both for partner organizations and external stakeholders
-2000 sensors
-12 exchangeable wall elements
-common ground floor spaces (public/private use)

Name: -Green Village

Location: -Delft University Campus, TU Delft, Delft, The Netherlands

Mission/Aim: -accelerating innovation for a sustainable future

Form : -a green field at the TUDelft Campus where the Building Code is not applicable, and where basic infrastructure is available

Size: -terrain approx. 100 x 150 meters

Key Aspects: -facilitates and accelerates sustainable energy technology in built environment
-can facilitate all innovations that would fit a normal street (i.e. underground infrastructure, roads, houses, offices, cars bikes, charging, etc.)
-provides the location and regulatory framework. The project owners are responsible (financially and organisational) for the projects. Per project a financial contribution to the platform is paid.

figure 1.1.1: HSB Living Lab, Gothenburg, Sweden (photo: Felix Gerlach)

figure 1.1.2: Green Village, Delft, The Netherlands (photo: Shea Hagy)

Toolbox

LIVING LABS ARE PUBLIC RESEARCH ARENAS

ENGAGING USERS AS ACTIVE CO-CREATORS SUPPORTS OI

ESTABLISHING CLEAR ROLES AND RULES FOR ENHANCED COOPERATION

LIVING LABS ARE CREATIVE SOCIAL SPACES

MODULARITY, FLEXIBILITY, ADAPTABILITY, OPENNESS, SOCIAL INTEGRATION ARE KEY

ESTABLISHING AN EFFICIENT COLLABORATIVE FRAMEWORK/ INFRASTRUCTURE

STRUCTURE AND CULTURE OF NETWORKS AND ORGANIZATIONS SURROUNDING LL NEED TO FULLY EMBRACE OI

02_ LIVING LAB STRUCTURES

2.1 INNOVATION & ECOSYSTEMS

The aim of this chapter is to describe the concepts of Open-Innovation Pipeline and Innovation Ecosystem in relation to Living Labs. The first section of this chapter is dedicated to briefly define what open and closed innovation as well as innovation systems are. This is followed by a presentation of the living lab's positioning and the analysis of the two living lab case studies in relation to these terms. The concepts have been incorporated into a general diagram showing an innovation ecosystem structure that is then used to map the two case studies. "Mapping" in this context refers to the allocation and identification of the various known entities in each case study ecosystem and their respective roles pertaining to that ecosystem. In the final section, a discussion of the key elements presented along the chapter takes place.

> *"Innovation is the process, including its outcome, by which new ideas respond to societal or economic needs and demand and generate new products, services or business and organisational models that are successfully introduced into an existing market or that are able to create new markets and that provide value to society;" European Institute of Innovation and Technology (EIT)*

Closed and Open Innovation

In the following section a brief overview of closed and open innovation concepts are described. This is done in order to better understand how these innovation concepts differ from one another and highlight key elements of OI, which will be developed further in the next chapters.

Closed innovation (CI) is the conventional industrial approach where the innovation process is based on traditional goods-dominant New Product Development (NPD). This process includes detailed planning, relying on in-house capabilities, and operating under secrecy and functions according to a linear pipeline model (Chesbrough, 2003a, b, 2004; Michel et al., 2008, cited in Sivunen et al., 2013). A common way to conceptualize the traditional NPD process is the stage-gate model. In stage-gate systems, methods similar to product manufacturing processes are used to manage the innovation process. The development process is divided into sequential stages with decision gates between them, which act as quality control checkpoints. Although there is some variance in the practice, the set of stages often resembles the following: preliminary assessment of potential R&D ideas; detailed investigation; development; testing and validation; and full production and market launch (Phillips et al., 1999; Ettlie and Elsenbach, 2007, cited in Sivunen et al., 2013).

"There is evidence that innovation processes like the stage-gate model have been successful in improving a company's NPD" (Ettlie and Elsenbach, 2007, cited in Sivunen et al., 2013, p.148), however, it is debated if they can be successful for innovation activities focused on discontinuous innovations.

The development of discontinuous innovations is high-risk by nature and therefore needs to be handled differently than linear NPD innovations. The use of spiral gate process is one way of dealing effectively with discontinuous innovations. To be successful in this it has been suggested that companies need to utilize resources external to their organizations (Sivunen *et al.*, 2013), i.e. open innovation. Spiral-gate and OI processes should be used within the BTA Living Labs, as they aim to address complex challenges (climate mitigation and sustainability focused technology within the built environment) and consist of a large and diverse network of partners and programs. Furthermore, open-innovation is endemic to the Living Lab concept and methodology.

The foundations of successful innovation processes have been shifting away from developing technologies 'in-house' towards a technology development process that interacts and uses external knowledge and resources. This, for example, can include collaborations with different suppliers, both competitive and non-competitive companies, academic institutions and end users. (Chesborough, 2007, 2008, cited in Sivunen *et al.*, 2013).

Open innovation (OI) is a "paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology. Open innovation provides opportunities to both reach a previously unknown or unreachable market as well as create new markets" (see figure 2.1.1). (Hagy and Balaÿ, 2014, p.10).

Therefore, open-innovation processes are suggested as essential to meet the needs of the dynamic multi-stakeholders networks of the BTA Living Labs. Due to the complexity of OI simplified representations are needed to manage and communicate its processes.

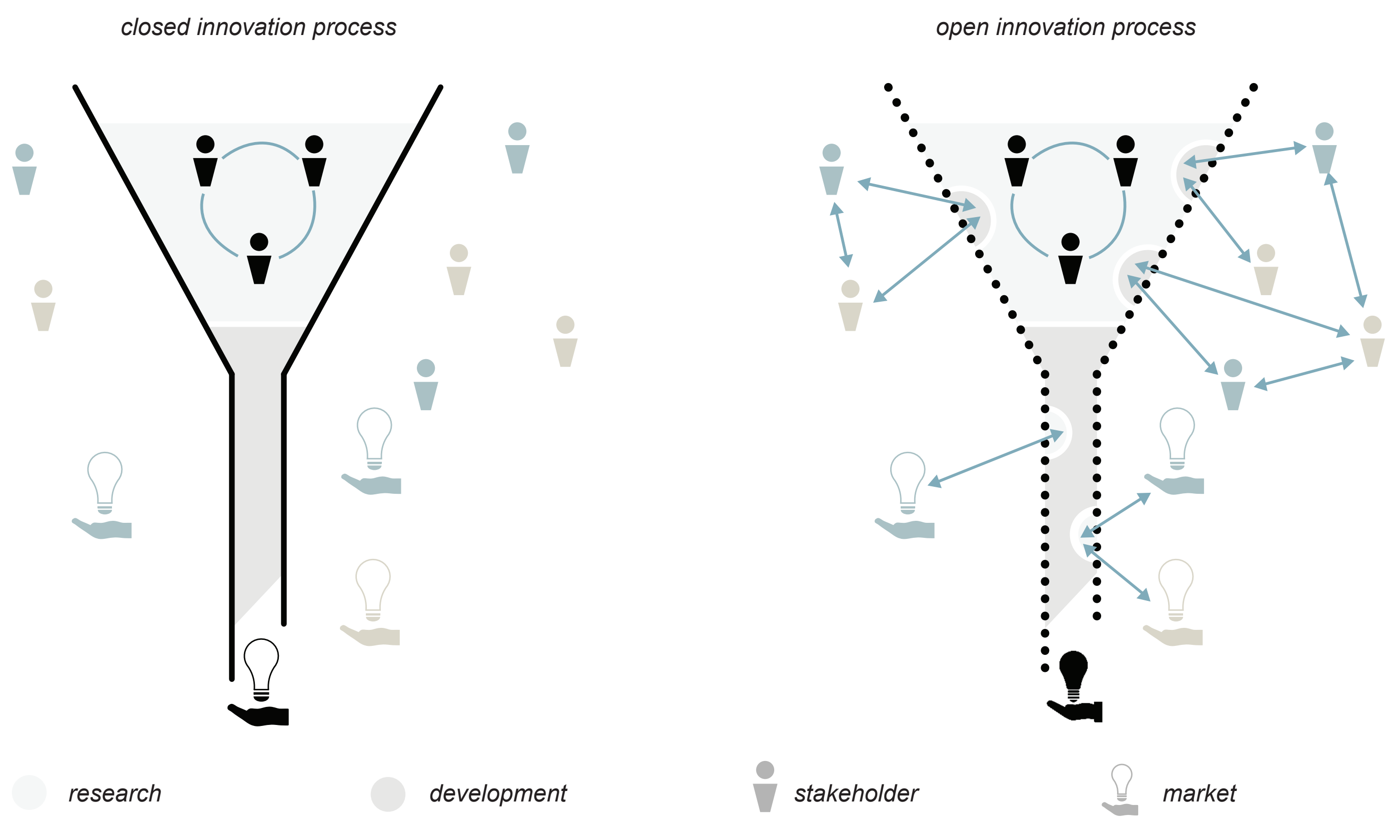


figure 2.1.1 Closed vs open innovation funnel (adapted from Chesbrough, 2004, cited in Hagy and Balay, 2014)

Innovation Management

Innovation management is a combination of the management of innovation processes, and change management. It refers to product, business process, and organizational innovation. It provides managers and stakeholders a way to cooperate with a common understanding of processes and goals. Innovation management allows organizations to respond to external or internal opportunities, and use its creativity to introduce new ideas, processes or products (Kelly and Kranzberg, 1978, cited in Simsit, Vayvay and Öztürk, 2014, p.691).

Innovation management encompasses many aspects and elements, some of which are commonly described in diagrams such as with pipelines, funnels, frameworks, etc. Different organizations choose different approaches to illustrate their process. For example, the EIT Climate-KIC's innovation process is described through what they refer to as the 'Innovation Framework' (see figure 2.1.2). It encapsulates innovation management best practice and provides a methodological framework where the value propositions of the organizations are contained. It is used as a communication tool to show how to (1) achieve shared objectives with stakeholders, (2) explain use of funding to funders, and (3) guide and engage the EIT Climate-KIC community (Barker, no date). This framework was specifically created to address the complex nature of climate innovation processes.

Using simplified management diagrams and structures is a challenge as innovation can take a long time and usually defies structure. Diagrams and descriptions of the innovation process are then useful and necessary in simplifying and understanding what is a complex and often chaotic process by nature.

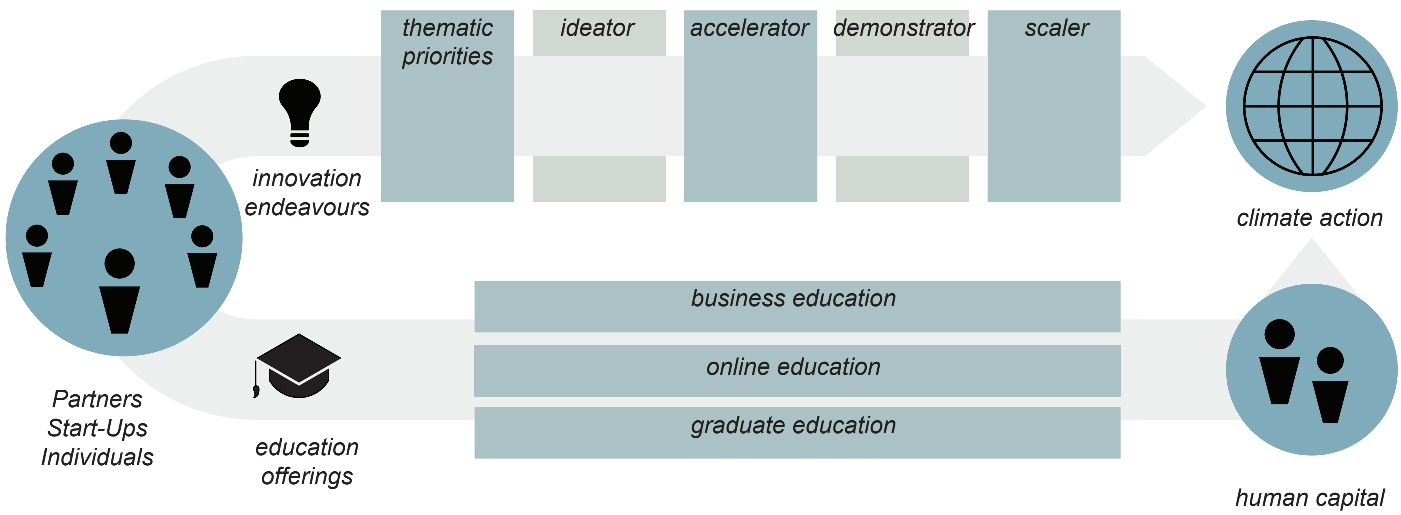


figure 2.1.2: EIT Climate-KIC innovation Pipeline diagram (adapted from Barker, no date)

This means that the reality of innovation processes is one where nothing follows the classic path of progress (figure 2.1.3). Many ideas fail and even appear to go backwards, or come to a stop along the way, only to start up again later (Barker, no date).

Innovation management representations, such as figure 2.1.2, while created to address the complexity of climate innovations and large networks, still lack an iterative and co-creative layer needed to represent Living Lab processes. Therefore, an innovation management diagram pertaining to Living Labs must be more complex than more traditional representations but at the same time remain simple in order to be understandable and usable. Figure 2.1.4 shows a conceptual overview of a linear innovation funnel combined with iterative Living Lab innovation processes. This concept should be further developed for each specific Living Lab and/or innovation case.

Using such an innovation management diagram can help when implementing projects within a living lab infrastructures. However, these management diagrams do not account for the diverse set of actors needed for OI. Actors from different organizations engage, with their respective resources/knowledge, at different moments in the innovation process. The relationships between these actors will also adapt based on the ideas, processes, products or technologies that are in the various innovation pipelines. This is where the Innovation Ecosystem becomes a tool to understand these relationships and their position in the respective innovation management process.

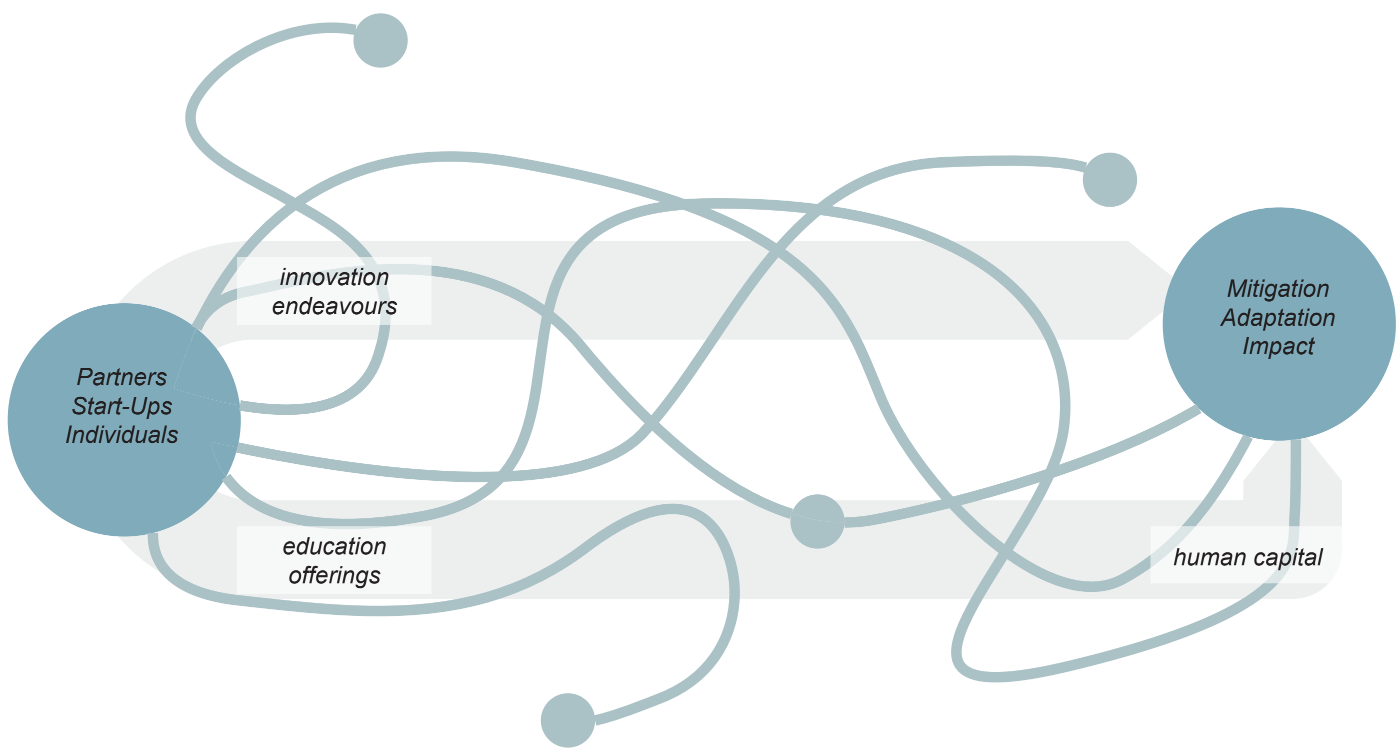


figure 2.1.3: Reality of the Innovation Process (adapted from Barker, no date).

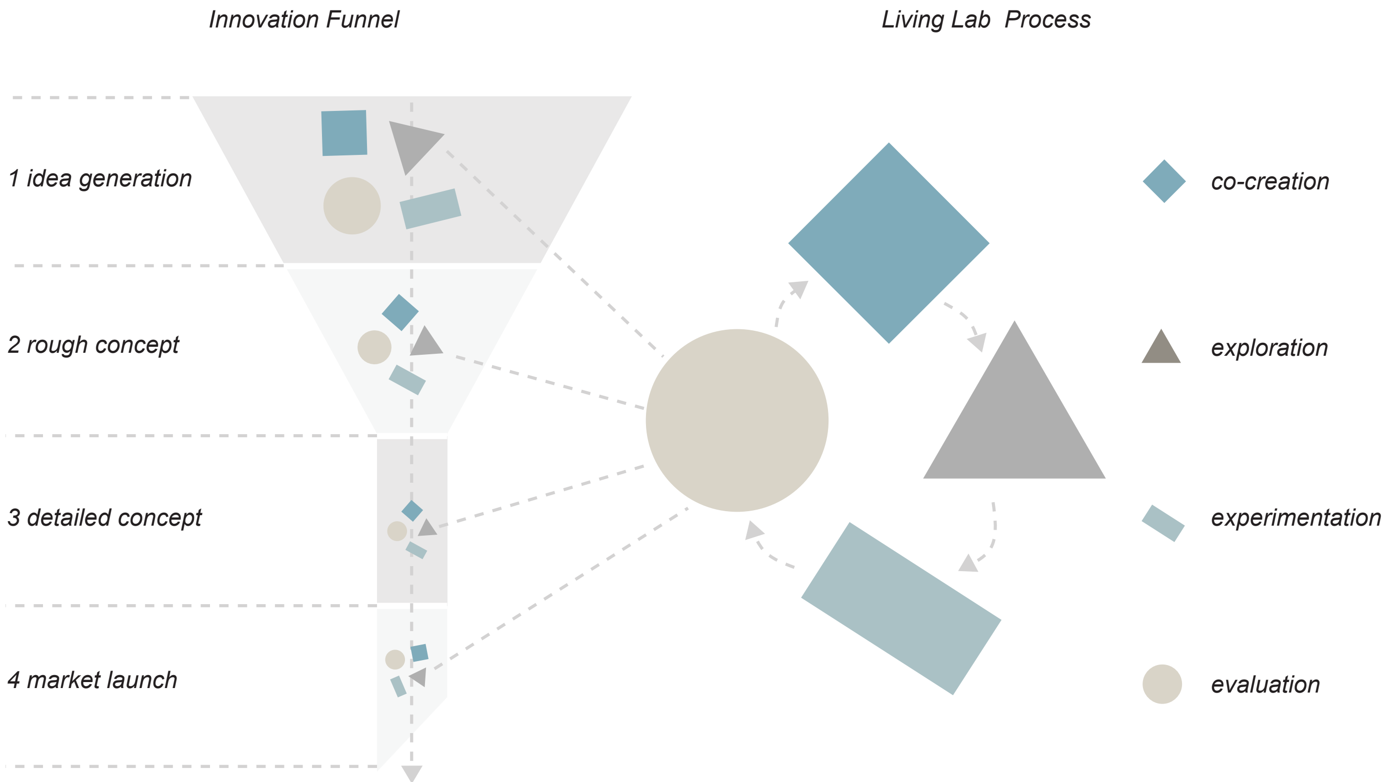


figure 2.1.4: Combination of innovation funnel and Living Lab iterative process

Innovation Ecosystem

An ecosystem in biological terms can be described as "an interactive system established between living creatures and their environment in which they live" (Tansley, 1935, cited in Kraus et al., 2009, cited in Jucevicius and Grumadaite, 2014, p.127). On the other hand, innovation is the process designed to transform knowledge or ideas into commercial revenue streams. The result of the innovation process can range from new products, to companies, markets and even processes (Smith, 2006).

The ecosystem concept has been applied to innovation and business in order to better understand the interactions between actors surrounding business and innovation. There is extensive literature discussing and describing these concepts of business and innovation ecosystems. The intent here, however, is to look at the Innovation Ecosystem concept and apply it to Living lab Infrastructures and their involvement towards supporting innovation in the built environment. The creation of an innovation ecosystem model for Living Labs and subsequent case study 'mapping' is needed in order to provide insights on how to strengthen such systems and in turn increase the impact of Living Labs towards market implementation of sustainable innovation.

As with biological ecosystems, innovation ecosystems are complex with extensive interconnections, large quantity of actors and entities and constantly changing and adapting. An in-depth understanding of these interactions, actors and changes allows the actors to better understand their roles, identify gaps, and work together to evolve to meet the demands of the rapidly changing markets and associated paradigm shifts. Before an in-depth analysis and competency can be achieved a simplified structure and general understanding is needed, herein lies the aim of the following sections.

The Living Lab Perspective

The stated goal of the EIT Climate-KIC's Building Technology Accelerator Flagship Program (BTA) is to "support innovative building technologies and construction services to reduce CO2 and create new businesses and jobs in the European building sector" (bta.climate-kic.org, no date). To achieve this the BTA works through its network of Living Labs which are real-life infrastructures, both of 'permanent' and 'temporary' (POP UP LL) nature, consisting of home or work environments. Living Labs can be situated in different settings and are used for testing and research in the building sector where inhabitants/users are engaged in product testing and providing feedback to the Innovating Organizations.

The BTA Living Lab network aims to provide OI infrastructures that support the global transition from an industrial economy through the knowledge economy and into the creative/innovation economy. In order to be successful in this new creative economy, innovation must combine technical potential and creative ideas with business opportunity (Smith, 2006). This is most viable through Open-Innovation, and the creation of comprehensive Innovation Ecosystems as described in the previous section.

In order for the BTA to successfully meet its goal it is necessary to develop strong ecosystems around the existing Living Lab infrastructures and ensure that the essential components are present, supported and have the capacity to evolve and adapt.

After surveying the literature no generic Innovation Ecosystem model was found that could be used to incorporate both Living Lab infrastructures and the built environment, yet a simplified generic model to use for mapping the case studies was still needed.

In order to produce a more accurate representation of the Innovation Ecosystem for Living Lab infrastructures, the following methodology was followed: (1) literature review; (2) interviews with various actors working within both the HSB Living Lab and Green Village Living Lab ecosystems; (3) a workshop done with end-users and actors both internal and external to Living Lab ecosystems; and (4) the authors' own experiences working with innovation and research within the HSB Living Lab ecosystem.

Open-Innovation Ecosystem Diagram

The process of developing a 'new idea' until it reaches a full market roll-out is described as a stream up the hill in figure 2.1.5. The support which can be received along the way is illustrated as 'fish ladders' where the ideas (represented in the figure by the fish) can easily climb up the stream. The stronger ideas which need less support can sometimes take a shortcut and skip the ladders to get further up the stream faster. Below the hill, in the Innovation Lake, all the actors who play a role within the innovation ecosystem can be found. The Innovation Lake gets nourished by inflows (3,4,5) from the rivers leading to it (representing elements which contribute to creating a stronger innovation ecosystem). Depending on the amount of inflow reaching the lake from the rivers, the shoreline can expand or contract, allowing for the innovation ecosystem to get larger or smaller.

As seen in the figure, when an idea is conceived or generated, it may or may not need more support from other actors (represented in the figure as the lake) within the ecosystem in order to develop further and eventually reach the market. The phases where support may be needed is in validating/developing the idea, validating the market and introducing the idea to the market. Some ideas may not need much of this support if the idea is already in a more mature stage of development, or if it is run by a large company which has a lot of internal resources for developing a business model and financing the development of the idea.

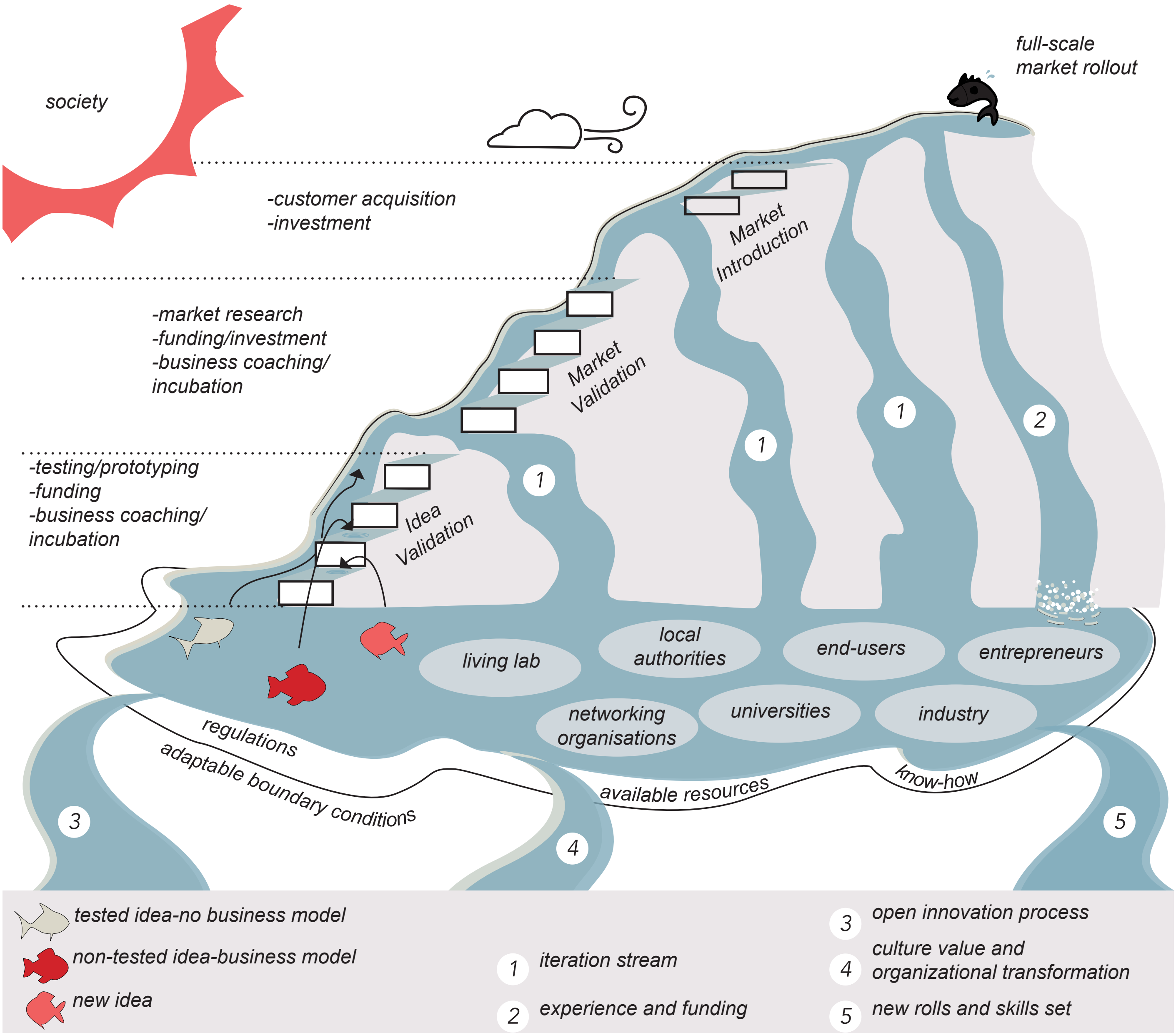
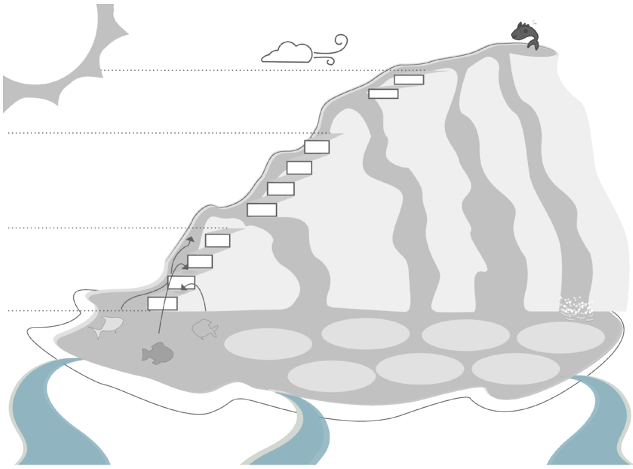


figure 2.1.5: Innovation Ecosystem (adapted from DiGiorgio and Harris,2013; Smith, 2006)

Inflow streams, innovation lake and shoreline



The inflow streams represent three overarching components of an Innovation Ecosystem According to Smith (2006).

(1) The Innovation Process: Describing the way organizations a) generate and capture, b) evaluate and select, c) develop and shape, d) commercialize ideas and technologies. "This process needs an exceptional level of cross-functional cooperation, thus there must exist a culture that values and rewards those involved in the innovation process"(Smith, 2006, p.222).

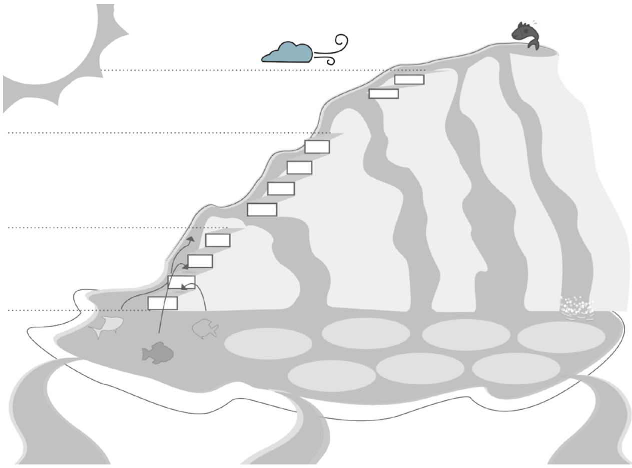
(2) Culture, Values and Organizational Transformation: Here the goal is to both support creativity and capture value, where the actors within the ecosystem work within a process but are flexible with regard to the engagement of those closest to both the customer and competition. The university as an actor can create new relationships between scientists, both students and academics, and business students that can then investigate the commercial potential of the research ideas. To be successful in accelerating the rate of innovation, organizations must create an openness that neutralizes organizational resistance to change. Many good ideas are rejected before their potential has been fully understood (Smith, 2006). "Radical innovations are not the product of exploitation, but rather exploration" (Roberts, 2004, cited in Smith, 2006, p.222). The organization should work on the people and the culture in what Roberts refers to as 'high commitment human resources management' (Smith, 2006).

(3) New Roles, Responsibilities and Skill Sets: These must support the process and culture of innovation. The innovation culture of any unit depends largely on the attitudes of its supervisors. "Senior managers must have the abilities to delegate, develop and empower, to develop relationships and build teams, and to reconcile differences while maintaining tension" (Bartlett and Ghoshal,1997, cited in Smith, 2006, p.222).

These components as described are necessary for a healthy open-innovation ecosystem and are represented as 'inflow streams' (3,4,5) into the ecosystem in figure 2.1.5. In the figure another important aspect is flexible boundary conditions shown as the 'shoreline'. This 'shoreline' is made up of regulations, available resources, and know-how. As these change, so too must the 'shoreline' boundaries, as ecosystems are not static states rather they are constantly changing and adapting.

The different levels of development of the ideas are illustrated as different types of fish in figure 2.1.5. There are three types of ideas included in this diagram. The first type is simply the 'New idea', it is a completely new idea of an innovation or a solution which has not been tested and does not have any business model developed around it, this idea is likely to need a lot of support to reach the market (i.e. the top of the hill in the figure). The other two types of ideas are the 'Tested idea without business model' and 'Not tested idea with business model'. These two types are likely to need less support and are more likely to reach the market faster. In the figure they are illustrated by two other types of fish which are able to sometimes skip the fish ladders (the development support) and swim up the stream by themselves.

Inspirational and Sparking Events

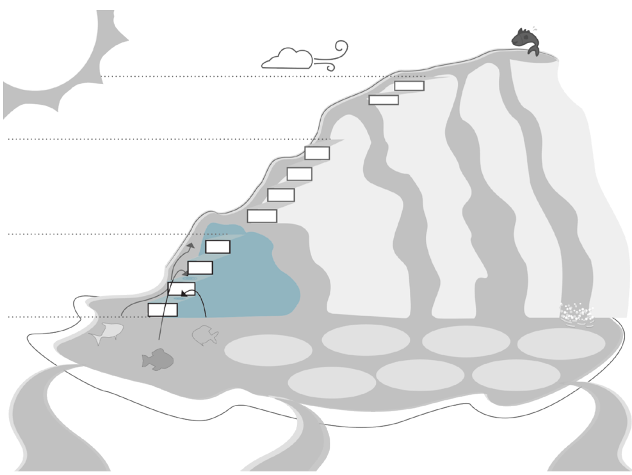


The wind clouds in figure 2.1.5 represent inspirational and sparking events, these can vary over the years but are generally pitching or demonstration days as well as challenges in the form of hackathons, workshops or online competitions, etc. These elements are often considered as essential parts of a healthy innovation ecosystem and can contribute to both new ideas being generated as well as means to acquire relevant contacts, partners or funding needed in order to take an innovation to the next stage.

The nature of such events varies depending on the organizers and context. There are some identified recurring events related to the BTA, Chalmers and TU Delft, which can be placed in this category. The EIT Climate-KIC Climathon and YES! Delft Discovery Day, which focus on idea generation and inspiration of innovation development. At HSB Living Lab, Chalmers frequently hosts co-creation workshops (see Co-creation Workshop Chapter). In addition, EIT Climate-KIC regularly hosts the Climate Launchpad which is somewhat similar to the previously mentioned events but where participants bring their own innovation ideas to develop during the event, which then have the chance to be accepted into the EIT Climate-KIC Accelerator program.

Other hackathons, challenges and workshops which may occur on specific topics in context with other projects or events, may be important elements within the innovation ecosystem as well. Examples of past events related to the BTA and EIT Climate-KIC are the Climate-KIC Circular challenge in Amsterdam and the SOLution in Gothenburg. Events of this character can have the effect of bringing together people from different backgrounds and create synergies which can trigger innovative ideas to emerge. These events can also help people who already have an idea to find potential collaborators and become inspired to take the ideas further.

Idea Validation/development



The phase of Idea Validation/Development is generally where the new idea is tested and developed. Here an evaluation is done of how well the idea functions and fulfills its purpose. Through the testing process iterations can be performed, new ideas can be uncovered or new purposes for the original idea can be identified. An 'Iteration stream' is illustrated in figure 2.1.5, where the idea fish swims back into the 'Innovation lake'. Here the innovating organization can interact with support and input from the stakeholders in the innovation lake, after which the idea can be tested again. If it turns out the idea functions well in the validation and testing process it may continue to the next phase. Some actors might have already tested their ideas, these are represented in the figure as the fish with tested idea and no business model, this idea may skip the fish ladder, i.e the support in the Idea Validation phase and move on directly to Market Validation.

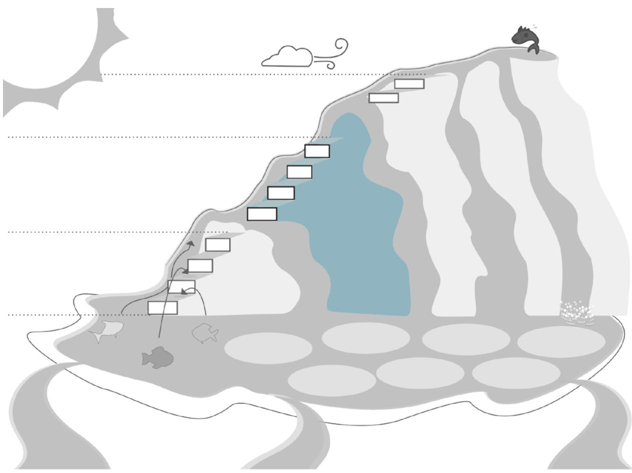
Common activities within the Idea Validation phase, and those which may require support from other actors within the innovation ecosystem, are the following:

(1)Testing the idea: Generally new innovations are tested in conventional laboratories at universities, institutes or industries active in research and development. In order to speed up the process of taking the idea from laboratory out to the market, ideally a living lab is utilized in this phase. To get direct user feedback and allow for full-scale testing in real-world conditions.

(2) Funding: This is an early phase of the idea development and funding may generally be acquired from sponsors, incubation programs, research funds or in-house resources if developed by a financially strong actor.

(3) Business coaching: Support in this phase may come from incubation programs, innovation support at university or mentors active in the industry.

Market Validation



When an idea is validated and it shows that it can work, it is time to evaluate its market potential. The second fish ladder in figure 2.1.5 represents the support a new idea might need in the Market Validation phase. An idea which is generated within a large company might have in-house resources to easily develop the idea in a way that also fits with the business plan of the company. However, support from other organizations within the ecosystem should be utilized in order to maximize the potential of the idea and even find new markets and business models. If findings in this phase show that there are weaknesses in the market potential of the idea, the idea may need to go back to the beginning of the process (the Iteration stream in figure 2.1.5). From there the idea can be improved and reworked in order to strengthen its market potential. If needed, it may be tested again in the Idea Validation phase, or skip it and go directly back to the Market Validation phase.

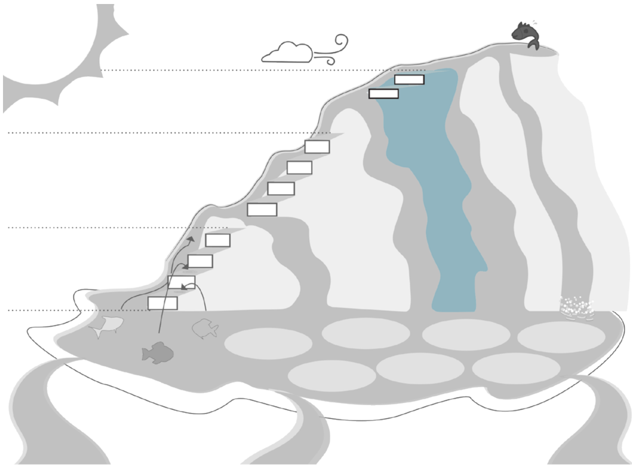
Common activities within the Market Validation phase, and those which may require support from other actors within the innovation ecosystem, are the following:

(1) Market research: i.e. Students in entrepreneurship and business development can use the idea as a case study in their studies and thereby support the development of the idea. Further, the university's service in innovation support may be of help. Other actors in the ecosystem may also be clients and can provide unique insights into market potentials.

(2) Funding or investment: Similarly to the funding in the Idea Validation phase, it might be acquired from incubation programs or research grants, etc. When the idea reaches this phase it might also be relevant to look for potential investors, this can ideally be supported by organizations with wide networks within industry.

(3) Business coaching: Support in this phase may come from incubation programs, innovation support at university or mentors active in the industry.

Market Introduction



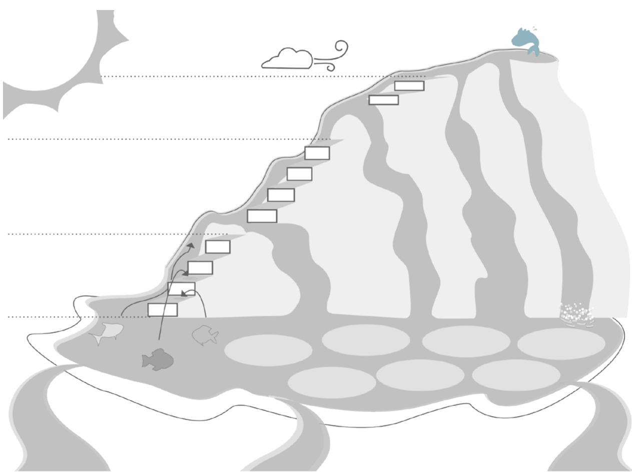
In this phase the idea is ready to be introduced to the market. Less support is generally needed here since the crucial stages of investigating if the idea works or not are already completed. Ideas developed within companies have generally an easier process, since the company's existing customers and finances can be utilized when introducing the new idea to their own market. Being a part of an open-innovation ecosystem allows for the potential to find new markets. Similarly to the two previous phases, even here an iteration loop might be needed, in case the market introduction is not successful. This is illustrated as a third Iteration stream in figure 2.1.5.

Common activities within the market introduction stage, and those which may require support from other actors within the innovation ecosystem, are the following:

(1) Customer Acquisition: Organizations with wide networks including industry, institutes and authorities may be useful in order to reach desired target groups. Further, direct collaborations with industry actors may be very useful.

(2) Investment**:** At this phase it is normally less focused on acquiring grants, etc. Ideally, investment can be found through support from organizations with wide networks within industry or collaborations with other industry partners.

Full-scale Market Roll-out



If a market introduction is successful, the idea may reach more and more customers and eventually achieve a full-scale market roll out. At this stage the idea is capable to stand on its own, support from other actors within the innovation ecosystem is not needed in the same way anymore. The activities within this phase are not described or analyzed further since it is out of the scope of the purpose of this investigation. However, it can be noted that in this phase, money which is earned from sales can be reinvested in new idea development as well as experiences gained from the whole process. This is illustrated as the waterfall in figure 2.1.5, which is flowing back into the Innovation lake and 'nurturing' the whole innovation ecosystem with both new experiences which may be shared and money which may be invested in new idea development.

Case Studies

Two living labs within the BTA network were chosen for evaluating the innovation ecosystem around them. This was done in order to demonstrate how the innovation ecosystem mapping can be used as a tool to identify gaps and weaknesses within the ecosystem and how to address them. Choosing the HSB Living Lab (HLL) as one of the case studies was a natural choice since the main authors are located at Chalmers University and have been directly involved with the creation and development of HLL. The other case study is The Green Village at TU Delft, which was chosen since it is the other 'non-office' focused living lab within the BTA and therefore allows for a better comparative study.

The assessments are based on information gathered through interviews with several actors within the two innovation ecosystems in combination with the author's own experiences. To ensure an unbiased evaluation, the assessment tables were also sent to all of the interviewees to obtain their perspectives in a second iteration. A list of all interviewees is included in the reference list of this report. Further, a workshop on the topic of innovation pipelines/processes was performed where innovations currently being tested in HSB Living Lab were used as examples. The workshop helped to identify gaps in the innovation ecosystem as well as functioned as a test to evaluate how the innovation process can be easily communicated in the context of open innovation and living labs.

The two case studies are presented in the two following sections, with four tables within each section. The first table, Actors and their engagement in the living lab, identifies the roles of each actor within the innovation ecosystem around the living lab. In the middle column, each actor's current known engagement in the living lab is briefly described. In the right column, suggestions have been made on how their engagement could be changed in order to strengthen the innovation ecosystem, based on the needs and elements outlined in the Living Lab focused open-innovation ecosystem diagram from the previous section.

In the three remaining tables the actors, within the respective innovation ecosystems, are listed based on their capacity to contribute in each of the main activities within the three different general stages of the innovation process; Idea Validation/Development, Market Validation and Market Introduction, respectively. In the two columns to the right it is first stated what capacity the actors possess (in terms of specific programs or general skills and knowledge), secondly it is described what measures could be taken for engaging the actors more directly in the living lab and thereby strengthening the innovation ecosystem and innovation processes.

HSB Living Lab (Chalmers)

Table 2.1.1: Actors and their engagement in the HSB living lab

Actor (ecosystem role according to figure 2.1.5)	Current engagement in HLL	Potential strengthening measures
Chalmers (University)	• One of three main partners in HLL consortia • Research • Responsible for HLL building as a research infrastructure (sensor network and data)	• Implement fee system for projects in HLL in order to fund further advancement of the infrastructure • Engage all departments at Chalmers to use living lab for research and prototyping • Simplify and clarify 'project process'
Industry partners within HSB Living Lab consortia (Industry R&D)	• Run own projects in HLL • Collaborate in other organizations' projects in HLL • Provide and use funding of HLL research fund	• Act as mentors or advisors to other projects in HLL run by academia and SMEs • Engage in more knowledge sharing to foster open innovation
HSB (Industry R&D)	• One of three main partners in HLL consortia • Owner of the HLL building • Landlord to the tenants in HLL	• Facilitate communication between project leads and residents • Test and upscale successful HLL projects in their own building stock • Simplify and clarify 'project process'
Gothenburg municipality (Local authorities)	• Makes decisions on requests for changes on the HLL building or interaction with surrounding infrastructure	• Be part of HLL consortia in order to learn about needed changes in regulations, etc. • Engage more in projects and utilize HLL for testing
HSB Living Lab (Living Labs)	• Research infrastructure for testing in a real life, inhabited environment • Research fund co-financing projects run in HLL • Connects project leads with potential partners to strengthen projects	• Provide support in business development throughout projects in HLL • Speed up, and simplify project application process and give more feedback to candidates during application process

Table 2.1.1 cont. : Actors and their engagement in the HSB living lab

Actor (ecosystem role according to figure 2.1.5)	**Current engagement in HLL**	**Potential strengthening measures**
Johanneberg Science Park (Networking organizations)	• One of three main partners in HLL consortia • Connects project leads with potential partners within all sectors	• Streamline a process for investigating potential collaborations in all incoming projects in HLL
Chalmers Ventures (Networking organizations)	• Does currently not have any process for connecting their services directly to projects in HLL	• Directly inform ongoing HLL projects about coaching programs and funding options • Connecting to possible incubators, investors, partners and customers. • Use HLL for validating innovation ideas which has already started a program within Chalmers Ventures
Chalmers Innovation Office (Networking organizations)	• Does currently not have any process for connecting their services directly to projects in HLL	• Support HLL projects to find possible funding options • Directly inform ongoing HLL projects about programs they offer • Connecting to possible incubators, investors, partners and customers
EIT Climate-KIC (Networking organizations)	• HLL is part of BTA Flagship • HLL is not currently included in the European Living Lab Network (EnoLL)	• Support ongoing projects in HLL to find relevant connections to other projects or actors within the BTA network • Actively inform ongoing projects in HLL about funding options from EIT Climate-KIC
Chalmers School of Entrepreneurship (Entrepreneurs)	• There is currently no direct link to HLL	• Innovations applied in the Master's Program can be tested in HLL • Innovations developed and tested in HLL can be pitched to the School of Entrepreneurship in order to get support in commercializing them

Table 2.1.1 cont. : Actors and their engagement in the HSB living lab

Actor (ecosystem role according to figure 2.1.5)	Current engagement in HLL	Potential strengthening measures
Residents living in HSB Living Lab (End-users)	• Participating in testing and evaluating ongoing projects in HLL	• A common communication channel with residents is needed in order to encourage more to participate actively, as well as facilitate for project leads to reach them • A process for picking up and implementing project ideas coming from the residents

Table 2.1.2 : Idea Validation HSB Living Lab Ecosystem

Activity	Actor	Capacity	Potential Strengthening Measures
Idea testing	HSB Living Lab	Infrastructure for testing	Streamline the application process, candidates need clearer feedback
Funding	HSB Living Lab	HSB Living Lab project fund	Target and inform external actors to run projects in HLL
	EIT Climate-KIC	Ideation, Pathfinder, Start-up Accelerator	Increase awareness of the programs and create a link to the HLL process
	Chalmers Innovation Office	Verification, Applying for research funding	Increase awareness of support available and create a link to the HLL process

Table 2.1.2 cont. : Idea Validation HSB Living Lab Ecosystem

Activity	Actor	Capacity	Potential Strengthening Measures
Business coaching	Chalmers Ventures	Start-up Camp	Increase awareness of the program and create a link to the HLL process
	Chalmers Innovation Office	Utilization strategies	Increase awareness of support available and create a link to the HLL process
	EIT Climate-KIC	Start-up Accelerator	Increase awareness of the program and create a link to the HLL process
	HLL industry partners	Mentoring	Create official mentoring process for relevant projects

Table 2.1.3 : Market Validation HSB Living Lab ecosystem

Activity	Actor	Capacity	Potential Strengthening Measures
Market research	Chalmers School of Entrepreneurship	"Encubation" and market potential research through courses	Create link between the program and project leads in HLL to utilize each other.
	Chalmers Innovation Office	Advice on patenting and licensing, Collaboration with external partners	Increase awareness of support available and create a link to the HLL process
Funding/Investment	Chalmers Ventures	Accelerator	Increase awareness of the program and create a link to the HLL process
	EIT Climate-KIC	Demonstrator, Scaler, Start-up Accelerator	Increase awareness of the programs and create a link to the HLL process
	Chalmers Innovation Office	Verification, Applying for research funding	Increase awareness of support available and create a link to the HLL process

Table 2.1.3 cont. : Market Validation HSB Living Lab ecosystem

Activity	Actor	Capacity	Potential Strengthening Measures
Business coaching	Chalmers Ventures	Accelerator	Increase awareness of the program and create a link to the HLL process
	Chalmers Innovation Office	Utilization strategies, Impact communication	Increase awareness of support available and create a link to the HLL process
	EIT Climate-KIC	Start-up Accelerator	Increase awareness of the program and create a link to the HLL process
	HLL industry partners	Mentoring	Create official mentoring process for relevant projects

Table 2.1.4 : Market Introduction HSB Living Lab Ecosystem

Activity	Actor	Capacity	Potential Strengthening Measures
Investment	Johanneberg Science Park	Connection to potential investors or collaborators	Create link between the program and project leads in HLL to utilize each other.
	Chalmers Innovation Office	Connection to potential investors or collaborators	Increase awareness of support available and create a link to the HLL process
Customer Acquisition	HLL industry partners	Potential clients or link to large customer groups	Create a process for linking partners to project leads, supporting in identifying potential clients
	Chalmers Ventures	Connection to potential clients or collaborators	Increase awareness of support available and create a link to the HLL process

Green Village (TU Delft)

Table 2.1.5 : Actors and their engagement in the Green Village Living Lab Ecosystem

Actor (ecosystem role according to figure 2.1.5)	Current engagement in GV	Potential strengthening measures
TU Delft (University)	• Supports activities in GV and the team running it	• Increase awareness among all researchers of the opportunties GV offers
Industry partners within The Green Village Team (Industry R&D)	• Limited engagement in; GV platform, financial support for startups, and in-kind for PM	• Industry partners directly supporting the GV platform financiallly, in-kind or combination
Delft municipality (Local authorities)	• Sponsoring stakeholder and partner of the green Deal consortium • Has given The Green Village permission to not follow the current building regulations • Actively involved in supporting legal/regulatory issues related to safety and environmental permit issues.	• Good relation with Municipality - uses GV as case for the development of their own 'flexible regional plan" • Relation can be strengthened by involvement in more projects, a 'launching customer' role for innovations to move out from the GV
The Green Village (Living Labs)	• Offer a location for experimental set ups on empty plots which form the system environment • Provides the regulatory and organisational framework in which the experiments/projects of external parties can be implemented • Offers an ICT-DATA platform that is obligatory to be used in order to share experimental data between the different projects/ consortia/companies	• Currently no suggested measures available
TU Delft Valorization Centre (Networking organizations)	• Connects with external stakeholders and increases awareness of opportunities and offers present at GV	• Directly inform ongoing GV projects about support they offer for business development • Connecting to possible incubators, investors, partners and customers. • Link researchers to GV for validating innovation ideas

Table 2.1.5 cont. : Actors and their engagement in the Green Village Living Lab Ecosystem

Actor (ecosystem role according to figure 2.1.5)	**Current engagement in GV**	**Potential strengthening measures**
YES! Delft (Networking organizations)	• Yes Delft offers 'discovery days' to help start-ups developing their business models and value propositions at the GV	• Directly inform ongoing GV projects about coaching programs and funding options • Connecting to possible incubators, investors, partners and customers. • Use GV for validating innovation ideas which has already started a program within YES! Delft
EIT Climate-KIC (Networking organizations)	• GV is part of BTA Flagship • GV is included in the European Living Lab Network	• Support ongoing projects in GV to find relevant connections to other projects or actors within the BTA network • Actively inform ongoing projects in GV about funding options from EIT Climate-KIC
Delft Centre for Entrepreneurship (Entrepreneurs)	• There is currently no direct link to GV	• Innovations applied in the Programs and courses can be tested in GV • Innovations developed and tested in GV can be pitched to Delft Centre for Entrepreneurship in order to get support in commercializing them
End-users in The Green Village (End-users)	• Participating in testing and evaluating ongoing projects in GV • GV is an 'open' terrain, people can visit as part of walking and cycling routes • People are living and working at the Green Village • Social acceptance is an obligated part of the research projects at GV	• A common communication channel with end-users is needed in order to encourage more to participate actively, as well as facilitate for project leads to reach them • A process for picking up and implementing project ideas coming from the end-users

Table 2.1.6 : Idea Validation Green Village Living Lab Ecosystem

Activity	Actor	Capacity	Potential Strengthening Measures
Idea testing	The Green Village	Infrastructure for data collection and sharing between projects and with the public	Increase interface and visualizations of the data from the different projects to show their interactions in the system environment
Funding	TU Delft Valorisation Centre	Supporting the application of research grants, support on intellectual property, advice on subsidy programs, co-operation with SME & Industry	Better exploit the opportunity of building scientific setups in a system environment; bridging at an early stage the gap between scientific research and practice
	EIT Climate-KIC	Ideation, Pathfinder, Start-up Accelerator	Communicating the GV services towards the European community of SME's, startups, etc.
Idea testing	YES! Delft	Launchlab	Value proposition of GV should be included in the Yes!Delft launchlab program
	EIT Climate-KIC	Start-up Accelerator	Value proposition of GV should be included in the Start-up Accelerator program
	TU Delft Valorisation Centre	Business relations, Project management and development	Value proposition of GV should be included in the project development portfolio
	Industrial parties or consortia that run projects at GV	Mentoring other projects and testing own projects	More interactions and synthesis between partner projects

Table 2.1.7 : Market Validation Green Village Living Lab Ecosystem

***The Green Village organisation is part of the ecosystem that can provide market validation, but currently has no active role in this. Responsibility lies with the project/startup. GV requires a research project plan with at least research questions in 1 of the 4 quadrants: Technical system, Business case, Social acceptance, Regulatory framework. A project can enter GV without a business case, and not complying with any rules/regulations if the solution has the potential to contribute to a sustainable future.*

Activity	Actor	Capacity	Potential Strengthening Measures
Market research	TU Delft Valorisation Centre	Advice on patents and licensing	This service is for the TUDelft scientists or students, one may consider to broaden it
	Delft Centre for Entrepreneurship	Courses, BSc and MSc programs	Increase awareness of free access via MOOC online courses to those outside TU Delft
Funding/Investment	YES! Delft	Connection to investors and loaning banks	Increased awareness of GV proposition within Yes!Delft will strengthen 'capacity' of the mentioned actors
	EIT Climate-KIC	Demonstrator, Scaler, Start-up Accelerator	Currently no suggested measures available
	TU Delft Valorisation Centre	Applying for research grants	Currently no suggested measures available
Business coaching	YES! Delft	Incubation, Launchlab	Increased awareness of GV proposition within Yes!Delft will strengthen 'capacity' of the mentioned actors
	Climate - KIC	Start-up Accelerator	Currently no suggested measures available
	Industrial parties or consortia that run projects at GV	Mentoring	Currently no suggested measures available

Table 2.1.8 : Market Introduction Green Village Living Lab Ecosystem

***Market introduction is part of the value proposition of GV, by providing an environment for testing of early stage working prototypes in a relevant system environment to show to investors/customers.*

Activity	Actor	Capacity	Potential Strengthening Measures
Investment	TU Delft Valorisation Centre	Connection to potential investors or collaborators	Expand service for other projects outside TUDelft
	Yes! Delft	Connection to investors and loaning banks	Increased awareness of GV proposition within Yes!Delft will strengthen 'capacity' of the mentioned actors
Customer Acquisition	Industrial parties or consortia that run projects at GV	Potential clients or link to large customer groups	Currently no suggested measures available
	YES! Delft	Connection to potential clients or collaborators	Expand service for projects initiated outside of Yes!Delft
	TU Delft Valorisation Centre	Connection to potential clients or collaborators	Currently no suggested measures available

Discussion

The following is a brief discussion on relevant elements identified and described in chapter 2.1.

Culture, Values and Organizational Transformation

Resistance to change is a major challenge in creating new effective open-innovation ecosystems and in establishing these around living lab infrastructures. Many organizations, especially large companies and Universities, are embedded in their processes and find it difficult to change. When working in an open innovation Living Lab environment, this becomes a barrier as the 'change-averse' organizations often come in conflict with the 'change-valued' organizations (such as Small to Mid-size Enterprises or SMEs and entrepreneurs). This is a hindrance to collaboration and innovation. This also pertains to the organizational structures of Living Labs, which will be discussed more in the next chapter. Where living labs by nature need to be adaptable and flexible, often the larger 'change-averse' organizations struggle to adapt to this need, hindering the speed and effectiveness of innovation developed in living labs and their subsequent open-innovation ecosystems.

The Innovation Process

"This process needs an exceptional level of cross-functional cooperation, thus there must exist a culture that values and rewards those involved in the innovation process" (Smith, 2006, p.222).

There is also the need to establish effective collaborations and partnerships between scientists/engineers and business entrepreneurs. "Scientists and engineers need to understand markets, customers, and the technological transfer process" (Smith, 2006, p.223). This can be accomplished by creating new programs for scientists and engineers where engineering students work in collaboration with business students on projects and in environments that will prepare students for their future roles in the creative economy. Addressing this in academia can influence and promote systemic change in the industry (Smith, 2006). Such a program is currently being developed at Chalmers University of Technology via the DARE2build platform. In addition, a new collaboration program between engineering students and business students at Rice and Chalmers is being explored in order to expand the HSB Living Lab ecosystem to an intercontinental platform.

These programs are needed to create a successful innovation ecosystem around the HSB Living Lab but organizational and leadership support is still needed in order to create sustained collaborations. Some of these same ideas could potentially be applied between Chalmers School of Entrepreneurship and HSB Living Lab as well as Delft Centre for Entrepreneurship and GV.

New Roles, Responsibilities and Skill Sets

It may be beneficial for the actors within a Living lab open-innovation ecosystem to more clearly communicate their roles and processes, as they are complex and difficult for those outside the management structures to understand. This will facilitate a path for engagement and allow for actors to self-identify and find their role within the process. One way this could be achieved is through a Decision Chain Tool (figure 2.1.6). Such a tool has the potential to be useful in streamlining communication and processes as well as insuring a 'wide net' is in place to capture innovation ideas within the ecosystem. The integration of the 'new roles, responsibilities and skill sets component' into the main partner organizations is crucial for success of the ecosystem. During the case studies it has been identified that large organizational partners with a long history of working within older regimes that have been successful in the industrial and knowledge economy can have difficulties in the transition to the new creative economy.

In order to meet the goals of the involved organizations and BTA Network, as well as make a living lab successfully intertwined into its ecosystem, "first-line managers should be considered as operating-level entrepreneurs trained to 'recognize potential and make commitments, to motivate and drive people and sustain organizational energy around demanding objectives' and balancing support for innovation with commitment to routine work" (Bartlett and Ghoshal, 1997, cited in Smith, 2006, p.222). In the context of HLL, it has been recognized that there has been some slow but steady movement and progress in this area

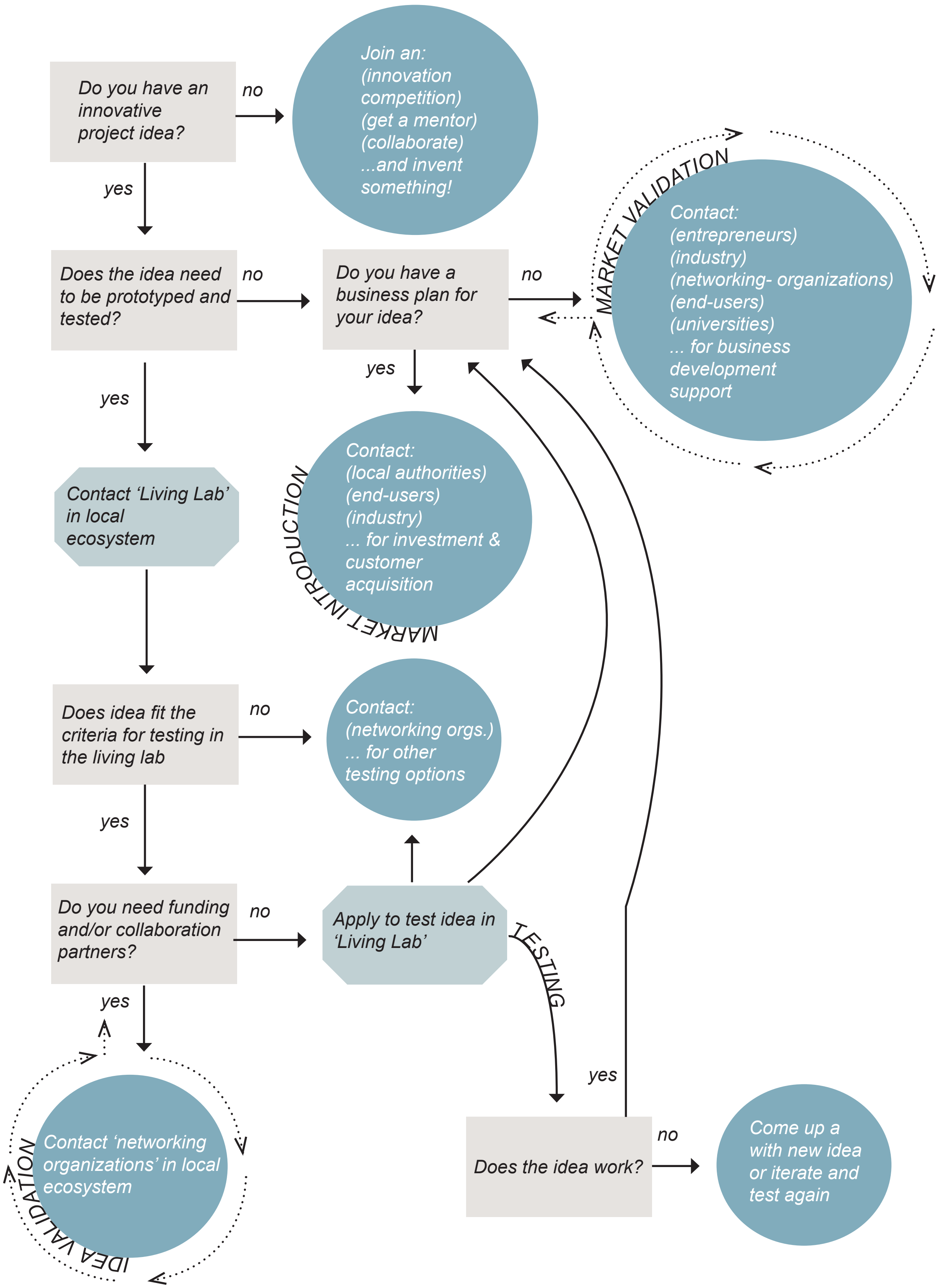


figure 2.1.6: Decision Chain Diagram (inspired by TUDelft VC Patent Diagram)

with one of the main partners, but for the ecosystem to function properly all involved partners must incorporate these leadership ideas and models into their organizational structures.

Interaction Between Actors

In-depth analysis of interactions and actors and how they match with current trends in the building industry, end-users, technology, regulations, climate goals, etc is needed. This report is a first step towards identifying and understanding these interactions. The next step is to "define the main agents, forces, relationships and outcomes resulting from this interaction in every subsystem and between them; then, to identify the weakest parts of the system and forces, and relationships or results having the greatest impact on them... There is a list of general mechanisms to manage complex adaptive systems:" (Jucevicius and Grumadaite, 2014, p.127-128).

The two that are most relevant to this work are:

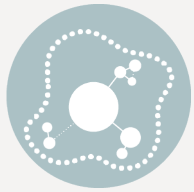
- "Pattern formation (analyzing existing system patterns, which are influenced by history (Ciliers, 1998), and finding out the aspects that could play a role for the development of an ecosystem (Laihonen, 2006).

- Tagging, i.e. identifying people, ideas, processes and other aspects that are giving the sense to actions and showing direction to aggregation (Lao et al., 2008; Laihonen, 2006)" (Jucevicius and Grumadaite, 2014, p.128).

A better understanding and process for how end-users can become involved as co-creators within a living lab is needed as they are important part of an open innovation ecosystem and essential to the Living Lab methodology. Currently, in HLL they mostly function as testers and evaluators, in most circumstances not really co-creators. A common communication channel with residents is needed in order to encourage more of them to participate actively, as well as facilitate for project leads to reach them. A process for picking up and implementing project ideas coming from the residents is also needed.

Toolbox

FOCUS ON SPIRAL GATE OI PROCESSES



ECOSYSTEM STRUCTURE AND INTERACTIONS NEED TO BE DYNAMIC AND FLEXIBLE

LIVING LABS ARE CO-CREATIVE PLATFORMS FOR CONTINUOUS EXPERIMENTATION

OI REQUIRES CROSS-FUNCTIONAL COOPERATION

CREATE A SIMPLE FRAMEWORK FOR COMMUNICATION AND IMPLEMENTATION OF OI

INSPIRATIONAL AND SPARKING EVENTS PUSH THE INNOVATION TO THE NEXT LEVEL

ECOSYSTEM MAPPING PROVIDES BETTER UNDERSTANDING OF INTERACTIONS TO SUPPORT OI

LIVING LABS ARE ACCESS PLATFORMS TO FUNDING, TEST BEDS AND BUSINESS OPPORTUNITIES

USERS FEEDBACK AND DATA COLLECTION ARE USEFUL FOR ITERATION OF OI PROCESSES

CREATE GOOD COMMUNICATION CHANNELS BETWEEN THE END USERS AND INNOVATION ORGANIZATIONS

2.2 ORGANISATION & OI

The following chapter aims to understand and highlight how different organizational elements foster Open Innovation (OI) focusing specifically on the Living Lab perspective. Based on a literature review, the first part of this chapter presents important elements for both the creation of new organizations and the transition of existing organizations in relation to open innovation processes. The second part analyses the current organizational structures of two Living Lab case studies and seeks to identify the important organizational elements presented in the first part.

After a literature review it was found that organizational structure is one of the most important elements when it comes to implementation of open innovation. "The propensity to innovate given by structural organization is an essential condition for absorbing new knowledge and mastering new technologies" (Sarrasin, Ramangalahy, 2007, cited in Steiner, Morel and Camargo, 2014, p.93).

Chiaroni in parallel affirmed that the "...journey towards Open Innovation is triggered by a change in the organizational structure of the innovating firm" (Chiaroni, Chiesa and Frattini, 2010, p.243). Within this crucial role organizational structures can act both as an enabler or a barrier. Commonly identified organizational barriers are cultural systems, rules and policies, hierarchical positions, organizational facilities, and complex organizational structures. (Mortara *et al*, 2009). However, especially in the case of already established organizations, the structure and culture can be hard to change. It is important, therefore, to have a thorough understanding of this framework both for the organization in focus, as well as the other stakeholder organizations within the larger innovation ecosystem. This is needed in order to assess the success of open innovation.

The changes needed to overcome these structural and cultural barriers occur in four different dimensions according to Chiaroni, Chiesa and Frattini (2010). Some of these transition actions have been identified as important aspects for organizational change regarding the BTA Living Labs and are listed below.
(1) Network: Establish an extensive network of inter-organizational relationships with a number of external actors.
(2) Organizational structure: (a) establish open innovation business units or tasks forces, dedicated to cross-functional teams (structure), (b) assign champions to lead the process of transition or gatekeepers to manage the interface between the firm and its external environment (roles), (c) establish incentive systems which include open-oriented goals and metrics.
(3) Evaluation processes: (a) Implement systems to continuously monitor the range of technologies available in the external environment, (b) establish new strategies for involving external actors in the innovation process.
(4) Knowledge management system: Use of Information and Communication Technology and Intellectual Property management systems (purpose of facilitating the inflow of knowledge from outside sources). (Chiaroni, Chiesa, Frattini, 2010).

The aforementioned actions may be of use for creating effective open-innovation organizations. However, it is also important to conceptualize these organizations as systems that interact with their environment, rather than isolated entities (Steiner, Morel and Camargo, 2014). It is key then, in this context, that the boundaries of an organizational system are porous (as previously described in figure 2.1.1). This porosity enables interactions both inside and outside of the system and in turn, influences the organization and its objectives (Steiner, Morel and Camargo, 2014). The interactions between the inside and outside of the system can be created and maintained through three elements of the organization; (1) structure (ontological) (2) strategy (genetic) and (3) mechanisms of influence (functional)(Steiner, Morel and Camargo, 2014). It is crucial to create an organization that from the start has a strategy oriented towards a collaborative way of working. Also, the structure of the organization must be able to change quickly according to changes in strategy, thus making it possible to account for influence factors across the organization (Steiner, Morel and Camargo, 2014).

Steiners organizational classification (table 2.2.1) is useful for existing organizations to self-identify and understand better where their organizations can change and move towards open innovation processes. In the following case studies, only some of the elements of the table 2.2.1 are used and combined with the previously mentioned actions, in order to qualify the strengths and the weaknesses of the case study organizations in regards to open innovation.

Type	Structure	Influence Mechanism	Strategy	Open Innovation Ties
J-Form	Functional unit, community, internal labor market, learning and knowledge sharing, long-term employment relationship, problem solving	intensive interaction (inter-team)	Incremental innovation oriented, continuous improvement	Collaboration enhancement *(Lewkowics, Koeberlè, 2008.)*
Adhocracy	Organic, partially decentralized, multi-disciplinary team, learning, horizontal specialization, young team, high technical system	Integrator manager (inter-team)	Grassroots type	External factors and environmental influence on the structure *(Mintzberg, 1983.)*
Learning Organization	Dynamic network, systemic, project team decentralized, flexible, flat organizational chart	Learning engineers (inter-team)	By top management and shared by employees: Learning Map	Largely dependent on firm's contacts with external knowledge sources *(Lane, Lubatkin, 1998.)*
Self-Organization (Auto-poietic)	Decentralized	Spontaneous ties, local interactions	Individual Goals	High decentralization structure able to support OI *(Kiemen, 2011.)*
Memetic Organization	Meme drives the overall behavior of the organization	-	Evolve with meme's watch	Mergers and acquisitions are led by memetic self-replication *(Vos, Kelleher, 2001.)* Strategy arises from external meme analysis *(Pech, 2003.)*
Bureaucracy (Mintzberg view)	Central bureaucracy, importance of hierarchy, business units, division of work, logistical support very important, techno-structure standardizes taks	High standardization of tasks, hierarchical control	Planning, high and long stability of strategy, resistance facing change	Focus and control activities towards collective goals *(Adler, 1999.)*

Table 2.2.1 summarizes different organization types and their capability to implement OI (adapted from Steiner, Morel and Camargo, 2014, p.101-102).

Case Studies

As mentioned previously, Living Labs offer a dynamic platform characterized by multiple actors, and plentiful knowledge sources and information flow, all of which play central roles for achieving radical innovation (Leminen *et al,* 2016). Living Labs differ among themselves in terms of their activities, network structure and organization, therefore there are multiple ways of categorizing different typologies.

One of these methods is exemplified by Leminen *et al* (2016) who categorizes living labs based on the main 'driving-actor', the network structure and the type of innovation outcomes.

However, in this report it is not applicable to categorize the case studies based on the living lab typology.

The aim is to understand how the already established living lab organizations can move more holistically towards becoming truly open-innovation systems. This is done in the upcoming sections by mapping the known organizational components of the case studies and comparing them to selected elements/actions necessary for achieving OI.

This is important as Living labs are intrinsically OI environments and if the organizations managing the innovations and networks do not embody OI they will not be able to reach their full potential.

HSB Living Lab (Chalmers)

The HSB Living Lab is a unique research and collaboration project of 12 partners in the built environment sector. Its main aim is to facilitate and develop sustainable solutions for the future of living. The Living Lab is built as a residential building with 29 apartments for students and guest researchers on the campus of Chalmers University of Technology in Gothenburg, Sweden. The involved partners, the available sensor systems, and the established processes all aim to facilitate and develop sustainable solutions for the future of living. The qualitative analysis shows that HSB LL has many elements needed for OI implementation, yet there are still areas that can improved (see table 2.2.2).

The organizational structure consists at its core of what is known as the 'project group'. The project group is made up of members from the 12 partner organizations. The group's main role is as a collaborative management body that regularly meets and discusses project ideas. Once discussed and filtered by the project group the ideas get transferred to the decision group, which is made up of many of the same members. Here decisions are made on which projects will be approved and funded for test and implementation in the Living Lab. Project ideas can come both from internal and external stakeholders and those living in the living lab. There are two other tiers of management within the organization. The management group is comprised of members from the three main partners, and runs the 'day-to-day' operations including data and building management. The steering group is also represented by these three main partners but only meets once or twice a year and focuses on overarching strategy. (See figure 2.2.1).

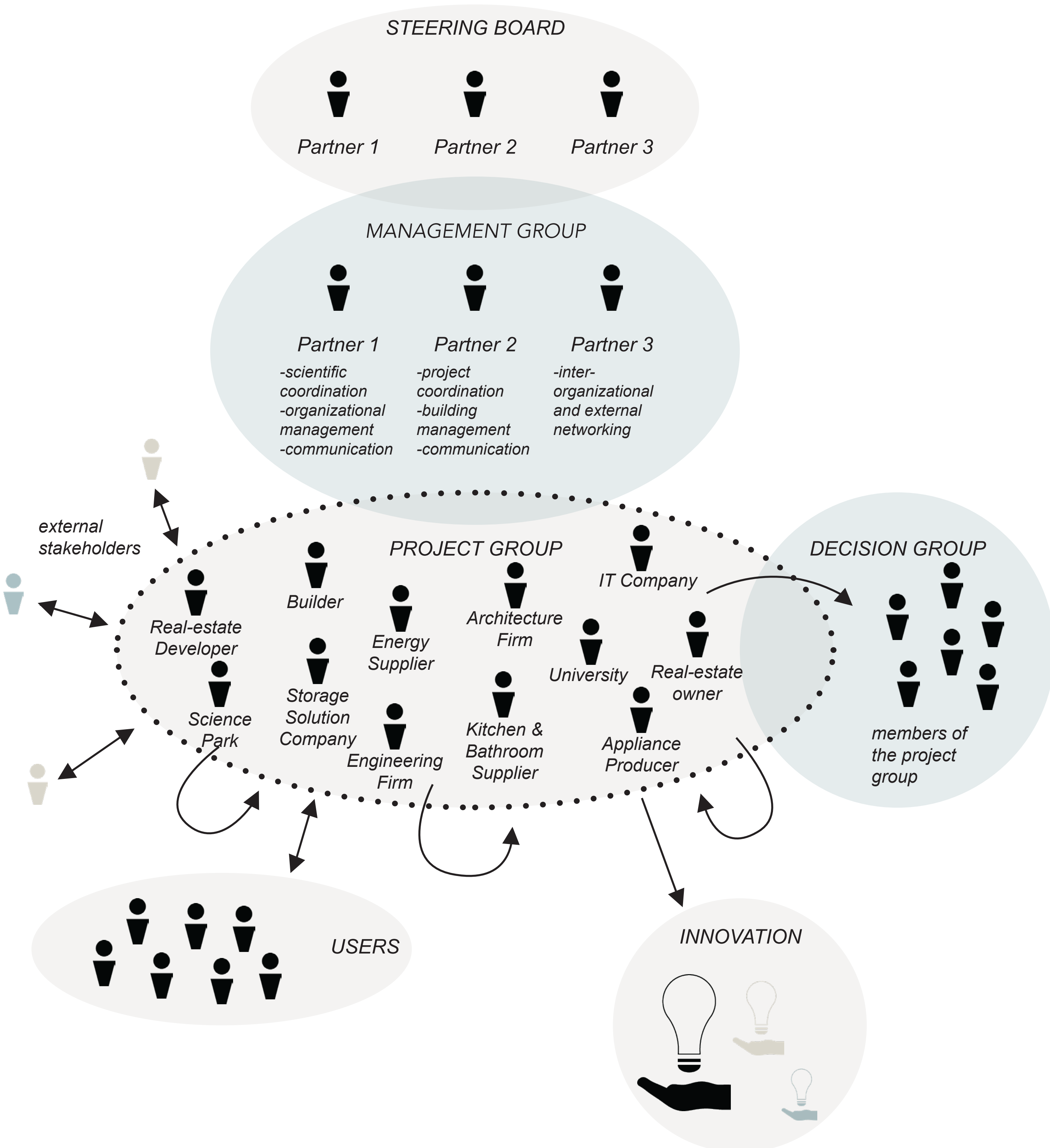


figure 2.2.1: HSB Living Lab Organization Diagram

OI Supporting Elements	HSB LL Strengths	HSB LL Weaknesses
Network of inter-organizational relationships	The "Project Group" is made up of 12 partners from different organizations within the Building Sector.	Lack of involvement from local municipal authorities.
Network of external actors	Internal actors of the "Project Group" are also external actors through their respective organizations.	Organizations members of the "Project Group" partially limit access to other external stakeholders .
OI business units or tasks forces, dedicated to cross-functional teams	The "Project Group plays the role of a cross functional team.	There are no specific business or task units established.
Roles to manage the interface between the firm and its external environment	Due to its unique set-up, "Project Group" provides the interface between the LL and the external environment.	The interface is limited to the partners belonging to the "Project Group" and could be further extended.
Incentive systems which include open-oriented goals and metrics	Incentive system exists in the form of a common fund to provide seed funding for approved projects.	There is no clear evaluation metric.
Monitoring systems for different technologies available in the external env.	The information and knowledge about state of the art technologies/ideas comes through the "Project Group".	There is no specific system in place.
Strategies for involving external actors in the innovation process	There is a web-based system to bring innovation ideas into the Living Lab.	There is no clear strategy for getting innovation into the market.
Use of ICT and IP management systems	There is an extensive sensor network providing data for projects and for innovation.	IP management is still unclear.
Decentralized structure	The "Project Group" and "Decision Group' form a decentralized structure.	Due to different degrees of engagement from respective Project Group's organizations the structure is not completely flat.
Orientation toward collective goals	There are some collective goals developed within the "Project Group" and "Steering Group"	The goals are not always clearly defined.

Table 2.2.2 Ten elements to support Open Innovation and qualitative analysis of HSB Living Lab strengths and weaknesses

Green Village (TU Delft)

The Green Village site takes a unique position in the innovation chain from fundamental research and development to large-scale application of innovations in society. Many innovations never leave the lab of a company or university and find an application at a pilot location. This can be due to technological risks, uncertain ROI, safety/privacy concerns, or regulatory non-compliance. The Green Village (GV) provides an environment where universities and businesses can test and demonstrate their innovations without these concerns. The GV's goal is to accelerate the development and implementation of radical innovations. TUDelft initiated the Green Village foundation with the mission to develop the 15,000 m^2 'plot', on the TU Delft campus, into a living entrepreneurial environment, facilitating cooperation between universities, Industry, and external stakeholders, in order to accelerate innovations that contribute to a sustainable environment.

The GV board is assigned by TUDelft, the board selects a Director who in turn selects a management team (MT) to implement the decisions of the board. The MT of four (Director, MGRs building & realisation, Marketing & Communication, Partners& Finance) is responsible for the daily operations of GV. Parties that want to use the GV for their projects apply to the MT who decide if the project fits the GV mission; (1) contributes to sustainable future, (2) can be implemented safely, (3) fits the physical location/plot, (4) relevant research question fitting one of the four main quadrants (technical, business case, social acceptance, regulatory framework).

If the project fits, it is then supported by a GV project manager to ensure a smooth process in the following stages: Initiation, Preparation, Live and Exit. Every stage is separated with a 'go/no-go' decision gate. A contract must be in place before the Preparation stage describing the activities and responsibilities of the project owners and the GV, including a fee for the use of the GV. During Preparation, Live and Exit stages GV supports the project using the official governmental network and/or using the innovation ecosystem in place (both formal and informal). An active role of the GV MT is matchmaking using Co-Creation workshops. These workshops are hosted and organised by the GV MT in cooperation with stakeholders representing a theme or topic relevant for multiple projects running at the GV. When the project is finished (research questions answered or contract period ends) the project is removed from the GV site.

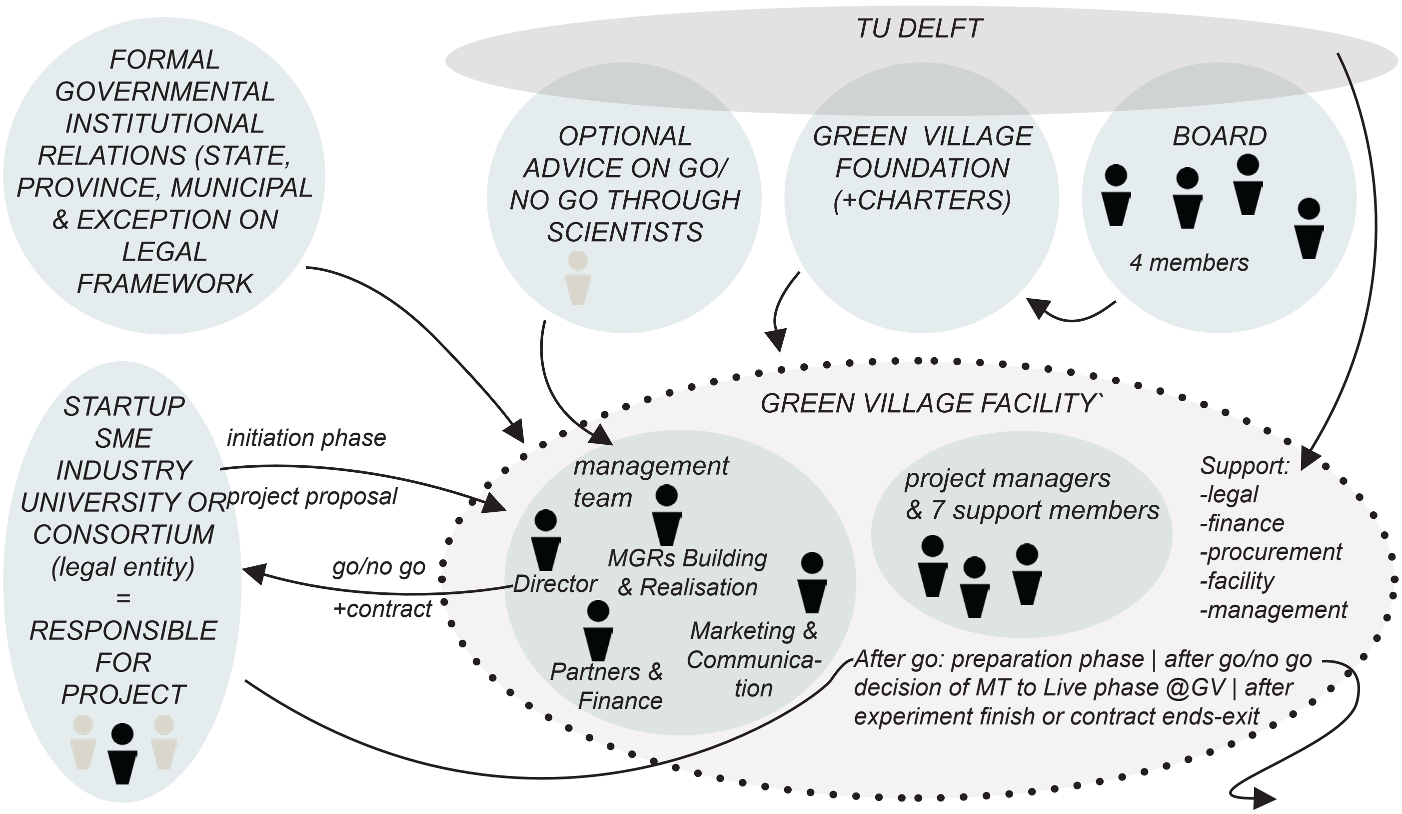


figure 2.2.2: Green Village Organization Diagram

OI Supporting Elements	GV LL Strengths	GV LL Weaknesses
Network of inter-organizational relationships	Part of the network of regional development agencies, provincial cooperation networks, governmental economical development initiatives	more information needed
Network of external actors	Large industrial network and with authorities (State authorities, provincial and municipal).	more information needed
OI business units or tasks forces, dedicated to cross-functional teams	GV team connects the different projects in the Living Lab system environment.	more information needed
Roles to manage the interface between the firm and its external environment	The GV Management Team manages its external environment, relations distributed among the 4 members.	more information needed
Incentive systems which include open-oriented goals and metrics	N/A	more information needed
Monitoring systems for different technologies available in the external env.	The external project owners are responsible for the description/motivation of project idea based on available technologies.	more information needed
Strategies for involving external actors in the innovation process	Thematic workshops, and through the Green Deal. Also free and accessible to the public as active part of the projects (real live confrontation with new technology)	more information needed
Use of ICT and IP management systems	ICT platform to share data among the different projects and project outcome of with the public through the website using real-time visualization of the interconnected projects/systems.	more information needed
Decentralized structure	Small independent team, license to operate and develop the field per foundation mission/vision. Technical expertise from Innov. Ecosys. is used when needed.	Technical expertise is not available within the team.
Orientation toward collective goals	GV Foundation mission: “develop the Green Village plot to help accelerate innovations that contributes to a sustainable future”	more information needed

Table 2.2.3 Ten elements to support Open Innovation and qualitative analysis of Green Village Living Lab strengths and weaknesses

Toolbox

USE MONITORING SYSTEMS FOR DIFFERENT TECHNOLOGIES AVAILABLE IN THE EXTERNAL ENVIRONMENT

CREATE A NETWORK OF INTER-ORGANIZATIONAL RELATIONSHIPS AND EXTERNAL ACTORS

IMPLEMENT STRATEGIES TO INVOLVE EXTERNAL ACTORS IN THE INNOVATION PROCESS

ESTABLISH OI BUSINESS UNITS OR TASK FORCES, DEDICATED TO CROSS-FUNCTIONAL TEAMS

USE OF ICT AND IP MANAGEMENT SYSTEMS

ASSIGN ROLES TO MANAGE THE INTERFACE BETWEEN THE FIRM AND ITS EXTERNAL ENVIRONMENT

DECENTRALIZED STRUCTURE SUPPORTS OI

IMPLEMENT INCENTIVE SYSTEMS WHICH INCLUDE OPEN ORIENTED GOALS AND METRICS

ORIENTATION TOWARDS COLLECTIVE GOALS

03_ LIVING LAB TOOLS

3.1 CO-CREATION

The following chapter briefly describes co-creation and its application through workshops, as co-creation is an essential part of the living lab methodology. Co-creation has been an essential part of both the Green Village and HSB Living labs. In the NGLL project, four co-creation workshops on different topics have been conducted in order to explore the concept, find potential areas of improvement and test this method to generate new innovation ideas. Qualitative assessments of these workshops are listed along with various tools that were used.

The Co-Creation Methodology

Co-creation is based on the fact that new knowledge and insights are generated when bringing together people from various relevant disciplines, and through creative and collaborative methods inspire them to discuss and come up with new ideas or concepts. In recent years, co-creation methods have been increasingly recognized as efficient and relevant tools for generating new ideas and solutions. Further, it has been acknowledged that co-creation processes lead to more relevant products and services being generated faster, by bringing together stakeholders from various backgrounds and knowledges (Hughes, 2014). The trans-disciplinary approach is not only about connecting various disciplines but it can also be seen as a way to bring together society, business and academia with the aim of generating ideas which are more likely to meet the market needs in an appropriate way, thus co-creation is a relevant tool to meet the requirements of OI environments (Bard and Ntemiris, no date).

Preparing a co-creation workshop is a co-creative activity in itself, as inputs from others outside the organizers' discipline and competence is often necessary. The test examples were facilitated by Chalmers employees in combination with project leaders related to each workshop. Each workshop has its own preconditions and requires its own co-creative process where all the involved parts could contribute with their knowledge and experiences.

Part of the co-creation methodology is to enable the participants to think freely and be as creative as possible. This can be challenging when bringing together people from very different backgrounds who have never met before. It is important to try to prevent dominating personalities to take over the discussions as well as enable persons who are less likely to speak in groups, to get their ideas across. This can be done by starting the workshop session with exercises which do not allow for extensive discussion and allowing individuals to present their ideas to the rest of the group. In this series of workshops, a method called 'Brain Writing' was used, which has been proven to be extremely useful and important both in idea generation and in setting and fostering group dynamics and communication.

The group work which usually follows a Brain Writing session encourages the participants to be creative and co-create new concepts or ideas together. The most basic materials used in a co-creation workshop are sketching tools such as paper, pens, clay, wood, cardboard, glue and computer programs. Having a wide diversity of material allows participants to choose the medium they are most comfortable with or are keen to use. It also enables participants to explore the topic at hand from different points of view through mixed media.

Digital Living
This workshop was conducted to generate ideas for the creation of an innovation competition, which was focused on the topic of digital services in homes. The result of the workshop was used in formulating the challenge of the innovation competition and defining criteria for it. The aim of the workshop was to collectively formulate how digital services can help people to adopt more sustainable lifestyles as well as discussing what needs to be considered when introducing more and more digital services into our lives. Two main tools used during the workshop were 'Brain Writing' and 'Around the World'. At the end of the workshops a survey was given to participants in order to get feedback on the process itself.

Pros:
+diversity of the group and respective interactions
+tools used were engaging and useful
+generated discussions were interesting and useful

Cons:
-some participants thought the time (3,5 h) was too short to fully develop certain ideas

Bioloops
The purpose of the workshop was to explore how closed loops (Bioloops) can be created within the living environment by using biological household waste to produce food for the residents. The workshop also aimed to investigate how prototypes can be tested and developed in order to get them to the market faster and answer the questions: What components in these loops can be suitable for implementation in a living environment? What effects can it have on the behavior of users? How it is best managed and maintained?

The workshop consisted of several elements: conference, study visits and collaborative building. The conference provided the necessary perspectives on different projects, study visits gave an insight into functioning, already existing examples, while the prototyping process brought the participants together around the theme from a practical perspective.

Pros:
+conference and study visit provided the participants with information for the following building phase
+different workshop elements enabled inclusion of a more diverse variety of stakeholders
+integration of a practical element into the workshop, provided an increased cohesion and it solidified the Bioloops concepts (e.x. some of the participants developed the concept further after workshop)

Cons:
-the integration of all three elements in the workshop was challenging to plan
-homogeneity of the group in the building session (most of the participants were students)

figure 3.1.1: Photos from Co-Creation Workshop, Gothenburg, Sweden

Rice

Chalmers and HSB Living Lab (HLL) have a close collaboration with Rice University. A group from Rice has visited HLL on several occasions. This has inspired Rice University to create their own living lab on the Rice campus in Houston, Texas, USA. The idea is at an early stage and few formal decisions have been taken. A class of Rice students in a summer course, on the topic of sustainable transitions, visited HLL and this opportunity was taken to explore the students' point of view and inform what elements a LL on their campus could include. The students were divided in several groups focusing on four different aspects: stakeholders/collaborations, layout/architecture, technology/sensors and research/testing. Various tools were used, including brain-writing and innovation pipeline sketching. The outcomes were summarized and taken back to the University for further development.

Pros:
+diverse group of students from different backgrounds, which brought multiple perspectives to the discussion
+engagement level was high as the students were enthusiastic about being able to contribute to the creation of a LL on their campus
+since the students were engaged in the process at such an early stage they have interest and continued discussing the topic further in their courses

Cons:
-the time frame for the workshop was short
-there were only a few faculty members present, it would have been beneficial if more decision makers were present

Drive Sweden

A project exploring how autonomous vehicles can add value to cities was conducted as a part of a national innovation program called Drive Sweden. In this project co-creation methods were used, with the overall aim to explore hidden values autonomous transportation can bring, and identify knowledge gaps and challenges. In addition, the co-creation workshops aimed to increase awareness among stakeholders and contribute in establishing a common view facilitating new collaborations between stakeholders from different sectors. The whole project has been summarized in a booklet where methods and findings are presented along with the Drive Sweden project leaders' reflections and recommendations for how to use the findings from the workshops.

The workshops in this project were devoted to four specific city challenges. They were performed in four distinct exercises with around 25-30 participants per session in the first three and around 15 in the fourth workshop. The groups were broad, with people from industry and academia as well as city authorities and other public services. The tools used included brain-writing and back-casting while the main findings and outcomes were visually summarized by a local artist.

Pros:
+a lot of experts and decision makers were involved in the workshop, providing higher potential impact
+the artist helped stakeholders to channel and communicate their ideas visually finding connections that they could not express verbally
+the creation of the final booklet, allowed the project leaders to communicate the findings and further develop some of the ideas formulated during the workshop

Cons:
-the planning process was complex and time consuming

figure 3.1.2: Drive Sweden Workshop, Gothenburg, Sweden

Toolbox

CO-CREATION IS A TOOL THAT SUPPORTS OI

BRAIN WRITING AS AN IMPORTANT TOOLS TO ENSURE ALL THE VOICES ARE EQUALLY HEARD

TRANS-DISCIPLINARY STAKEHOLDERS ARE KEY FOR CO-CREATION

DIVERSITY OF WORKSHOP MATERIALS ALLOWS AND ENABLES PARTICIPANTS' ENGAGEMENT AND SELF EXPRESSION

PLANNING OF CO-CREATION WORKSHOPS SHOULD BE CO-CREATIVE ITSELF

PROPER DOCUMENTATION OF THE WORKSHOP OUTCOMES IS CRUCIAL FOR POTENTIAL PROJECTS' FURTHER DEVELOPMENT

3.2 DATA SYSTEMS

As previously mentioned, Living labs allow for the testing of experiences, inventions and innovations in a real-world context. To be able to quantify the impact of new ideas, data is needed to measure and visualize how interventions done in a living lab infrastructure affect users and change behavior.

The data collected by such systems informs how to most effectively develop an innovation to meet user needs and is key to the iterative nature of the Living Lab methodology. Innovations iterated in such real use scenarios are more likely to achieve their intended results, without undesired side effects introduced by unforeseen contextual elements.

HSB Living Lab (Chalmers)

The sensor system at the HSB Living Lab (HLL) was developed in collaboration with the BTA project, Home Energy Management (HEM). The HEM project aimed at improving the utilization and operation of building services in residential houses. In order to do this tools were to be provided to tenants enabling them to tailor the performance of building systems to meet their needs. This included, for example, technologies to address fluctuating grid energy mixtures allowing the use of more renewables. (Sasic Kalagasidis, Hagy and Marx, 2017).

In order for these tools to function a data-base and its respective sensor network was needed to capture all the building system data, as well as user behavior data.

This was realized through the creation and implementation of a sensor matrix, and data handling system in the HLL which included:

- wall plug electricity consumption
- room temperature
- room relative humidity
- room CO2 level
- room air particle concentration
- mass flow of main ventilation intake
- mass flow of ventilation exhaust
- temperature of ventilation exhaust
- relative humidity of ventilation exhaust
- tab hot water consumption
- tab cold water consumption
- waste water temperature
- heating energy consumption per heat circuit
- heat circuit mass flow
- heat circuit temperature
- location and acceleration of tags
- outside temperature
- outside relative humidity
- outside CO2 level
- wind speed
- wind direction
- global irradiation
- PAR irradiation
- precipitation
- elevator position and move direction
- elevator load
- in-wall temperature
- in-wall relative humidity (Sasic Kalagasidis, Hagy and Marx, 2017, p.7)

Approximately 2000 sensors were dispersed throughout the four story Living Lab infrastructure providing a comprehensive data set. All sensor data is recorded with similar resolution to allow correlations to be done between different measured parameters.

Flexibility and ease of changing the system to meet future needs of sensor integration is key when working with a Living Lab infrastructure, therefore cable based Power-over-Ethernet-network as well as wireless communication hubs were implemented with extra capacity.

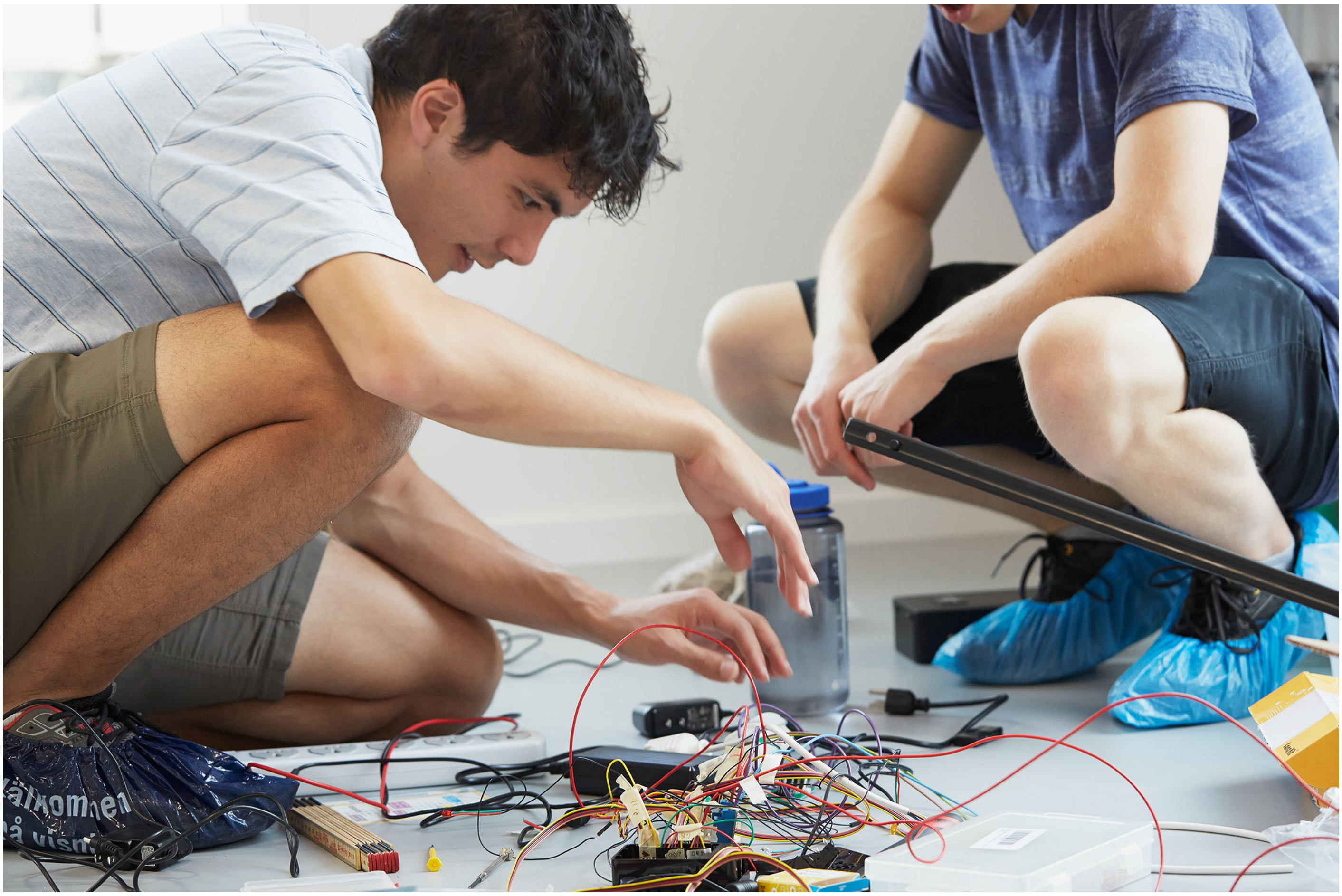


figure 3.2.1: Sensor Prototyping, HSB Living Lab, Gothenburg, Sweden

A unique data handling architecture was designed in order to accommodate the wide range of sensor and data types. Important considerations for the design of this system include :

(1) ability to communicate with all sensor types
(2) secure storage and reliable sorting of data
(3) ease of data accessibility

To allow for these the data management system was created with decentralized nodes, using different servers and data exchange interfaces. In order to access the data, a procedure was implemented guiding the user through a Graphical User Interface (GUI) to specify and select data and accessing it via a protected PGP key (3). Various program languages were used in creating this system in order to enable fast sorting and processing of data (2). The data handling system is a portal free solution which enables it to communicate with a wide range of sensor types (1) (Sasic Kalagasidis, Hagy and Marx, 2017).

The implementation of such a system in a living lab aims to provide metrics and data for the development, commercialization and the implementation of innovations in a real world setting together with users as collaborators and co-creators. Both the implementation of the sensor matrix and the data handling system also enables a transfer of the created know-how and the process experiences to other living labs and applications in the future.

Toolbox

SENSOR AND DATA MANAGEMENT SYSTEM PROVIDE EVALUATION OF INNOVATIONS

INTERFACES AND VISUALIZATIONS THAT ENABLE THE USER TO TAYLOR THE SYSTEM TO THEIR PERSONAL PREFERENCES

FLEXIBILITY AND EXTRA CAPACITY OF THE SYSTEM TO ALLOW FOR EXPANSION AND INTEGRATION OF NEW TECHNOLOGY

DATA MEASUREMENT SHOULD HAVE SIMILAR RESOLUTION TO ALLOW PROPER COMPARISON AND ANALYSIS

DATA MANAGEMENT SYSTEM SHOULD BE DECENTRALIZED AND BUILD IN NODES

RETRIEVAL AND DATA FORMATION SHOULD MATCH THE NEEDS OF THE TARGET GROUP

04_ CONCLUSION

Recommendations & Next Steps

Next Generation Living Labs are strongly embedded in Open Innovation Ecosystems where all the respective organizations have systematically transitioned and reshaped their structure and culture to be able to foster Open Innovation processes.

In order to increase the impact of Living Labs towards market implementation of sustainable innovation, ecosystem mapping is recommended to provide insight and strengthen aforementioned systems.

Considering the importance and urgency of transitions towards OI processes, a digital tool could be developed, to help different organizations in their transition (transitional) process. In order to develop such a tool, it is necessary to collaborate with stakeholder organizations that are involved in Living labs and build upon existing research and experiences. This has been initiated by The Enoll Harmonization Cube , which is a tool to share best practices between Living Labs. However, this needs to be expanded to include the organizations that are within the ecosystem, collaborating and driving the Living lab innovations. It is suggested that more analysis of existing practices and tools is needed as this report covers experiences from just two case studies. A more detailed elaboration is crucial to develop the aforementioned digital tool.

The findings gathered and summarized in this report (see next chapter), could be used for this purpose and be digitally translated into a dynamic platform/tool that provides instructions on how to create a Living Lab and the necessary structure surrounding it. (see *Toolbox Summary*).

The dynamic and interactive nature of the platform/tool would enable different stakeholders to upload information and continuously upgrade the system with new knowledge and findings. This kind of platform/tool would not only be a source of information but also a networking platform for different stakeholders, and could both directly and indirectly stimulate co-creation, collaboration and the creation of new Next Generation Living Lab infrastructures.

Harmonization Cube

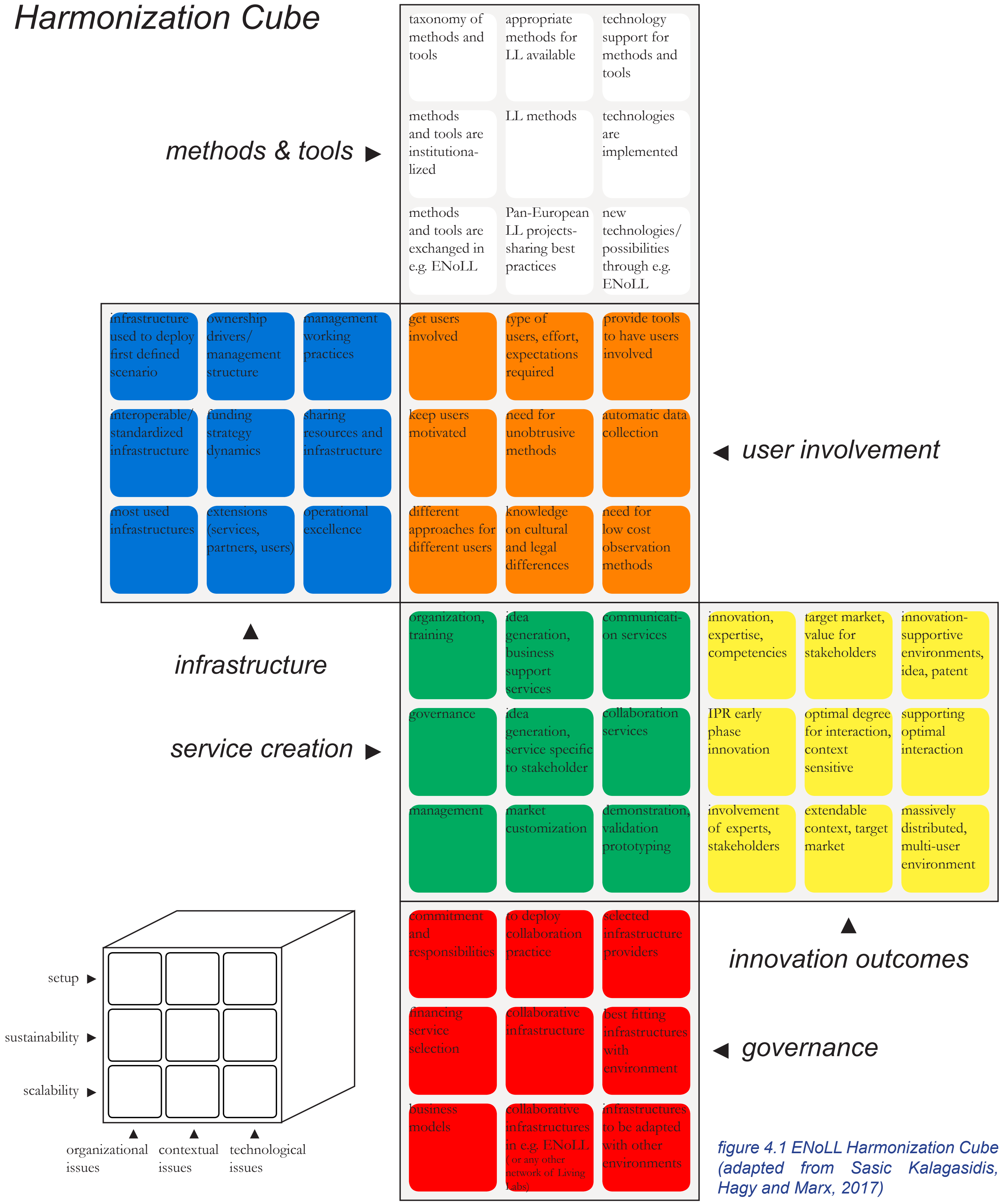
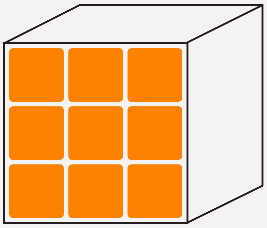


figure 4.1 ENoLL Harmonization Cube (adapted from Sasic Kalagasidis, Hagy and Marx, 2017)

Toolbox Summary

The categorization of the findings of this report has been done using the ENoLL Harmonization Cube elements (see figure 4.1). This report is focused on organizations transitioning towards OI processes, while the Harmonization Cube focuses specifically on Living Labs. An initial paring of the findings with the Harmonization Cube categories, aims to allow further research and development for the creation of a methodology/tool. This would help organizations involved with Living Lab infrastructures to maximize their innovation potentials.

User Involvement

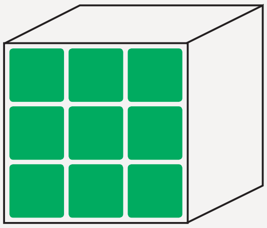


ENGAGING USERS AS ACTIVE CO-CREATORS SUPPORTS OI

USERS FEEDBACK AND DATA COLLECTION ARE USEFUL FOR ITERATION OF OI PROCESSES

INTERFACES AND VISUALIZATIONS THAT ENABLE THE USER TO TAYLOR THE SYSTEM TO THEIR PERSONAL PREFERENCES

Service Creation



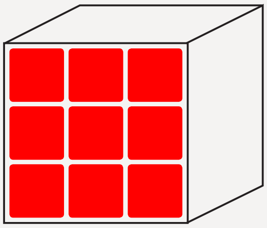
LIVING LABS ARE CO-CREATIVE PLATFORMS FOR CONTINUOUS EXPERIMENTATION

CREATE A SIMPLE FRAMEWORK FOR COMMUNICATION AND IMPLEMENTATION OF OI

LIVING LABS ARE ACCESS PLATFORMS TO FUNDING, TEST BEDS AND BUSINESS OPPORTUNITIES

CREATE GOOD COMMUNICATION CHANNELS BETWEEN THE END USERS AND INNOVATION ORGANIZATIONS

Governance



ESTABLISHING AN EFFICIENT COLLABORATIVE FRAMEWORK/ INFRASTRUCTURE

CREATE A NETWORK OF INTER-ORGANIZATIONAL RELATIONSHIPS AND EXTERNAL ACTORS

ESTABLISHING CLEAR ROLES AND RULES FOR ENHANCED COOPERATION

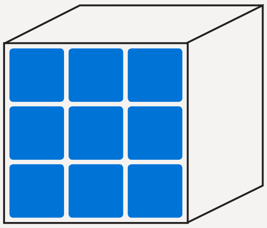
ASSIGN ROLES TO MANAGE THE INTERFACE BETWEEN THE FIRM AND ITS EXTERNAL ENVIRONMENT

MODULARITY, FLEXIBILITY, ADAPTABILITY, OPENNESS, SOCIAL INTEGRATIONARE KEY

DECENTRALIZED STRUCTURE SUPPORTS OI

OI REQUIRES CROSS-FUNCTIONAL COOPERATION

Infrastructure



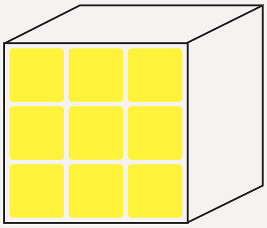
LIVING LABS ARE CREATIVE SOCIAL SPACES

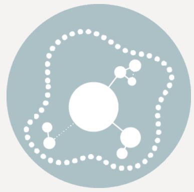
LIVING LABS ARE PUBLIC RESEARCH ARENAS

MODULARITY, FLEXIBILITY, ADAPTABILITY, OPENNESS, SOCIAL INTEGRATIONARE KEY

FLEXIBILITY AND EXTRA CAPACITY OF THE SYSTEM TO ALLOW FOR EXPANSION AND INTEGRATION OF NEW TECHNOLOGY

Innovation Outcomes





ECOSYSTEM STRUCTURE AND INTERACTIONS NEED TO BE DYNAMIC AND FLEXIBLE

STRUCTURE AND CULTURE OF NETWORKS AND ORGANIZATIONS SURROUNDING LL NEED TO FULLY EMBRACE OI

INSPIRATIONAL AND SPARKING EVENTS PUSH THE INNOVATION TO THE NEXT LEVEL

FOCUS ON SPIRAL GATE OI PROCESSES

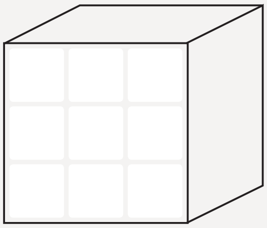
ESTABLISH OI BUSINESS UNITS OR TASK FORCES, DEDICATED TO CROSS-FUNCTIONAL TEAMS

CREATE A SIMPLE FRAMEWORK FOR COMMUNICATION AND IMPLEMENTATION OF OI

IMPLEMENT STRATEGIES TO INVOLVE EXTERNAL ACTORS IN THE INNOVATION PROCESS

ECOSYSTEM MAPPING PROVIDES BETTER UNDERSTANDING OF INTERACTIONS TO SUPPORT OI

TRANS-DISCIPLINARY STAKEHOLDERS ARE KEY FOR CO-CREATION



INSPIRATIONAL AND SPARKING EVENTS PUSH THE INNOVATION TO THE NEXT LEVEL

ORIENTATION TOWARDS COLLECTIVE GOALS

IMPLEMENT INCENTIVE SYSTEMS WHICH INCLUDE OPEN ORIENTED GOALS AND METRICS

CO-CREATION AS A TOOL THAT SUPPORTS OI

USE MONITORING SYSTEMS FOR DIFFERENT TECHNOLOGIES AVAILABLE IN THE EXTERNAL ENVIRONMENT

PLANNING OF CO-CREATION WORKSHOPS SHOULD BE CO-CREATIVE ITSELF

USE OF ICT AND IP MANAGEMENT SYSTEMS

BRAIN WRITING AS AN IMPORTANT TOOLS TO ENSURE ALL THE VOICES ARE EQUALLY HEARD

DIVERSITY OF WORKSHOPS MATERIALS ALLOWS ENABLES PARTICIPANTS' ENGAGEMENT AND SELF EXPRESSION

DATA MANAGEMENT SYSTEM SHOULD BE DECENTRALIZED AND BUILD IN NODES

PROPER DOCUMENTATION OF THE WORKSHOP OUTCOMES,CRUCIAL FOR POTENTIAL PROJECTS' FURTHER DEVELOPMENT

RETRIEVAL AND DATA FORMATION SHOULD MATCH THE NEEDS OF THE TARGET GROUP

SENSOR AND DATA MANAGEMENT SYSTEM PROVIDE EVALUATION OF INNOVATIONS

DATA MEASUREMENT SHOULD HAVE SIMILAR RESOLUTION TO ALLOW PROPER COMPARISON AND ANALYSIS

Toolbox

The following is an uncategorized summary of the findings from this report.

ENGAGING USERS AS ACTIVE CO-CREATORS SUPPORTS OI

ESTABLISHING CLEAR ROLES AND RULES FOR ENHANCED COOPERATION

LIVING LABS ARE CREATIVE SOCIAL SPACES

MODULARITY, FLEXIBILITY, ADAPTABILITY, OPENNESS, SOCIAL INTEGRATION ARE KEY

ESTABLISHING AN EFFICIENT COLLABORATIVE FRAMEWORK/ INFRASTRUCTURE

STRUCTURE AND CULTURE OF NETWORKS AND ORGANIZATIONS SURROUNDING LL NEED TO FULLY EMBRACE OI

LIVING LABS ARE PUBLIC RESEARCH ARENAS

FOCUS ON SPIRAL GATE OI PROCESSES

Toolbox

LIVING LABS ARE CO-CREATIVE PLATFORMS FOR CONTINUOUS EXPERIMENTATION

OI REQUIRES CROSS-FUNCTIONAL COOPERATION

CREATE A SIMPLE FRAMEWORK FOR COMMUNICATION AND IMPLEMENTATION OF OI

INSPIRATIONAL AND SPARKING EVENTS PUSH THE INNOVATION TO THE NEXT LEVEL

ECOSYSTEM MAPPING PROVIDES BETTER UNDERSTANDING OF INTERACTIONS TO SUPPORT OI

LIVING LABS ARE ACCESS PLATFORMS TO FUNDING, TEST BEDS AND BUSINESS OPPORTUNITIES

USERS FEEDBACK AND DATA COLLECTION ARE USEFUL FOR ITERATION OF OI PROCESSES

CREATE GOOD COMMUNICATION CHANNELS BETWEEN THE END USERS AND INNOVATION ORGANIZATIONS

ECOSYSTEM STRUCTURE AND INTERACTIONS NEED TO BE DYNAMIC AND FLEXIBLE

CREATE A NETWORK OF INTER-ORGANIZATIONAL RELATIONSHIPS AND EXTERNAL ACTORS

Toolbox

ESTABLISH OI BUSINESS UNITS OR TASK FORCES, DEDICATED TO CROSS-FUNCTIONAL TEAMS

ASSIGN ROLES TO MANAGE THE INTERFACE BETWEEN THE FIRM AND ITS EXTERNAL ENVIRONMENT

IMPLEMENT INCENTIVE SYSTEMS WHICH INCLUDE OPEN ORIENTED GOALS AND METRICS

USE MONITORING SYSTEMS FOR DIFFERENT TECHNOLOGIES AVAILABLE IN THE EXTERNAL ENVIRONMENT

IMPLEMENT STRATEGIES TO INVOLVE EXTERNAL ACTORS IN THE INNOVATION PROCESS

USE OF ICT AND IP MANAGEMENT SYSTEMS

DECENTRALIZED STRUCTURE SUPPORTS OI

ORIENTATION TOWARDS COLLECTIVE GOALS

CO-CREATION AS A TOOL THAT SUPPORTS OI

TRANS-DISCIPLINARY STAKEHOLDERS ARE KEY FOR CO-CREATION

Toolbox

PLANNING OF CO-CREATION WORKSHOPS SHOULD BE CO-CREATIVE ITSELF

INTERFACES AND VISUALIZATIONS THAT ENABLE THE USER TO TAYLOR THE SYSTEM TO THEIR PERSONAL PREFERENCES

BRAIN WRITING AS AN IMPORTANT TOOLS TO ENSURE ALL THE VOICES ARE EQUALLY HEARD

FLEXIBILITY AND EXTRA CAPACITY OF THE SYSTEM TO ALLOW FOR EXPANSION AND INTEGRATION OF NEW TECHNOLOGY

DIVERSITY OF WORKSHOPS MATERIALS ALLOWS ENABLES PARTICIPANTS' ENGAGEMENT AND SELF EXPRESSION

DATA MEASUREMENT SHOULD HAVE SIMILAR RESOLUTION TO ALLOW PROPER COMPARISON AND ANALYSIS

PROPER DOCUMENTATION OF THE WORKSHOP OUTCOMES,CRUCIAL FOR POTENTIAL PROJECTS' FURTHER DEVELOPMENT

DATA MANAGEMENT SYSTEM SHOULD BE DECENTRALIZED AND BUILD IN NODES

SENSOR AND DATA MANAGEMENT SYSTEM PROVIDE EVALUATION OF INNOVATIONS

RETRIEVAL AND DATA FORMATION SHOULD MATCH THE NEEDS OF THE TARGET GROUP

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Interviews *(conducted by Hagy, S. and Bard, F.)*

Green Village, TU Delft:
- Lippmann, Friso- Business relations, TU Delft Technology Partners. (16th of May 2017)
- Segers, Rolph- Business Coach, YES! Delft. (16th of May 2017)
- Steensma, Sybren- Programme manager, BTA Climate-KIC. (15th of May 2017)
- Tamboer, Rene and Spanjer, Willy- Programme managers, The Green Village. (16th of May 2017)
- Winkles, Zeno- Business Developer, BTA climate-KIC. (15th of May 2017)

HSB Living Lab, Chalmers:
- Alsholm, Anne- Innovation advisor, Chalmers Innovation Office. (14th of June 2017)
- Axelsson, Håkan- Business coach Greentech, Chalmers Ventures. (26th of June 2017)
- Berg, Mats- CEO Johanneberg Science Park. (16th of June 2017)
- Sarin, Emma- Project manager HSB Living Lab, HSB. (13th of June 2017)

Annex 1 - HSB Living Lab Sensors

Indoor Environment Quality Sensor

Measurements	Accuracy
Temperature	0,6 °C
Relative humidity	2,5 %rH
CO_2 concentration	50 ppm
Number of sensors in the building	80 units

In-Wall Sensors

Measurements	Accuracy
Reading time and date	1 s
Temperature (in-wall)	0,5 °C
Relative humidity (in-wall)	2,5 %rH
Dewpoint temperature (in-wall)	0,5 °C
Moisture content (in-wall)	1 g/kg air
Wood moisture equivalent (in-wall)	1% WME
Number of sensors in the building	15 units

Electrical Energy Sensor

1-phase meter

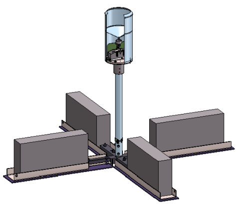
Measurements	Accuracy
Present active power, wattage	1 %
Total energy, accumulated	0,1 kWh
Minimum measurement interval	1 s
Number of sensors in the building	
1-phase meters	490
3-phase meters	40

Also measures present voltage (V), present current (A), present reactive power (var), present apparent power (VA), power factor (-) and frequency (Hz)

Waste Water Sensor

Measurements	Accuracy
Temperature	0,15 °C
Minimum measruement interval	10 s
Number of sensors in the building	28 units

Roof Top Weather Sensor

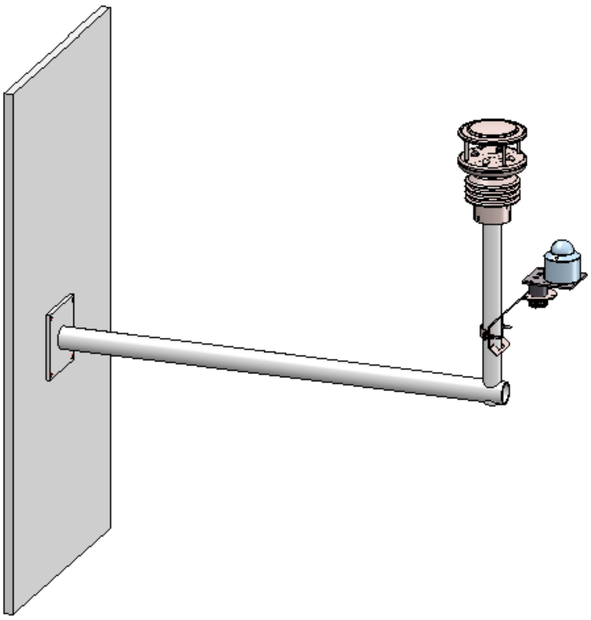


Measurements	Accuracy
Wind direction	1°
Wind speed	1 m/s
Relative humidity	3 %rH
Temperature	0,6°C
Percipitation	0,1 mm
Percipitation intensity	max 11 mm/min
CO2 concentration	3%
Irradiation, PAR (400-700nm)	1 µmol/m2s
Irradiation, global (380-3500nm)	1 W/m2
Irradiation balance, net albedo (W/m2)	1 %
Brightness and twilight	0,1 klux and 1 lux
Air pressure	10 hPa
Minimum measurement interval	5 s
Number of sensors in the building	1 unit

Water Flow Sensors

Measurements	Accuracy
Flow	0,2 l/min
Temperature	0,15 °C
Minimum measurement interval	10 s
Number of sensors in the building	207 units

Facade Weather Stations



Measurements	Accuracy
Wind direction	1 °C
Wind speed	1 m/s
Relative humidity	3 %rH
Temperature	0,6 °C
Percipitation yes/no	-
Irradiation, global (380-3500nm)	1 W/m2
Brightness and twilight	0,1 lux and 1 lux
Air pressure	10 hPa
Minimum measurement interval	5 s
Number of sensors in the building	4 units

Heating System

Measurements	Accuracy
Heating flow	0,1 l /s
Heating temperature	0,1 °C
Heating energy	10 Wh
Minimum measruement interval	10 s
Number of sensors in the building	47 units

Positioning System

Measurements	Accuracy
Acceleration, tag based	0,01 m/s2
Position x-y-z, tag-based	0,2 m
Minimum measurement interval	0,2 s
Number of sensors in the building	54
Number of available positioning tags	300

Senses position with tags, allows triggering, in-zone notification, ID etc.

Ventilation Sensors

Measurements	Accuracy
Ventilation air flow	4 %
Ventilation volicity	2 %
Ventilation air temperature	0,15 °C
Ventilation air relative humidity	3 %rH
Minimum measurement interval	10 s
Number of sensors in the building	42 units

Sensor Network Infrastructure

Objectives

Handles:	*Big data* *Real time data* *Project processes*
Number of servers involved	*5*
Number of databases involved	*6*