Research Centre on
ZERO EMISSION
NEIGHBOURHOODS
IN SMART CITIES

NTNU SINTEF

ZEN LIVING LABS DEFINITION, IDEAS, AND EXAMPLES

ZEN REPORT No. 18 – 2019

Ruth Woods, Thomas Berker, Daniela Baer, Lars Arne Bø | SINTEF, NTNU

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Lars Arne Bø (SINTEF)
ZEN LIVING LABS definition, ideas and examples
Keywords: living labs, participation, sustainable development, urban transformation
ISBN 978-82-536-1631-5
Illustration, front page: Figure 1 A drawing of the future ZEN pilot project 'New City – new airport' by Simon, 4th grade
Norwegian University of Science and Technology (NTNU) | www.ntnu.no
SINTEF Building and Infrastructure | www.sintef.no

https://fmezen.no

Preface

Acknowledgements

This report has been written within the Research Centre on Zero Emission Neighbourhoods in Smart Cities (FME ZEN). The authors gratefully acknowledge the support from the Research Council of Norway, the Norwegian University of Science and Technology (NTNU), SINTEF, the municipalities of Oslo, Bergen, Trondheim, Bodø, Bærum, Elverum and Steinkjer, Sør-Trøndelag county, Norwegian Directorate for Public Construction and Property Management, Norwegian Water Resources and Energy Directorate, Norwegian Building Authority, ByBo, Elverum Tomteselskap, TOBB, Snøhetta, ÅF Engineering AS , Asplan Viak, Multiconsult, Sweco, Civitas, FutureBuilt, Hunton, Moelven, Norcem, Skanska, GK, Caverion, Nord-Trøndelag Elektrisitetsverk - Energi, Numascale, Smart Grid Services Cluster, Statkraft Varme, Energy Norway and Norsk Fjernvarme.

The Research Centre on Zero Emission Neighbourhoods (ZEN) in Smart Cities

The ZEN Research Centre develops solutions for future buildings and neighbourhoods with no greenhouse gas emissions and thereby contributes to a low carbon society.

Researchers, municipalities, industry and governmental organizations work together in the ZEN Research Centre in order to plan, develop and run neighbourhoods with zero greenhouse gas emissions. The ZEN Centre has nine pilot projects spread over all of Norway that encompass an area of more than 1 million m2 and more than 30 000 inhabitants in total.

In order to achieve its high ambitions, the Centre will, together with its partners:

- Develop neighbourhood design and planning instruments while integrating science-based knowledge on greenhouse gas emissions;
- Create new business models, roles, and services that address the lack of flexibility towards markets and catalyze the development of innovations for a broader public use; This includes studies of political instruments and market design;
- Create cost effective and resource and energy efficient buildings by developing low carbon technologies and construction systems based on lifecycle design strategies;
- Develop technologies and solutions for the design and operation of energy flexible neighbourhoods;
- Develop a decision-support tool for optimizing local energy systems and their interaction with the larger system;
- Create and manage a series of neighbourhood-scale living labs, which will act as innovation hubs and a testing ground for the solutions developed in the ZEN Research Centre. The pilot projects are Furuset in Oslo, Fornebu in Bærum, Sluppen and Campus NTNU in Trondheim, an NRK-site in Steinkjer, Ydalir in Elverum, Campus Evenstad, NyBy Bodø, and Zero Village Bergen.

The ZEN Research Centre will last eight years (2017-2024), and the budget is approximately NOK 380 million, funded by the Research Council of Norway, the research partners NTNU and SINTEF, and the user partners from the private and public sector. The Norwegian University of Science and Technology (NTNU) is the host and leads the Centre together with SINTEF.

https://fmezen.no
@ZENcentre
FME ZEN (page)

Norwegian Summary

Living labs er brukersentrerte tiltak som har mål om å involvere ulike individer eller brukergrupper i tekniske eller bærekraftig endringer i samfunnet. The FME Research Centre on Zero Emission Neighbourhoods in Smart Cities (ZEN) har valgt living labs som et format til å organisere og sikre brukerengasjement i pilotprosjekter. Hovedformålene med bruk av living labs i ZEN-pilotprosjekter er å øke forståelsen blant ulike brukergrupper for ZENs målsettinger og til å støtte arbeidet med å realisere bærekraftige endringer. Rapporten presenterer ZEN-definisjonen av hva en living lab er, og hvordan den kan brukes i et ZEN-pilotområde. Rapporten gir også innsikt i brukermedvirkningsprosesser som allerede har funnet sted innenfor ZEN-pilotområder og presenterer eksempler på living labs som har inspirert ZEN-bruk av laboratoriekonseptet.

Rapporten understreker potensialet for å bruke ZEN living lab-konseptet. En ZEN living lab er et åpent inkluderende format som støtter brukerengasjement i ZEN-pilotprosjekter. Hensikten med å benytte living lab-konseptet er å bygge bro mellom den sosiale og tekniske konteksten. En ZEN living lab skal fungere som en kreativ arena for kunnskapsutveksling mellom mennesker, steder og teknologi. En arena som ideelt sett bør gir rom for læringsprosesser. En ZEN living lab skal inneholde fire hovedelementer:
1. Representanter fra de ulike brukergruppene som er berørt av bærekraftige endringer foreslått av ZEN.
2. Et klart definert geografisk sted.
4. Et sett av iterative aktiviteter.
3. Et eksperimentelt format basert på utfordringene og behovene i pilotprosjektet.

ZEN-definisjonen av null-utslippsområder fokuserer på tekniske løsninger for reduksjon av energiforbruk og CO_2-utslipp. Det er derfor en tendens til å benytte en målbasert living lab metodikk, som testing av tekniske løsninger, som et middel for å oppnå innovasjoner innen byggebransjen eller energisektoren. Enhver anvendelse av ZEN living lab konseptet bør imidlertid ikke miste fokuset på det primære målet, som er å engasjere brukergruppene som vil bli påvirket av endringene som følger med innføringen av nullutslippsteknologi. Dette bør være i form av en åpen og inkluderende prosess.

Summary

Living labs are user centred initiatives where knowledge production involves individuals or user groups affected by sustainable transitions. The FME Research Centre on Zero Emission Neighbourhoods in Smart Cities (ZEN) has chosen living labs to secure user engagement and as a framework for the organisation of user involvement in pilot projects. The report presents three main elements, firstly the ZEN understanding of what a living lab is and how it may be applied within a ZEN neighbourhood. Secondly, it offers examples of living labs that have inspired the ZEN use of the living lab concept, and thirdly, it provides insight into how user participation has already taken place within ZEN pilot neighbourhoods.

Historical and current applications of living labs are presented in the report, underlining the potential of using the ZEN living lab concept. *A ZEN living lab is an open, inclusive space that supports user engagement with ZEN pilot projects, bridging the gap between the social and technical context. A ZEN living lab should function as a creative arena for knowledge exchange, between people, places, and technology.* An arena that should ideally highlight learning processes. The ZEN living lab concept includes four main elements:

1. Representatives from the different user groups affected by the sustainable neighbourhood transition proposed by ZEN.
2. A clearly defined geographical place.
3. A set of iterative activities.
4. An experimental format based on the challenges and needs of the neighbourhood.

The definition of zero emission neighbourhoods applied by the ZEN Centre implies technical solutions to the reduction of energy use and CO2 emissions. This definition implies a target-based application of the living lab methodology: the testing of technical solutions as a means to achieve innovations within the construction industry or the energy sector. The ZEN living lab concept proposes as less target based understanding of the pilot projects, because any application of the living lab concept should not lose sight of the primary aim, which is engaging with the user groups who will be affected by the changes implied by the introduction of zero emission technology. This should take place in an open and inclusive process where the results may be learned from but not necessarily measured.

Contents

1 INTRODUCTION

Living labs may broadly be described as user centred initiatives where knowledge is produced by involving different individuals or user groups. The FME Research Centre on Zero Emission Neighbourhoods in Smart Cities (ZEN) has chosen living labs as a framework to support the Centre's intention to organise and secure user involvement in pilot projects. This report presents the ZEN understanding of what a living lab is and how it can be used within a ZEN pilot neighbourhood. The report also provides examples of living labs that have inspired the ZEN use of the living lab concept and insight into how user participation has already taken place within ZEN pilot neighbourhoods.

In general, living labs are characterised by a methodological openness that allows them to establish a form and develop tools that are site specific and associated with the real-life challenges that users are dealing with. This openness is pertinent within the ZEN Centre, which is working with nine pilot projects. Each pilot project is dealing with different challenges in their work towards establishing a zero emission neighbourhood. The variety of challenges means that a wide range of ideas and approaches to dealing with zero emission ambitions is required in ZEN living labs.

The report is based on a literature review about the contemporary use and understanding of living labs within a research context and 33 interviews with ZEN stakeholders that took place in 2017. The use of living labs was not an established concept in the nine pilot projects prior to partnership in the ZEN Centre. Living labs are, however, associated with user participation and involvement, and these kinds of processes have already taken place in several of the neighbourhoods that are now pilot projects, providing a useful a background to learn from and build upon.

The report starts with a discussion about which characteristics define living labs and which qualities are necessary for it to be stated that living lab activities have taken place. The following chapter provides examples of active living labs or ones that have recently been completed. The next chapter presents four of the nine ZEN pilot projects in more detail, focusing on participatory practices and what the actors themselves considered to be relevant living lab activities within the pilot project. The final chapter provides some conclusions about the application living labs within the examples presented and in ZEN pilot neighbourhoods.

2 UNDERSTANDING LIVING LABS

The methodological openness of the concept and often-temporary experimental format of living labs means that there exists a variety of definitions and uses, and it is, on occasion, difficult to grasp what their format and role is. This section provides the theoretical and methodological background to understand the ZEN Centre use of the living lab concept.

The ZEN Centre definition of a neighbourhood states that it is, "*a group of interconnected buildings with associated infrastructure, located within a confined geographical area. A zero emission neighbourhood aims to reduce its direct and indirect greenhouse gas (GHG) emissions towards zero over the analysis period, in line with a chosen ambition level with respect to which life cycle modules, building and infrastructure elements to include*." Therefore, the framework, methods and examples presented here look into living labs' potential to support changes within the built environment, with focus on energy and emission reduction. The ZEN Centre requires the means of bridging the gap between the technical and social context within the nine pilot projects and has chosen living labs as a framework to engage with users. The requirements of people living and working in the neighbourhoods should be accounted for along with the development of new technologies to support zero emission neighbourhoods (Ingeborgrud and Subotiki, 2018). The behaviour and requirements of people during their daily lives has impacts on the generation of greenhouse gas emissions. It is therefore important to account for users during all stages of the design and development process.

The term living lab has, since 2000, been much in use to describe and promote citizen participation in a real-life context[1]. It is also associated with a number of other terms, with other meanings and intended outcomes, such as urban labs, testbeds, and innovation processes, to name but a few. There are two main themes within this wealth of terminology, in addition to the ZEN Centre research aims, that have inspired ZEN living lab activity:

1. In 2003, Mitchell described his Placelab as a "new kind of scientific instrument – a 'microscope' to carefully study people and their interaction with new technologies in a living environment" (Schlirva and McCormick 2016). This definition, which refers to experiences made since the mid-1990s in the first informal living lab at MIT Media Lab, focuses on specific technologies that are tested and developed in a laboratory which aims to resemble as closely as possible every day or real-life situations.
2. The use of living labs within urban contexts after 2000 coincided with three main trends within municipal governance, the carbonisation of urban governance, experimental governance and the transition to a low-carbon economy (Evans and Karvonen 2014) [2]. Among the three types of urban living labs identified by Bulkeley et al. (2018) the actor constellation of ZEN pilot areas resembles most closely what they call 'civic living labs' in which user participation is included in a democratic process that is intended to guide the way towards policy change.

[1] The European network of living labs was established in 2006 (ENoLL) and the number of living labs increased after the network started (ENoLL 2015).

[2] Governance implies all the processes of governing, including interaction between decision-makers, the way an organization or country is managed and the systems for doing this. Urban labs through their use of scientific knowledge-production offer insight into carbon neutral governance, which is intended to enable an effective response to the carbon crisis.

Based on these two approaches two main motivations for the establishment of living labs can be distinguished:

1. **Innovation and technology driven** new market creation and product, service, and systems development.

2. **Citizen-centred urban or civic living lab**, whose aim is to include citizens in sustainable urban transitions[3].

Both of these motivations are relevant for ZEN. The ZEN Centre is working on developing new technologies that will support the development of zero emission neighbourhoods and the societal transition towards the CO2 reductions required to reach the level set by the Paris agreement. In addition, the ZEN Centre aims to engage citizens in this development, to secure use and engagement with this technology and in co-creative processes. To combine these different understandings of living labs and to enable a continuation of openness within the use and understanding of living labs, ZEN Centre has chosen to use the term "ZEN living lab".

The two main motivations are in place, but what characterises the main challenges living labs are dealing with? The innovation and technology driven living lab often has a limited locational concept, this is because it focuses on the technology being developed and tested and not on the environment around it. Innovation and technology development are central to ZEN Centre activities, but the broader locational urban neighbourhood context which is central to ZEN Centre research requires that the intentions and activities behind the instigation of living labs in the pilot projects is broader than new market creation and product development. A citizen-centric experiment has a broad social and locational concept, often known as an urban lab or urban living lab. When moving from user participation when designing isolated technologies or individual buildings to the urban context, urban planning and governance as topics for research and innovation are introduced. This includes the need to involve citizens in city development in order to make urban areas better suited to their needs (Veeckman and van der Graaf 2015).

A ZEN living lab will not have to deal with all these issues at the same time, but an openness that allows the interaction with the two main motivations associated with living labs would seem relevant for ZEN.

2.1 User engagement

The main motivations and aim related challenges behind the application of living labs by the ZEN Centre have been clarified, but it is important to emphasise that the main challenge, whatever the aims being dealt with, is citizen or user engagement when zero emission neighbourhoods are to be implemented. A living lab should allow different groups of people to meet, e.g. technology developers and users or city planners and citizens; people that perhaps would not have otherwise met (Gasco 2017).

Living labs are problem based (Steen and van Bueren 2017). The problem dealt with helps to define which groups are invited to meet in the living lab. A user or user group may for example imply company employees, researchers, residents, planners or activists. Getting different groups to meet is one thing, but getting people involved or engaged with the process is a far greater challenge. Living labs imply aim based interaction between different individuals and/or user groups. An initial negotiation of interests

[3] Sustainable transitions a research field, associated with STS, established in Manchester, associated with the Norwegian term "det grønne shiftet", but with perhaps more depth. https://transitionsnetwork.org/about-strn/research_agenda/

and values should be part of the first phase. This provides the basis to work with and the means to evaluate the impact of the living lab. This is important because the success of an experiment is often based on whether the aims of participants have been achieved (Sengers 2016). Including the aims of the user groups is an important part of securing user engagement in living labs. In the ZEN Centre living labs where the focus is on securing engagement with the development of specific technologies or zero emission neighbourhoods, the challenge may be connecting this aim with the aims of the different user groups. Outside the ZEN partner group and stakeholders involved in the development of zero emission technology and buildings, interest in the zero emissions and ZEN issues may be limited. There is a danger that the ZEN living lab activity is perceived as top-down.

The involvement of users is not a neutral process. Highly educated and affluent individuals working in government and universities often dominate knowledge production in living labs, and this can privilege certain urban actors (Evans and Karvonen 2014) and influence the choice of problems being dealt with. Living labs can end up simply reinforcing elite dominance. Living labs should therefore try to avoid a top-down process; this can be done by, for example, including a broad group of different users and by placing emphasis on the interests and values of those involved in the living lab.

Users influencing technology development or citizens being able to negotiate conditions of their involvement in urban planning and governance suggest actual control (Arnstein 1969). Not all processes where citizens are involved aim for a redistribution of power, but it is not useful to assume that all living labs are automatically beneficial to all involved groups. They can be top-down and carry a political agenda (Evans and Karvonen 2016). Veeckman and van der Graaf (2015) propose that success in living labs is based on a process that relies on the commitment and capacities of people to make sensible decisions through reasoned deliberation. Its empowerment is based on attempts to tie action to discussion. A “meet in the middle philosophy” is proposed where the voice of the citizen (bottom-up) meets governments and companies (top-down) (Veeckman and van der Graaf 2015).

2.2 A framework for activity

Inspired by ethnographic studies of what happens in scientific laboratories (Latour and Woolgar 1979; see also Callon et al. 2011), three main characteristics for living labs are proposed by Evans and Karvonen (2014). These characteristics are also central within the ZEN use of the living lab concept:

1. Geographically bounded space
2. An experimental format
3. Iterative learning.

Geographical bounded space

A characteristic of living labs is the active use of a real-world or real-life context. The place associated with living labs can be powerful because it combines "*the authority of the experiment and the authenticity of the real-world*" (Evans and Karvonen 2014). Living labs have boundaries that establish a geographical and social arena for the experiment. A neighbourhood is an example of such a space, but living labs can take place in public or private companies and in institutions such a universities and government departments. Urban living labs can be understood as territorial (Steen and van Bueren 2017, Evans and Karvonen 2016), and this implies strong boundaries. However, because living labs are dependent on social networks and actor activities, boundaries are not always clearly defined, and people move between overlapping places and networks.

Experimental format

The challenge in living labs is imposing control on a social context. In the previous section we have described living labs as a space for different groups of people to meet and engage with each other and with ZEN goals. It is, however, not enough that people simply meet and engage; a framework is required which encourages the meetings to produce new knowledge. An experiment provides this framework. It also allows the meticulous recording of conditions and outcomes. Sengers (2016) suggests that living labs are a form of transition experiment where the aim is to stimulate complex processes of social and technical co-evolution, but where the focus is on who participates, what is learned and who appropriates what is learned. In sum, this means that once a place has been decided upon and given boundaries, a group is chosen and invited, a specific challenge is identified, and an experimental process should be established. The interests and needs of the group invited into the laboratory are part of the conditions that are varied in a controlled manner.

A process that is often associated with activities in living labs is co-design or co-creation. In these cases a specific technology, process, or design is part of the challenge driving the lab. This kind of experimental process finds citizens participating alongside professionals in the definition and delivery of services or products that are intended to be better tailored to their needs (Nesti 2017). During co-creation or co-design the end-users are co-producers and innovators, but not guinea pigs (Mikela and Lukac 2011). They are contributing their experience and knowledge to a democratic process.

Four stages during co-production can help to secure a procedure where the co-producers are actively involved (Pierson and Lievens 2005):

1. Contextualisation - experts evaluate a situation, define a framework, and choose users
2. Concretisation – experts describe the everyday behaviour of users
3. Implementation – users are involved in design and testing
4. Feedback – users give opinions about their experience. They assess variations in perceptions and attitudes related to a product or service created. Recommendations are then issued.

Ideally a living lab during the contextualisation or start-up phase will provide users with the tools to help describe their situation and to define and understand the challenges being faced. They will be given information about what a living lab is, about the other users or user groups, and about the opportunity to define the aims for the process. Establishing a joint understanding about the aims of the living lab will enable a co-design process with a degree of citizen participation. They should have a clearly defined start and conclusion, with activities that are relevant within the framework, often temporary, highlighting the challenges within the context.

Iterative learning

The final characteristic required in a framework to work with living labs is an iterative process. This means that although the laboratory can begin with a standard set of tools and processes, adaptation to the challenge or site is always a possibility. An iterative process is based on the experiences and learning which arise from the activities taking place in the lab (Leminen and Westerlund 2017). It encourages the repetition of processes and underlines the engagement of users. It is a means to avoid a linear process or a pre-established path. A linear process often includes a standardised set of predefined tools that support a series of established linear phases. Evans and Karvonen (2014) suggest a three-stage feedback loop for urban living labs that supports the iterative process:

1. Labs are established and experiments are conducted (translation 1).

2. They generate data and results (translation 2).

3. They feed into policy and development and the process begins again (translation 3).

In the process described by Evans and Karvonen the knowledge developed feeds into governance, but it does not have to end there. The process continues, with good governance continuing to learn and transform. An iterative approach is useful when evaluating and monitoring citizen participation (Veeckman and van der Graaf 2015).

2.3 What is a ZEN living Lab?

ZEN living labs should ideally highlight learning processes and include knowledge about people, places, and technology. They provide an arena for knowledge exchange in an inclusive, creative atmosphere where the results are not necessarily measurable but are relevant to the people and context involved. A ZEN living lab should allow for a variation in focus or motivation, enabling it to deal with innovation and technology driven challenges or citizen-centred civic urban transitions.

A ZEN living lab

1. Includes representatives from all relevant user groups affected by the sustainable neighbourhood transition implied by involvement with ZEN.

2. Is established within a clearly defined geographical place, in the case of ZEN this is one of the nine pilot neighbourhoods, a ZEN case or take place within a ZEN laboratory.

3. Includes a clearly defined set of activities which can be replicated and evaluated. At the same time, the activities should be iterative, adaptable to the social and physical context, and encourage learning processes.

4. An experimental format, and whilst applying ZEN aims and ambitions the ZEN living lab will engage with users by working with the challenges and needs associated with the neighbourhood context. The experiment should primarily be about the social context, but also highlight the requirements of the physical and technical context. An important part of experimenting is controlled and repeated trial and error. Control in this context means the rigorous analysis and recording of conditions and outcomes.

The data and results generated should be relevant for the users engaged with, the pilot project and the ZEN Centre in general and should not have to be quantifiable.

3 LIVING LAB EXAMPLES

ZEN living labs do not have to invent the wheel, there already exist examples of living labs that are fulfilling the requirements of the ZEN concept. This section proves an overview of living labs that offer examples of how ZEN user involvement and citizen participation could take place within a living lab context.

We have not found any examples of living labs dealing specifically with zero emission neighbourhoods. This chapter therefore presents examples of living labs that deal with associated issues or aspects involved with the ZEN Centre approach. Examples chosen are good practice examples that provide knowledge and inspiration. Each example is presented as a brief snapshot. The chapter starts with living labs that are primarily focused on technology development before we move on to examples that include a civic mission related to urban development.

3.1 ZEB living lab

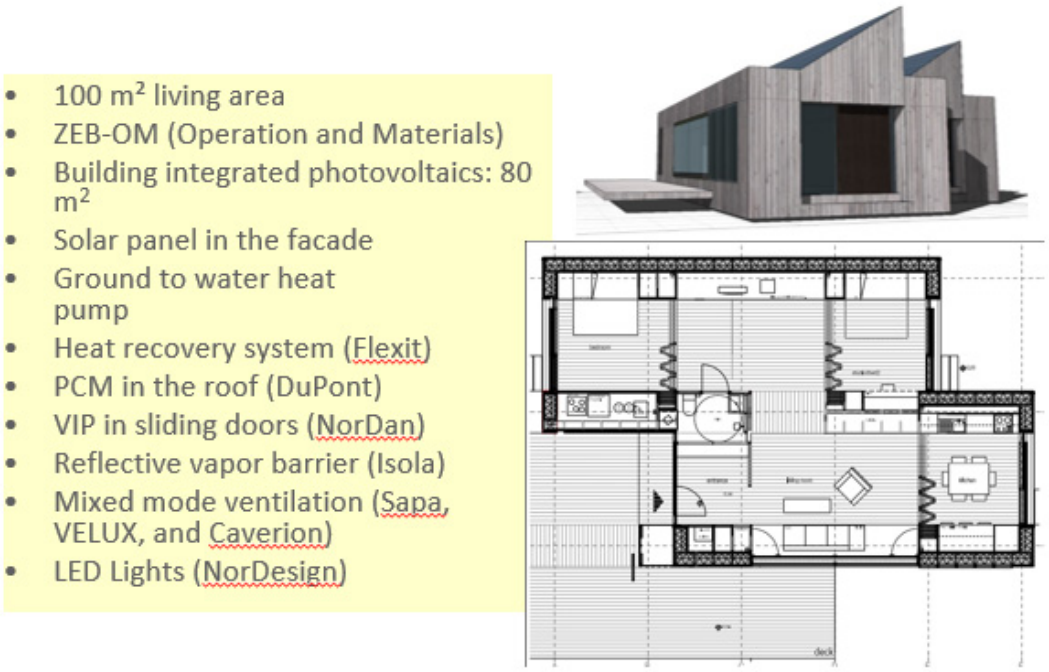

Figure 1. The design and technology included in ZEB living lab, Illustration NTNU

The ZEN Centre is dealing with sustainable transitions on a neighbourhood level, leading to zero greenhouse gas emissions. Overarching planning processes that look at the relation between buildings, energy system, mobility, and people, play an important role in fulfilling this mission. Another, complementary set of activities in the ZEN Centre aims at developing individual solutions, such as zero emission buildings and their technologies, or efficient and flexible energy distribution systems. The ZEB living lab is a residential research facility where zero emission building systems can be tested a long with residents in a situation as close to real-life as possible[4]. It is a single-family house with a heated

[4] https://www.zeb.no/index.php/en/pilot-projects/158-living-lab-trondheim
https://www.sintef.no/alle-laboratorier/living-lab/

floor area of approximately 100 m2. The walls are 40 cm thick, ensuring low heat loss and passive indoor temperatures. The house also includes a broad selection of the technical systems that have potential within zero emission buildings (Goia et al. 2015). It is a Scandinavian house built with many of the elements typical for the current construction of houses in Norway, for example walls, floors, and roofs have a wooden-frame structure. The house's orientation is intended to optimise the collection of solar energy.

A residential experiment took place in the ZEB Living Lab from October 2015 until April 2016 (Table 1) and aimed to gather understanding about how people and zero-emission technology interact together before the technology is available on the wider market (Korsnes et al. 2018). The residential experiment broadly had the form of a "transition experiment", where a design process is being studied within a real-world context. The intention is not to establish facts, but to stimulate a process of socio-technical co-evolution (Sengers et al. 2016). Six different households were chosen to live in the house for a period of twenty-five days each. A new residential experiment is planned in 2019, organised by the ZEN Centre.

Table 1: Overview of the residential groups

Group	**1**	**2**	**3**	**4**	**5**	**6**
Category	Student	Student	Family with children	Elderly	Family with children	Elderly
Details	Male and female couple, 22 years old. Live in a 52m^2 student apartment, built 1964.	Two female friends, 20 and 21 years old. Live in a shared apartment together with three other roommates, built 1905.	Mother 31 years old and father 36. Son 6 years old and daughter 2. Live in a terraced house of 185m^2, built 2007.	Husband 81 and wife 68. Live in a detached house of 170m^2, built 1980.	Mother 31 years old and father 37. Two daughters of 3 and 2 years old. Live in a detached house of 135m^2 plus 70m^2 garage, built 1987.	Husband 61 and wife 56. Live in a semi-detached house of about 120m^2, built 1959.

Korsnes et al. 2018

Completed	August 2015
Location	NTNU Trondheim
Architect:	Luca Finnochiaro
Function	Part of the laboratory infrastructure established by the Research Centre for Zero Emission buildings (ZEB) between 2009 - 2017. https://www.zeb.no/index.php/no/ Currently part of the ZEN Centre's laboratory facilities
Contact	Centre Director Arild Gustavsen, PhD candidate Kristian Skeie

The physical format of the ZEB living lab is clearly defined through the ZEB definition. According to the ZEN criteria it is a building-based technology and innovation focused living lab, with clear geographic boundedness. Which actors should be included is also easier to define than in civic living labs, where there is larger more open physical context and a often a number of different user groups. The ZEB living lab followed closely an experimental format, in which demographic parameters - mainly age - of the occupants were varied while the building was kept as stable as possible. Moreover, the occupants were given the same information about how to use the technical aspects of the building.

Despite the relatively high degree of control that was enabled by the fact that the building was purpose-built for this kind of experiment, other variations influenced the validity of the results, such as technical defects occurring during some of the occupancy periods, and a particularly cold period that affected how one family experienced its time in the building. These flaws were followed up through a careful qualitative study of the occupant's reasons for their evaluations. The experiments produced relevant knowledge about conditions that have to be met when a zero emission building is built: among others, a rapid and reliable response when occupants adjust environmental parameters and that the occupants have to trust the technical systems to work as intended (Korsnes et al. 2018).

3.2 NEST (Next Evolution in Sustainable Building Technologies)

Fig. 2: NEST, Illustration Zooey Braun, Stuttgart

NEST is a state-of-the-art technology and innovation based living lab that aims to support innovation processes by providing a platform where new developments for the construction industry and energy sectors can be tested and demonstrated under realistic conditions, narrowing the gulf between the lab and the market[5].

Gramazio Kohler Architects designed the architectural concept for NEST, that consists of a central "backbone" and three open platforms, where individual research and innovation modules can be installed based on the "plug-and-play" principle. People live and work in these units. National and international research teams from universities, architectural firms and companies from the building industry are collaborating. NEST has a consortium of 23 research and industry partners. Including Empa who leads the NEST consortium, the Swiss federal Institute of technology in Lausanne, Gerberit sanitary products, and Holcim building materials.

[5] https://www.empa.ch/web/nest/aboutnest

NEST – a modular innovation arena[6]

Urban Mining & Recycling: The unit demonstrates how a responsible approach to dealing with natural resources can work alongside attractive architectural form. The intention is "that all the resources required to construct a building must be fully reusable, recyclable, or compostable".

Active Assisted Living: Apartments are equipped with intelligent, digital systems, intended to help elderly people in everyday life. The elderly often want to remain in their own homes for as long as possible. This is the goal of "Active Assisted Living" module. For instance, a digital butler reminds them to take their medication, and a communication device designed especially for the elderly connects senior citizens with their relatives and caregivers.

Vision Wood: The housing unit demonstrates that it is possible to combine a well-known and well-used material with new solutions for ecological construction and attractive design. The unit was developed by the Department of Applied Wood Materials at Empa in collaboration with ETH Zurich. It combines the latest developments in wood research with expertise in modern wood construction, and wood has been given new functions. Two doctoral students live in the apartment, testing the suitability of the new applications for daily use by residents and other users.

Leadership	Empa - Swiss Federal Laboratories for Materials Science and Technology
Location	Duebendorf, Switzerland
Funding	Funding: The international network of Living Labs of the Climate-KIC Flagship Building Technologies Accelerator (BTA) comprises six living labs located in the Netherlands (Concept House Village, The Green Village), Sweden (HSB Living Lab), Switzerland (House of Natural Resources, NEST), and Spain (CIES).
Partners	23 partners from research and industry
Contact	Reto Largo reto.largo@empa.ch
Webpage	https://www.empa.ch/web/nest/overview

Applying our ZEN living lab criteria on this case, it is clear that this example goes beyond the ZEB living lab in providing a bounded space for the study of a variety of challenges. Its 'research and innovation units' can choose whether they work with residential or non-residential spaces testing technologies in the context of dedicated modules enabled by the modular design of the building. The experimental protocols are developed and employed in project teams and involve different degrees of occupant participation. From the information available publicly, it is not clear to which degree the cohabitation of the projects under one roof produces effects that are more than the sum of the projects. It can be expected that the goal to create a 'bustling' space for innovation is easier to achieve because of spatial proximity and shared facilities. But since the units involve different networks of research institutions and companies, and operate within different time frames, this mutual learning will not happen automatically and will have to be supported actively.

3.3 Oxford road corridor, Manchester

The Oxford road corridor living lab contains elements of both civic urban living labs and technology and innovation-based living labs. Like the ZEB living lab it is used to study among others zero carbon solutions, and like the NEST it provides a space open to a variety of loosely connected experiments. It goes, however, beyond these two examples, first of all by including a much larger geographical space. It is locatedsouth of Manchester city centre, running the length of Oxford Road. It currently functions as an Innovation District defined as a *"geographic area where leading-edge anchor institutions and companies cluster and connect with start-ups, business incubators, and accelerators. Compact, transit-*

[6] https://www.empa.ch/web/nest/units

accessible, and technically-wired, innovation districts foster open collaboration, grow talent, and offer mixed-used housing, office, and retail." [7]

The Corridor Manchester Partnership was originally established in 2007 between Manchester City Council, Manchester Metropolitan University, The University of Manchester, and the Hospital Trust. The corridor offers examples of how urban laboratories, particularly carbon laboratories, are deployed to reach sustainability goals; they are real-world projects and highlight the importance of place, as well as the willingness of local actors to commit to a shared vision to realize a low-carbon future. Initial activities aimed to redevelop city infrastructure and used monitoring equipment to create recursive feedback (Evans and Karvonen 2014).

Manchester itree example,

A carbon lab, also known as the university living lab, was used to demonstrate the importance of trees and other types of greenery in the fight against climate change in cities. Led by researchers from the Faculty of Life Sciences, the I-Treeproject monitors how trees can influence local climatic conditions in an urban setting8, by, for example, studying how effective trees and grass are at preventing run-off and flash flooding. Nine test sites were established. Evans and Karvonen (2014) proposed that carbon laboratories provide something solid to aim for and something to write policy about. Framing innovation in an urban context as a process of knowledge production and application (Evans and Karvonen 2014). In Manchester, the urban lab offered the opportunity to install monitory equipment. A wireless network was installed which collected data about the climate, natural environment, and carbon use as well as socio-technical and economic conditions. The aim was to provide a complete picture of how the Oxford road corridor functions (Evans and Karvonen 2014).

Fig. 3: Illustration: http://www.oxfordroadcorridor.com/gallery.html

The Oxford Road Corridor is still running, and the area is currently one of the demonstrator sites for

[7] http://www.oxfordroadcorridor.com/
[8] http://universitylivinglab.org/i-trees#overlay-context=project-report-research-profile

the Triangulum project, a Horizon 2020 Lighthouse project running until 2019 to demonstrate smart green growth across energy, mobility, and ICT[9]. Manchester City Council, Manchester Metropolitan University, The University of Manchester, Siemens, and Clicks & Links are working together on these themes, with additional pilot activity in Stavanger, Norway and Eindhoven, the Netherlands.

Organisation	Five contributing partners; Manchester Metropolitan University, The University of Manchester, Manchester City Council, Central Manchester University Hospitals NHS Foundation Trust, and Bruntwood, Manchester Science Partnerships and Royal Northern College of Music.
Location	Manchester UK
Established	2007 expected to run until 2025
Webpage	www.oxfordroadcorridor.com

In relation to the ZEN living lab criteria, the corridor is an example of a bounded space which is more open and includes a wider set of actors and factors than the more controlled spaces of the ZEB living lab and the NEST. Evans and Karvonen (2014) describe the challenge facing this living lab, such as how to include a sufficient number of stakeholders into the existing partnership and avoiding a reproduction of existing power structures. Instead of acting as civic laboratory with democratizing effects, it tended to "reinforce the divide between the knowledge community and the surrounding neighbourhoods rather than to integrate these in new ways." (Evans and Karvonen 2014). This failure is published and reflected upon in the context of relevant theories, and is in line with the experimental character of laboratory work. It can therefore also be seen as welcome opportunity for learning.

3.4 SubUrbanLab

The SubUrbanLab project (2014-2016) examined how suburbs can be modernized and socially uplifted by involving residents and other stakeholders[10]. Urban Living Labs were here defined as "*forum for innovation, applied to the development of new products, systems, services, and processes in an urban area; employing working methods to integrate people into the entire development process as users and co-creators to explore, examine, experiment, test and evaluate new ideas, scenarios, processes, systems, concepts and creative solutions in complex and everyday contexts*." (SubUrbanLab 2016). While it describes itself in this definition first and foremost as innovation arena, a civic aspect exists in its mission statement: to turn the suburbs into more attractive, sustainable and economically viable urban areas. Six urban living labs were established, three in Alby, Sweden and three in Peltosaari, Finland. Each functioned as an arena for the co-creation of innovative urban solutions and a means to develop new forms of involving the residents and stakeholders. We have chosen here to focus on the Peltosaari urban living labs, which were organised according to two main methodological formats, focusing on different user groups:

1. "Energetic co-operation" aimed to enhance collaboration between residents, energy-saving solution developers, and a municipal housing company in order to explore ways to decrease energy use in rented apartment buildings. Discussion events with residents and other stakeholders were arranged to seek out energy saving ideas and the best ways to share information about energy efficient living. A procedure for improving energy efficiency in the buildings was co-developed.

[9] https://www.triangulum-project.eu/?page_id=82
[10] The SubUrbanlab project was part of the "Transition towards sustainable and liveable urban futures" – The strategic research agenda of JPI Urban Europe 2015.

2. “Sustainable decisions” brought together decision makers and municipality representatives to co-develop solutions for reaching the city’s targets for energy efficiency and renewable energy. Workshops were arranged and ideas for improving future practices were gathered. A result was that the sustainable targets became more closely linked to the daily work of participants. Cross-departmental cooperation was increased.

Fig. 4 (SubUrbanLab 2016).

Funding	SubUrbanLab was funded by VINNOVA and Tekes through the Joint Programming Initiative, Urban Europe.
Location	Alby, Sweden and Peltosaari, Finland
Active	2014-2016
Contact	riikka.holopainen@vtt.fi , maija.federley@vtt.fi , philip.thorn@ivl.se , anja.karlsson@ivl.se , gunilla.isgren@botkyrka.se, ilari.seitsonen@riihimaki.fi
Webpage	http://suburbanlab.eu

This living lab has strong focus a citizen centred civic living lab activities. The bounded area within which these living labs were conducted isa number of suburban neighbourhoods. The inclusion of two different national contexts ideally would enable comparison and exchange, and indeed this led to the identification of different institutional and cultural preconditions increasing living lab impacts (Karlsson et al. 2016: 82). Even though effects like this could be identified, according to the evaluation in general they are difficult to assess, because they are often attributable to many conditions and are mostly ’soft’, i.e. impossible to quantify (Karlsson et al. 2016). As in the Oxford Corridor, the evaluation points into the direction of limited user involvement particularly in the planning stage (Karlsson et al. 2016:83). To alleviate this, the following key success factors are described (SubUrbanLab 2016).

• Early involvement of the people
• Well-defined goals, context, and expectations
• Continuous and clear communication
• Methods adapted to goals and participants
• Participants are active partners from the planning and design to the developing, implementing, and evaluating stages

3.5 Kalasatama, Helsinki

The Kalasatama Living Lab is closely associated with Smart Kalasatama and is part of a Six City Strategy where Finland's largest cities have come together to learn how to become smarter and to cope with urban challenges. Kalasatama ("Fishing habour") is an old harbour area that is being developed into a new town with housing, offices, and public services. The development started in 2011 and is expected to be completed in 2030. Kalasatama Living Lab is a platform for open innovation collaboration where the entire community can participate in the development of user-oriented, smart products and services. Thirty different projects were initially planned and in 2017 twenty different projects that all aimed at reducing the residents carbon footprints were in motion. One method used is "agile piloting", here the team organises activities and invites different actors to run them[11]. The intention is to enlarge services and find new partners and equals, as a method for engagement. The activities dealt with include transport, grid, services, and the use of big data.

Fig. 5 https://mycourses.aalto.fi/pluginfile.php/286899/course/section/68401/Smart_Kalasatama_Aalto_VM.pdf

A Kalasatama example: *One more hour a day*

Time is a city resident's most precious resource, which is why Kalasatama aims to manage time efficiently. The time saving vision, created together with local residents and other stakeholders, is for everyone to gain an extra hour of free time every day. For example, valuable time is spent daily on queuing up, grocery shopping and commuting. Smart services improve both quality of life and time management. Time will be saved by improving the flow of traffic and logistics, as well as guaranteeing first-rate local services and flexible facilities for working away from the office. The extra hours can be spent on activities that bring happiness, whether that means relaxing in the local park, cooking with your children, studying, or taking dance classes. The objective is to deliver services to people rather than vice versa, which in turn reduces the time spent commuting[12].

[11] https://mycourses.aalto.fi/pluginfile.php/286899/course/section/68401/Smart_Kalasatama_Aalto_VM.pdf

[12] From Kaisa Spillings presentation about Smart Kalasamata in Trondheim, september 2017. https://trondheimhavn.no/nyhet/idemyldret-og-debatterte-om-nyhavnas-fremtid-1297.aspx

Organiser	Forum Virium Helsinki
Funding	Kalasatama living lab is funded by the European Regional Development Fund, European Social Fund, Finnish State, and the six participating cities.
Location	Kalasatama, Helsinki, Finland
Active	2016-2020
Contact	https://fiksukalasatama.fi/en/building-blocks/living-lab/

What sets this last example apart is that it combines geographic boundedness with a larger number of experiments. As summarized in Haukipiro et al. (2018), the development of eleven mostly ICT based products and services employed seven different methods (from a world cafe to online surveys) that the authors describe as being part of three overarching innovation tools: the aforementioned 'agile piloting', 'ideasprints', i.e. the co-generation of ideas with stakeholders, and 'innovation path', a one-year project in which solutions for a hospital were developed and tested together with their users. The process was described as an «easy, tailored, and low-resource-demanding, multi-method co-creation process» (Haukipiro et al. 2018: 33) that can be expected to contribute to knowledge generation through comparisons between more and less effective strategies, an opportunity that unfortunately is not used by Haukipiro et al. (2018) who present the living lab activities as exclusively 'promising' and the role of the living lab as 'crucial'. The impact is not documented.

4 PARTICIPATORY PRACTICES IN ZEN PILOT PROJECTS

Norway, unlike Sweden, Finland, or the Netherlands, does not have a long tradition of applying living lab approaches (Voytenko, et al., 2015). On the other hand, in a similar way to other Scandinavian and Northern European countries, Norway does have experience with participatory practices and user involvement (brukermedvirkning). This experience can be built upon, as can ideas about co-design, which have their foundation in Scandinavian participatory design from the 1960's and "includes all stakeholders of an issue, not just the users, throughout the entire process from research to implementation" (Szebeko & Tan, 2010)[13]. This chapter focuses on examples of participatory practices found within four ZEN pilot projects, Ydalir, Knowledge Axis + NTNU Campus, Knowledge Axis + Sluppen, and 'New City – new Airport' in Bodø.

The four pilot projects have been given particular focus because they each placed emphasis on user engagement prior to their partnership with ZEN and/or during the early stages of pilot project development. They provide context specific examples of how different user groups can be engaged. Urban planning and development processes characterize the four examples. They offer insight into the development of masterplans, feasibility studies, general area planning, and sub-plans. These processes are not new in themselves within urban development, nor can they be described as particular to the development of a ZEN pilot project. They do, however, offer insight into where and when different user groups or stakeholders are involved. They also highlight the importance of involving different users in dialogues around neighbourhood development. In addition, each process described represents a unique challenge to the people involved. What are described in the following four sections are the processes and who was engaged. The four neighbourhoods are still in the process of development, so the solutions are yet not in place. Each example ends with a description of ideas for potential living labs, extracted from the interviews with stakeholders involved with the ZEN pilot projects.

The chapter is based on a mapping of the ZEN pilot projects that took place in 2017 and includes 33 interviews with stakeholders from seven pilot project. The majority of the stakeholders were from ZEN partner organisations or own land or buildings within the pilot neighbourhoods. Interviews were conducted either as individual interviews or as group interviews. The interviews followed a semi-structured interview guide and were transcribed and analysed with the help of a qualitative content analysis methodology (Mayring, 2000).

[13] During the 60s was rooted in work with trade unions (Ehn, 2017). Scandinavian researchers and trade unions developed the work-oriented approach to democratization of design and co-design in the Scandinavian tradition.

4.1 Ydalir, Elverum

	KEY FACTS
Planned Function	Residential area with school and kindergarten
Area size (m^2)	430 000
Current function	Sand extraction, gravel depot
Construction	800 - 1 000 new detached houses and apartment buildings (ca. 100 000 m^2), a new school for ca. 300 students (5000 m^2), and a new kindergarten with 8 units (1500 m^2)
Project owner	Elverum tomteselskap, a land development agency owned by the municipality
Involved Stakeholders	- Elverum tomteselskap, land development agency (owns 80% of land) - Two private landowners (owns together 20% of land) - Elverum municipality, planning department - seven local private developers - Asplan Viak - Plan1 - tegn3 - Hedmark Trafikk, transportation agency - EIDSIVA, energy agency - SØIR IKS, waste management company
City population	14 877 (1.1.2017)

Figure 6. Key Facts on Ydalir, Illustration: Tegn3

The Ydalir project aims to develop a new neighbourhood with high energy and emission ambitions in the town of Elverum in Hedmark. The estimated timeframe for completion is 2030. 800 to 1 000 residential units are planned to be developed (approx. 100 000 m^2). The residential units are planned as a combination of detached houses and apartment buildings and are built around a school for approx. 300 pupils (approx. 5 000 m^2) and a kindergarten with eight units (approx. 1 500 m^2) (Asplan Viak 2016).

A masterplan for the neighbourhood that was developed in cooperation between the project owner and other stakeholders (fig. 6) has been central within the early stages of user involvement in Ydalir. The masterplan is a guideline for the development of the neighbourhood, with measures for energy, materials, and transport in focus. Starting in 2016, it was developed over a one-year period and included a collaborative process with the stakeholders mentioned in fig. 6 and was funded by the ENOVA[14]. The

[14] ENOVA is owned by the Ministry of Climate and Environment and contributes to reduced greenhouse gas emissions, development of energy and climate technology and a strengthened security of supply.

masterplan supports the sale of land contracts for nine parcels of land to private developers. The construction of the school and kindergarten in a central position within Ydalir started at the beginning of 2018, and the first pupils will start school in the autumn 2019. The contractual negotiations between the landowners and several private developers started in spring 2017, and the construction of the first residential buildings will start in 2019.

STAKEHOLDER INVOLVEMENT

The development of the Ydalir Masterplan was understood as vital not just to decide what the technical standard would be; it was also seen as an opportunity to engage with stakeholders who would potentially be involved in developing the neighbourhood. Five workshops over the period of six months were dedicated to different aspects of the project development, including topics such as aims and vision, energy, building and infrastructure, users and social quality, and transportation. A summarizing workshop concluded the process in April 2017, and the results are part of the "Masterplan for Ydalir", completed in 2017[15].

The project owner ETS deliberately invited a broad group to the masterplan workshops to integrate as many stakeholders as possible, including private, public and academic organisations. The participants when interviewed describe the process as "*fruitful"* and emphasised the importance of "*developing a common understanding"* for the project and the ZEN ambitions. The impact of the workshops and the importance of developing the social relations between the participants is highlighted by one the entrepreneurs, who describes the relationship between the participants as a feeling like *"one family",* where *"everybody is in to participate".*

Given the complexity of developing the systems required to establish a zero emission neighbourhood, workshops like the ones that took place in Ydalir are invaluable for developing a group of engaged citizens, establishing a network, and exchanging knowledge about the technical requirements and social values necessary when engaging in the complex process of developing and using zero emission technology. During the process, social relations among the partners were strengthened, and this is expected to have a positive impact on the later stages of development.

In addition to the masterplan development, the real estate department in Elverum has started a process to involve professional building users (facility management, cleaning, etc.) in the planning process to make sure that the building is appropriately planned and easy to operate. This will be important in the public buildings in Ydalir and Elverum in general, such as the school and kindergarten. Future professional users of the Ydalir School, such as technical management and representatives for the staff and pupils, were included.

Ideas for Living Labs

Stakeholders from Ydalir were asked for ideas that could be implemented in ZEN living labs and proposed three main ideas.

https://www.enova.no/about-enova/ The program that sponsored the masterplan was the 'Concept study for innovative energy and climate solutions in buildings, areas and energy systems' [Konseptutredning for innovative energi- og klimaløsninger i bygg, områder og energisystem].

[15] https://www.ydalirbydel.no/wp-content/uploads/2017/12/Ydalir-Masterplan.pdf

1. Testing innovative solutions in a "showroom" apartment

An apartment or house developed in cooperation with a property developer where new approaches to housing and energy technology could be tested and operated. This residential unit could be rented or loaned to different demographic groups, single and family households were proposed. A reality-TV concept was also suggested, where people get the chance to live for a limited time in this apartment under special conditions. This limited test period should be free of charge for the tenants. A similar concept was applied in the residential experiment in ZEB living lab between 2015-2016 (Korsnes et al. 2018). A stakeholder from a utility company proposed testing state of the art appliances that receive warm water directly from the hot water system, without using electricity to heat up the water within the machines. These solutions could be included in a “showroom” dwelling.

2. Solutions for mobility

Alternative mobility solutions, for example electric cargo bikes provided by a property developer. No cars would be allowed in the neighbourhood or car use should be limited. The mobility suggestions could be tested as an extension of the test apartment or house. Another idea is to test *"bus on demand"* and/or autonomous buses within the area. Testing zero-emission buses was also mentioned.

3. On-site concerts

A pop-up experiment or temporary action to raise awareness about the Ydalir development could be the use of cultural events, such as concerts in cooperation with a music festival. These events invite people into the neighbourhood.

4.2 Knowledge Axis with NTNU Campus, Trondheim

	KEY FACTS
Planned Function	University Campus
Area size (m^2)	339 031
Current function	University Campus
Construction	Retro-fitting and new construction (ca. 136 000 m^2)
Project owner	NTNU
Involved Stakeholders	- NTNU - Trondheim municipality - Trøndelag regional municipality - Several consultancy companies - The student organization SiT - Statsbygg (for Elgestergata 10)
City population	190 464 (per 01.01.2017)

Figure 7. Key Facts on NTNU Campus, Illustration: Koht Architects

The Knowledge Axis is a north to south bound route in Trondheim that includes a high concentration of knowledge-intensive institutions involved in research and education, as well as businesses and public sector organisations. The Norwegian University of Science and Technology (NTNU) is one of the primary actors along the axis, and the re-location of the social sciences and humanities campus currently found at Dragvoll to the Gløshaugen Campus will strengthen this position. The relocation requires 136 000 m2 of floor area, and, after the completion in 2025, it will provide space for 17 000 additional users. In total, more than 36 300 students and 7 550 employees will use the campus on a regular basis (Trondheim kommune 2012, 2014, NTNU 2011, 2014). In August 2017, three alternative concepts for construction west of the Gløshaugen Campus were presented, providing the basis for discussion. The main construction phase is expected to start in 2020, with an estimated start for the operational phase of the first buildings in 2025.

Participatory practices

User engagement is an important part of any large-scale building development in Norway. To highlight the relevance of this kind of process, we have chosen to present some of the activities from the early stages of the design process. The architectural design studio KOHT won the design concepts competition in 2017 for their campus concept 'Veien Videre' (The Way Forward). Ingeborgrud and Suboticki (2018) interviewed the architects and a communication representative for the NTNU campus project in 2017 and asked about their vision for the future campus and its integration within the city. Nurturing cohesion, dialogue, and inclusion was stated as important for the total design concept. KOHT's concept explicitly aims to integrate the university with Trondheim city, both by extending the existing urban structures and by creating shared and attractive spaces where citizens and the university community can meet. The team from the campus project aims to facilitate this through an inclusive planning process. Numerous public engagement events, field visits, and research activities have been organized in order to include different people and points of view in the design process, both within the university (students, academic staff, administrative staff etc.) and outside the university (neighbours, general public and primary schoolchildren) (Ingeborgrud and Subotiki, 2018). In addition to this initial process, university staff have been given the opportunity to offer their opinions about the design concept as recently as September 2018 through a series of meetings with the university administration.

With regard to city integration, the inclusive planning process has not made any recent actions to engage with citizens. The most active processes taking place are those opposed to campus development. The "save the university park" campaign ("Bevare høyskoleparken") has regular events and uses the trees in the park to share information and heighten awareness. The group has an active Facebook page and local neighbourhood support.

As a supplement to the more established format of an inclusive design process, researchers from the Department of Interdisciplinary Studies of Culture used the NTNU Campus for a series of sociotechnical experiments with students. The intention was to establish greater ownership to the process of developing a zero-emission campus and to foster dialogues and discussion around zero emissions lifestyles.

Three short qualitative experiments took place on the campus during autumn 2017. The experiments where short, intensive actions that were intended to highlight the impact of the physical context of the university on participants: (1) An experiment about vision and scenario making for the future ZEN campus, where participants developed ideas for a future life on a zero-emission campus, suggestions included urban gardening and the re-use of resources. (2) A low-tech classroom was created to examine what effect the abundance of technology has on activities taking place in the classroom. It was found, for example, that a lack of access to the internet fostered dialogue and critical thinking among participants. Suggesting new ways of engaging in the classroom. (3) A working day within a Zero Emission Building (ZEB Living Lab). The majority of participants in the three experiments were students from the Science and Technology master program at NTNU. The outcome from the experiments offers architects, engineers and planners insights into the attitudes and practices of future users towards zero emission neigbourhoods (Ingeborgrud and Subotcki, 2018). Researchers proposed that the short-term format of the experiments is a useful action for ZEN living labs.

Ideas for Living Labs

In general, Trondheim Municipality regards living labs on the NTNU Campus as offering research opportunities that support collaboration between state, regional, and industry actors, *"It's the geography that is available - everything here must be allowed. We should test on small and large scales - from the big research projects to the very small entrepreneurial ideas."* The municipality would like to establish

an *"ecosystem to foster start-ups"*. In addition, two main ideas for citizen participation within living labs were proposed. The municipal understanding is based on the importance of knowledge exchange. The NTNU campus is being centralized close to the city centre and this offers even greater opportunities for knowledge exchange. Living labs should support this process, taking into use the physical infrastructure being developed and offering new ways of engaging citizens.

1. **Test new solutions for the main transportation corridor 'Elgesetergata'**
   A one-day event where the main transportation corridor through the planned campus area, Elgeseter street (gate) is closed *"for all traffic, except for buses, for one day."* Small-scale interventions were also suggested, *"all traffic lights in Elgesetergate turn immediately green, instead of pedestrians and bicyclists having to wait."*

2. **Research as a visible element in the city - Living Lab as a show room**

   Trondheim Municipality would like to demonstrate ongoing research to the public. *"There is so much smart stuff going on, at Gløshaugen, SINTEF and St. Olav's (hospital), and people do not know about it, it's not visible and not yet an attraction."*

Three different approaches for active integration of research with the city were proposed:

- The first approach requires the development of a physical structure that supports information exchange. Making sure that first floor campus buildings are integrated with the outdoor public space, because *"you must show what you are doing…Things are happening inside the basements, that's good. The challenge is to make it visible."*

- City life as an "activity". The Elgeseter neighbourhood east of the Gløshaugen Campus is an example of an area that currently has an "*urban structure and form, but not much activity*." The idea is to create activity in the public space using ongoing research activities. The whole area would become an urban life lab.

- Some informants from the municipality perceived living labs as often having a technical focus. They suggested testing new non- technical solutions for public space. A concrete suggestion was *"erecting a small installation or four benches and conducting research on usage and satisfaction."*

4.3 Knowledge Axis with Sluppen, Trondheim

	KEY FACTS
Planned Function	Multifunctional Neighbourhood with a mobility hub
Area size (m^2)	275 000
Current function	Office, logistics, storage
Construction	Mobility hub, offices and residential buildings, two schools, multifunctional sports hall, day care centre
Status	Strategic planning phase for the whole neighbourhood, feasibility study autumn 2017
Project owner	Trondheim Municipality
Involved Stakeholders	- Trondheim Municipality - Trøndelag regional municipality - National Road Authority - Several land owners: Kjeldsberg Eiendom, Posten Norge, Statsbygg, Trondos, KLP Eiendom og Norske Shell, Trondheim Municipality
City population	190 464 (per 01.01.2017)

Figure 8. Key Facts about Sluppen, Illustration: Kjeldsberg Eiendom

Sluppen is currently primarily a commercial area, and the plan is to transform it into a multi-functional neighbourhood, with a strong focus on mobility. The E6 motorway runs through Sluppen, the main north to south route in Norway. The time scale for the neighbourhood development is 30 years. This is necessary to deal with finding a solution to rerouting the E6, such as funding for placing the motorway under a lid. The timeframe offers the opportunity to establish a good framework with which to develop the future zero emission neighbourhood. The participatory processes presented highlight the user involvement necessary when dealing with major urban transitions in urban planning processes. A feasibility study conducted in 2017 includes offices and residential buildings, a mobility hub, and social infrastructure such as a school and residential buildings16. In the Nidarvoll neighbourhood that overlaps with Sluppen, Trondheim Municipality is planning the renovation and building of two schools (Nidarvoll and Sunnland), a multifunctional sports centre and a new health care centre that will be opened in 2022. The private developer Kjeldsberg has already developed two office buildings with higher environmental standards than the current building standards described in TEK 1717. A third office building is under development.

[16] A planning strategy, closely followed by a municipal sub-plan for the area were developed in 2018.
[17] https://dibk.no/byggereglene/byggteknisk-forskrift-tek17/

User participation and stakeholder Involvement

Dialogue platform 'Forum Sluppen'

In 2015, the stakeholders in Sluppen established a dialogue forum called "Forum Sluppen"[18]. The goal was to test new forms of collaboration between public and private stakeholders in the area. Trondheim Municipality was the project leader, and Trøndelag County[19], the National Road Authority, NTNU and the biggest private landowner R. Kjeldsberg participated. Other stakeholders were invited, but only participated during the early stages.

In 2017, as part of an effort to achieve an open process with a broad academic discussion, a feasibility study for Sluppen was conducted as a parallel assignment. Forum Sluppen members invited three interdisciplinary teams with architects and advisory engineers, after an open tender competition with 13 contenders. In the period from March to June 2017 a start-up seminar, a mid-term seminar, and a closing meeting were organised to ensure discussions. The final meeting in June was open to the public, and approximately 55 people participated (Trondheim Kommune et al., 2017). A reference group with the members from the original Forum Sluppen, known as Forum Sluppen 2.0, was established in 2018. The intention is to continue the stakeholder collaboration established in the first phase and to guarantee continued dialogue in Sluppen.

Ideas for Living Labs

The idea for living labs proposed by stakeholders during interviews build upon the Sluppen area's existing strengths. There are a number of technology intensive companies in Sluppen, and the area is designated as a "techno-city" [tekno-by] by the municipality. Informants proposed further cementing this identity by developing a testbed for the establishment of new temporary knowledge intensive companies. The transformation of the area into a zero emission neighbourhood is also described as a topic suited to be included in the education of school pupils and university students. *"maybe using it in teaching and collaboration with companies and getting the university to do research here. To test how to transform it, because we've decided it's going to be a university city [Trondheim]… involving the school in the middle of such a techno-neighbourhood, to get such a meeting point between the soft and the very technological would be interesting."*

[18] The forum was partly funded by the Norwegian Ministry of Local Development and Modernization within the planning program for big cities (Storby Program http://www.ks.no/fagomrader/utvikling/fou/program-for-storbyrettet-forskning/).

[19] Trøndelag County was previous known as Sør-Trøndelag County. In 2018, it merged with Nord-Trøndelag County and became Trøndelag County. This report follows a short time from 2015 to 2018 and to avoid confusion when referring to past and present regional county representatives we have chosen simply to refer to Trøndelag County. The informants were the same.

4.4 'New City - New Airport', Bodø

	KEY FACTS
Planned Function	Multifunctional city centre extension with residential and business areas (planned)
Area size (m^2)	3 400 000
Current function	Airport (military and civil)
Construction	Re-use and new construction, 2 800 dwellings in the first construction stage
Project owner	Bodø Municipality
Involved Stakeholders	- Bodø municipality - Defence department for the military airport - AVINOR for the public airport - The National Road Authority
City population	51 002 (per 01.01.2017)

Figure 9. Key Facts on 'New City – New Airport', Illustration: Bodø Municipality

Bodø's former civil and military airport is to be replaced by a smaller civil airport, located 900m southwest of the existing one. The transformation area covers approx. 5 600 000 m2 and is located in close proximity to the city centre. An area of 2 200 000 m2 will be used for the civil airport development. The remaining 3 400 000 m2 – the same size as the current city centre - is dedicated to expanding the existing city centre and will include residential and business areas, as well as a logistic hub (flights, railway, shipping) close to the airport. The planned multifunctional urban area will be developed within the next 60 to 80 years. This is also the timeframe to plan and engage. The municipality regards this as an opportunity to test new methods and platforms for engagement, as well as using the more traditional means associated with planning and development processes.

Planning the re-location of the civil airport and the re-use of the site of the former airport started in June 2012, after the decision to relocate the military airport. The municipality conducted a conceptual analysis of the adequacy of the re-use options along with mixed-use city expansion and a focus on transport hub development. Parallel to this, Avinor is planning the new civil airport, in close collaboration with local, regional, and national authorities. In June 2017, the Norwegian Government accepted the plan to re-locate the airport to the southern part of the area. The construction of the new airport is planned to start

in 2019 and the first construction phase for the neighbourhood development with 2 800 dwellings is planned around 2025 (Bodø kommune 2015).

participatory practices

Bodø ByLab

The city of Bodø is experimenting with new forms of stakeholder engagement known as the Bodø ByLab[20]. The ByLab consists of a virtual and physical platform to test and implement future-oriented participation processes within its smart city strategy, especially the 'New City – New Airport' project. The ByLab will engage with users outside the municipal administration, at the same time as it aims to increase the competence of the municipality's employees when working with new methods and collaborating across the departments.

The virtual ByLab aims to facilitate easier access to information about urban projects, as well as opportunities to become involved with them. Using the platform municipal employees, citizens, and other actors in Bodø can start projects and create groups. For example, the platform allows users to define a geographical area of interest within the city, and whenever a planning process starts or a project on the platform is created within that area, they will automatically be informed about ongoing processes and possibilities for participation.

The physical ByLab opened in April 2018 at the Stormen library in Bodø city centre. It provides a meeting space for stakeholders and citizens involved in urban city developments. The library was chosen as its location to make it easier to involve citizens.

Figure 10. Impressions from the opening of the Bodø Bylab, Photos: SINTEF, NTNU

ByLab Bodø is the first municipal-scale concept of its kind in Norway. Experience and conclusions from ByLab Bodø will form the basis for a permanent lab in new town hall in 2019. The 'New City - New Airport' project is the first project involved in the ByLab. In addition to the ByLab platform, Bodø Municipality in 2017 invited citizens and stakeholders to send in their ideas and thoughts on the future development of the 'New City – New Airport' project through an online form (Figure 10)[21]. The mapping provided input to visions and goals that are part of the official planning process.

[20] www.bodobylab.no/
[21] https://nyby.bodo.kommune.no/

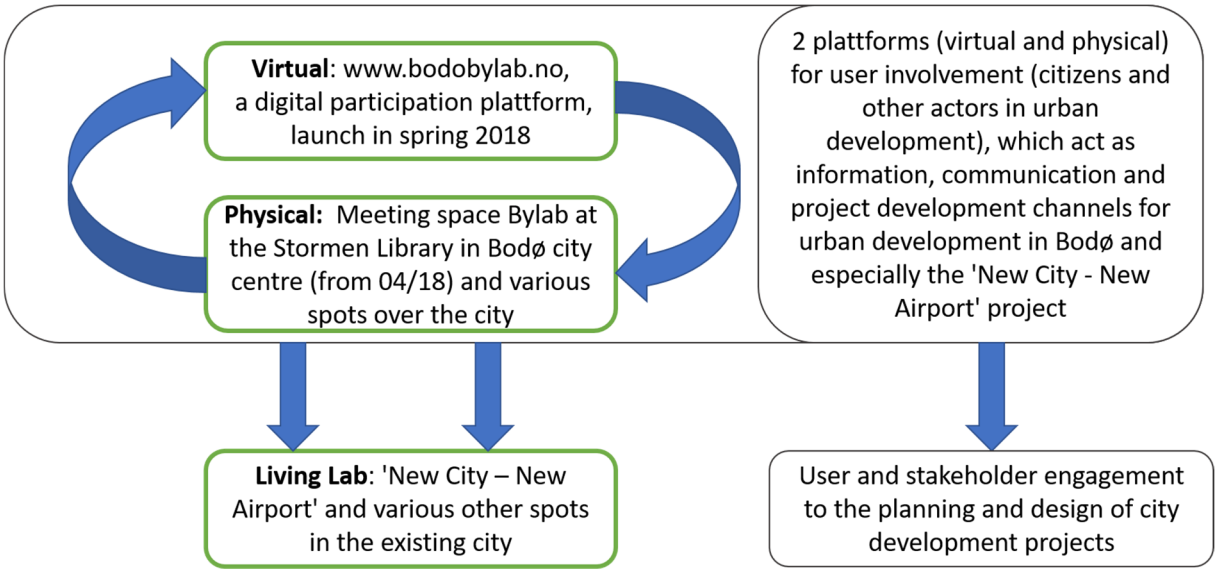

Figure 11. Structure of the Bodø ByLab; (Baer 2019)

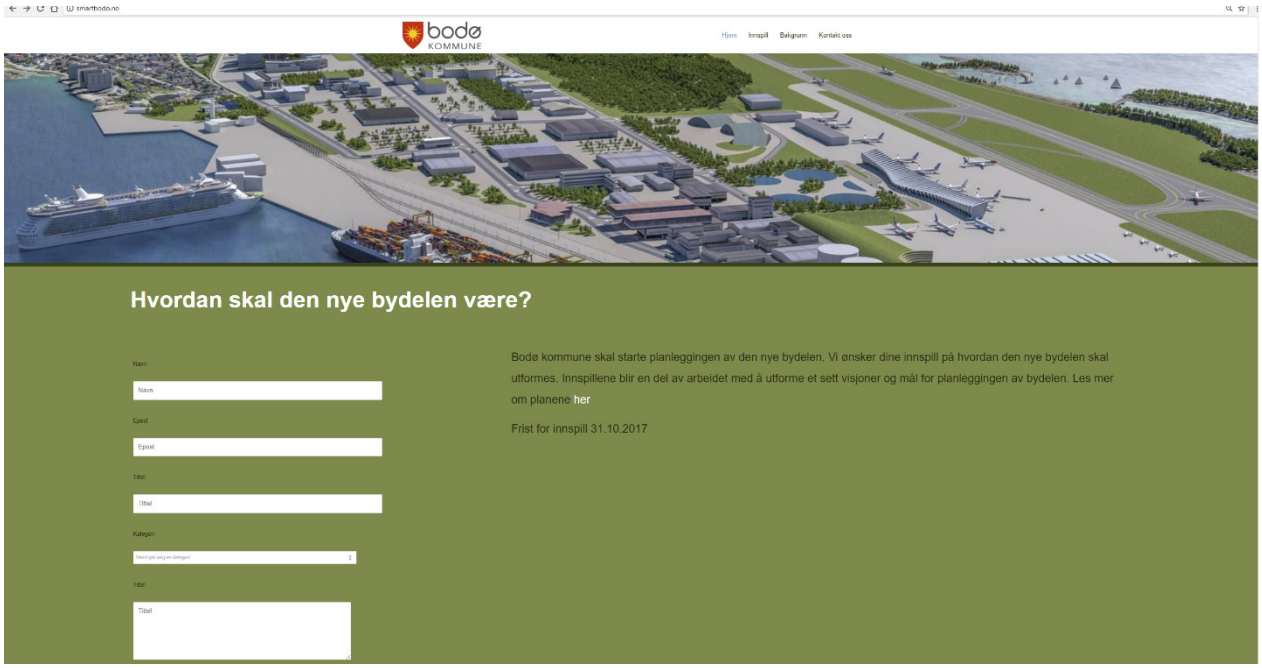

Figure 12. Screenshot of the consultation website on future ideas for the new 'New City – New Airport' development; Bodø municipality

Innovation camp for Smart Bodø

An innovation camp for the future Smart City Bodø, in collaboration with Young Entrepreneurship, took place in 2016, and 600 14-year-olds received concrete tasks to create ideas and solutions for planning the world's smartest city. A similar action was conducted in collaboration with the Culture School Rucksack (Kulturskolesekken), with the same target group and number of participants. Teenagers were given the task of running the whole planning process. They made planning descriptions, drew maps, and developed districts. The knowledge and solutions that emerged have been valuable in future city development projects, such as the "New city – new airport" project (Hvitsand et al., 2017). The project

manager of the "New City -New Airport" would like this approach to be included in the ZEN living lab activities. "*where we can take it up and present it to academia, businesses, the public sector, and residents. And this will be both an involvement and an innovation process. And it's exciting, incredibly exciting*."

Figure 13. Impressions from the Innovation camp and exhibition opening with results from the camp at the Stormen library, Pictures: Løkas, 2016 (left), Bodø Municipality

Ideas for Living Labs

The methods and platforms to support user involvement and participation developed by Bodø Municipality may be integrated with ZEN living lab actions. Interviews with members of Bodø planning department uncovered other themes that in the future could be incorporated in ZEN living labs.

Technology education

The Bodø planning department told us that the development of the "New City – New Airport" project will be accompanied by new technologies *"when you get so much technology into the city and so much new, it should be easy to use and understand. There are many examples today of buildings with for example lots of complicated lighting adjustment features, but the knowledge is not there to use it. Then you go back to conventional solutions because you do not know how to use it."* The living lab approach is regarded as a possible methodology to teach and involve users in the use of new technologies.

Knowledge development within a living lab

The same informants also stated that there is a gap in knowledge about developing buildings in line with zero-emission standards within the local building sector. *"It's clear we need to involve those who build residential buildings and big projects. They have to learn a lot of things, but then you have to involve them in the development I think. So that's something we have to work with because we want to have local producers. We do not want people to come from outside and do their work here in the city, and then leave. We want local anchoring, both knowledge and implementation. So, participating in the development is important.* Involving local stakeholders in a living lab and fostering knowledge development is a goal for the municipality.

5 Summary

This report has four main functions, it presents

1. A theoretical framework for understanding living labs.
2. The ZEN living lab concept.
3. Recent examples of how living lab methodology has been applied in Norwegian and European contexts.
4. How user participation is applied and understood in selected ZEN pilots.

The report therefore provides the means to understand historical and current applications of living labs, and it underlines the potential of using the ZEN living lab concept. A ZEN living lab is an open, inclusive space that supports user engagement with ZEN pilot projects. The intention is to bridge the gap between the social and technical context. A ZEN living lab should function as a creative arena for knowledge exchange, between people, places and technology. It is an arena that should ideally highlight learning processes. The concept includes four main elements:
1. Representatives from the different user groups affected by the sustainable neighbourhood transition proposed by ZEN.
2. A clearly defined geographical place.
4. A set of clearly defined activities that can be applied iteratively.
3. An experimental format based on the challenges and needs of the neighbourhood.

The technology driven and civic urban living labs that were presented in Chapter 3 have encountered three common challenges. First, the experimental format prescribes control of central parameters of the living lab activities that can cause tensions with regard to users and their ability or willingness to participate (Oxford Corridor, SubUrbanLab). A second topic related to controlled experimentation mentioned in the evaluations of the living lab examples is to what aspect of the experiment the effects are attributable (ZEB living lab, SubUrbanLab). A third and final issue encountered in several of the examples was the question of the added value of conducting several experiments under the umbrella of one living lab. The examples presented are relevant to the ZEN living lab concept for different reasons, for example, we saw particular relevance in the spatial proximity in the NEST example, a useful comparison between different (national) contexts (SubUrbanLab), and inspiration in the combination of many smaller, less resource-demanding experiments (Kalasatama).

The interviews with representatives from four ZEN pilot areas that were presented in Chapter 4 have shown varied and extensive user participation at these sites, pre-dating and in parallel to their participation in the ZEN centre. It is important that ZEN living labs are coordinated with these activities to avoid tensions and to generate synergies. Asked for ideas for living labs, the informants connect Ydalir and Knowledge Axis/Campus Gløshaugen with activities that match a civic urban living lab, whereas Sluppen and Bodø are clearly connected to ideas related to technological innovation.

6 Conclusion

The ZEN definition of zero emission neighbourhoods implies technical solutions to the reduction of energy use and CO2 emissions. There is therefore a tendency to lean towards a target-based application of the living lab methodology, i.e. the testing of technical solutions as a means to achieve innovations within the construction industry or the energy sector. However, any application of living labs should not lose sight of the primary aim, which is engaging with the user groups who will be affected by the changes implied by the introduction of zero emission technology within a neighbourhood context, in an open and inclusive process.

A ZEN living lab should be open enough to be able to deal with both kinds of living lab motivations: technology and innovation driven and citizen centred civic transitions. However, to be able to use the living lab methodology effectively, it is important to keep sight of the difference between these two main kinds of labs. Although both kinds are user centred, they are not interchangeable. They have different formats and relationships with the context, and their aims are different. Innovation and technology driven living labs are essentially about the testing new technical solutions within a limited physical framework. Civic living labs have a larger physical framework and focus on processes and policy change. Both goals are often set side-by-side without discussing their relation or even conflated as if they were the same thing. It is not difficult to imagine cases where the focus on innovation and the ambition to contribute to democratic urban development interfere with each other. If for example new sensor networks are implemented to monitor and optimize urban resource flows, the question of social justice and privacy is not at all dealt with by giving citizens access to the data through an urban dash-board or an app. On the other hand, within urban contexts, there is a danger of assuming that all planning processes or workshop-based activities imply that a living lab is taking place. If everything is a living lab then the application of the concept becomes irrelevant. Based on the literature on laboratory work presented above, we maintain that living labs are useful when they are aim based and have a clear research focus. That these laboratories are ‘living’ in the sense that they include users and citizens will create participatory effects and help to make innovation more user-centric. But, not every user-testing of technology and every participation exercise is a living lab. We find many living labs in Europe, but it is often difficult to establish what they have actually achieved, which experiments they have conducted, and what being a laboratory has added to the sum of their testing and participation activities. Labelling something a laboratory may be an expression of good intentions, but these are often not enough.

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