Living labs in a zero emission neighbourhood context

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Abstract. The Research Centre for Zero Emission Neighbourhoods in Smart cities has established a concept for living labs. Central to the concept is an experimental format that offers some control over the social and physical environment, as well as opportunities to observe and engage during a limited period. According to Bulkeley et al. 2018, an experiment offers a means to make sense of the present whilst also providing a vision of the future [1]. The paper asks, what are the implications for users when engaging with experiments and presents results from a ZEN living lab experiment that took place at Campus Evenstad in Hedmark, Norway.

Technical management at Evenstad proposed the experiment, they wanted to test if it was possible to reduce campus energy consumption and the starting point was the old administration building, which has the highest energy consumption on campus. The energy use reduction was to be achieved by turning off the building's heating and ventilation systems during a limited four-week period. This took place in July 2018, when the building users were expected to be on holiday or doing fieldwork. A workshop to anchor the experiment among building users took place a month before the experiment started. During the workshop challenges associated with the experiment and with the building, for users, became apparent. However, building users agreed to participation in the experiment because they saw it as an opportunity to highlight what they understood as necessary changes to the building. The experiment achieved the energy saving potential that the building managers envisioned, but the results for the building users are less tangible.

From a pragmatist approach, living labs and their experiments are about providing solutions, but the Evenstad example highlights the challenge of providing tangible solutions and how we engage users with more intangible future solutions. We discuss therefore the limitations and potentials associated with the experimental format. Moving beyond demonstrating what a sustainable future should look like and include [1p.1], and instead noting opportunities for the translation of societal learning into concrete actions that serve the user groups engaged as well as demonstrating, the potential to influence wider sustainable transitions.

1. Introduction

Living labs are a means to "gain experience, demonstrate and test ideas", that have the potential to be scaled up across systems [2]. They have therefore become an essential part of any sustainable transition toolbox. The starting point for this paper is the living lab concept developed by the Research Centre for Zero Emission Neighbourhoods in Smart Cities (ZEN). Using experiences with a ZEN living lab on Campus Evenstad, we ask what are the implications for end users when engaging with experiments in living labs? The ZEN Centre has chosen living labs as the main format to secure user engagement and to organise user involvement in pilot projects. The specific demands and conditions encountered in ZEN pilot neighbourhoods, require a tailored ZEN concept that provides structure for actions taking place, but is broad enough to deal with the various challenges arising in each neighbourhood. A ZEN living lab includes, representatives from different user groups affected by the sustainable neighbourhood transition proposed by ZEN. Secondly, it has a clearly defined geographical place. In ZEN, this is supplied by pilot projects. Thirdly, a ZEN living lab should develop an in-depth qualitative understanding of the social and physical context based on information collected by for example, interviews, workshops, and participant observation. Finally, an experiment arising from the qualitative understanding takes place, testing ideas, based on the challenges, technology, and needs, supplied by the neighbourhood.

Campus Evenstad is part of the Inland Norwegian University of Applied Sciences, one of three campuses that are part of the Faculty of Applied Ecology, Agricultural Sciences and Biotechnology. The campus has 60 employees and approximately 200 students and is one of nine ZEN pilot projects. The main aim behind the actions taking place in the pilot project is "*optimisation of energy management*". The living lab at Campus Evenstad took this aim as its starting point and the living lab has therefore a technology and innovation focus. Statsbygg who is responsible for the technical management of the campus buildings established this aim[1]. The campus has buildings dating from the late 1800's to 2017. Some buildings are energy efficient such as a ZEB administration building (ZEB-com) and the student dorms (Norwegian passive house standard). It also has buildings from the 1970's and 1980's that consume large amounts of energy to heat and ventilate. One of the least efficient buildings is the old administration building built in 1987, which every day is responsible for one third of the campus's energy requirements. From 01.07- 01.08.2018 an experiment took place based on one main action, the heating and ventilation systems in the old administration building were closed down.

The paper starts with a brief presentation of current living lab theory and practice. It then describes the different activities associated with the living lab at Evenstad. The next section takes a detailed look at the building users' response to the experiment, comparing their tangible expectations with their response to intangible aims for energy optimisation supplied by the ZEN Centre. The paper concludes with a brief discussion and conclusions.

2. What are living labs?

Living labs vary according to the problems they focus on, and because of the variety of problems they deal with there are large number of different kinds of living lab. It is however possible to identify two main types, the first is the technology and innovation based living lab, which have a limited social and physical concept and primarily focus on product development within a co-creative environment that is as close to real-life as possible. This kind of living lab stems from the original living lab developed in the 1990's by Mitchell at MiT. The second kind is the citizen centred or civic urban living lab that aims at sustainable urban transitions. Bulkeley et al. 2018 has identified three main kinds of design and practice within urban living labs, strategic, civic and organic, that are distinguished by the differences in control and contingency associated with how they are designed and practiced [1 p.6]. A civic urban

1 Statsbygg is a public sector administration company and advisor to the Norwegian government in construction and property affairs. Statsbygg was a ZEB partner and is a ZEN Centre partner. The campus was also at the centre of pilot activity between 2009 and 2017 because the Centre for Zero Emission Buildings (ZEB Centre) developed one of its eight pilot projects, a new administration building, on campus https://www.zeb.no/index.php/en/pilot-projects.

lab includes a larger and more complex physical, social and political context and a wider range og user groups than a technical and innovation based living lab [3].

Certain qualities characterise both the two main kinds of living labs, these qualities have inspired the ZEN concept. A living lab should, according to Pierson and Lievens 2005, ideally be "an experimental field" that deals with a social and technical challenge, have clear goals and structure and take place within the framework of everyday life [4]. This is relevant for the ZEN Centre because it requires the means of bridging the gap between the technical and social context within the pilot projects. In addition to being experimental living labs are interventions that are designed to improve, are characterised by the intention to observe and they can if successful offer the means to manipulate existing socio-material conditions, creating new forms of conduct [5]. These qualities are presented here in what we describe as two stages, and they can be applied in both civic and technical living labs.

2.1. The first stage: qualitative understanding of the social and physical context

Living labs live when they include people. A user or user group may be a company, employees, researchers, residents, planners or activists, include different age groups, cultures or social groups. Discovering the interests and values existing within a context are part of the first phase of any living lab, because aim-based interaction between different individuals and/or user groups is required, also the success of an experiment is often based on whether the aims of participants have been achieved [6].

Veeckman and van der Graaf (2015) propose that successful living labs organise a process that encourages people "to make sensible decisions through reasoned deliberation" [7]. However, the involvement of users is not a neutral process. Individuals working in government and universities often dominate knowledge production in living labs [8] and they influence the choice of problems being dealt with. This is a top down process and not the citizen empowerment or co-creation that the term living lab implies. Including a broad group of different users and emphasising their interests and values is one way to avoid this.

A living lab should have a clearly defined geographical place. A place that offers "a material, sensory, social and experimental environment" [9]. The place provides the boundaries, defining who is included and therefore sets the scene for the problems engaged with. Understanding place clarifies challenges and values of the people associated with it and supports an in-depth qualitative understanding of the context. This understanding can be said to support the introduction and use of technologies, because they are best "assessed in their relations to the sites of their production and use" [10]. However, although living labs are context dependent, a tension exists because of an underlying expectation that the interventions and experiments could have taken place anywhere [1 p.6]. Making their results relevant outside the context where they were gathered.

2.2. The second stage: experiment

"*experimentation provides the means through which diverse actors seek to navigate and make sense of the present whilst giving concrete form to particular visions of the future*" [11].

Living labs aim to impose control over a social and physical context. It is not enough that people simply meet and engage; a framework is required that enables the meetings to produce new knowledge. Experiments provide a framework by supplying a planned set of parameters and the opportunity for 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 [5 p.21].

The two stages include a broad set of qualities, and these are useful within the two main types of living lab, civic and urban and technology and innovation driven. There can exist an overlap between the two different types, but although both are user centred, they are not interchangeable. They have

different relationships with the context and aims, and the kinds of problems they deal with are different. This has implications for the format and the kind of experiments that take place. Keeping sight of the difference is important because living labs are most useful when they are aim based and have a clear research focus.

3. Evenstad living lab method and actions

This section presents the methodology applied in the technology and innovation living lab at Campus Evenstad. In addition to the flexible ZEN living lab concept presented above, a ZEN living lab has an anthropological approach to data collection and analysis. The ethnographic method applied by anthropologists produces insights into the informal aspects of social and cultural life, emphasising "the contrasts between what people say and what they do", and the more formal structures provided by the surrounding society [12]. Anthropology offers a perspective that does not take preconceived assumptions about human societies for granted and is sensitive to both similarities and differences. This makes its use pertinent within the context of a ZEN pilot project, where the difference between what ZEN plans and expects and what the local context requires is not always in focus. The anthropological approach applied in Evenstad, is not based on classical observational methods implied by participant observation, which due to limited access to places or practices can be "impractical and inappropriate" in a contemporary context [9]. New approaches to gaining access to people's lives are required. The Zen living lab concept provides an innovative approach for an anthropologist.

3.1. *The experiment*

Some of the actions associated with the living lab at Campus Evenstad were associated with general pilot project activities taking place on campus, such as the partner workshop in November 2017, which presented the plans for Evenstad to stakeholders involved with ZEN. The workshop provided the official start the living lab activities and was followed up by a ZEN living lab week in March 2018, that was tailormade for the living lab, and aimed to introduce ZEN and it's living lab to broad group of users on campus. Interviews, the questionnaire, the workshop in May followed up on ideas that came to light during the living lab week (see table 1). The workshop in May included representatives from different employee groups. Plans for the experiment were discussed, the intention was to uncover new challenges or issues associated with the experiment.

The idea for experiment in the old administration building arose during the living lab week and was proposed by the technical management who regarded it as concrete action that would not impose too many challenges on the social context. The building has three floors, four different ventilation systems, houses the canteen and library, as well as offices, a laboratory and storage space. From 01.07-01.08.2018 the heating and ventilation systems in the old administration building were shut down (this did not include the ventilation system used in the canteen on the ground floor). The pragmatic aims associated with the experiment were to highlight the energy costs associated with different buildings on campus and to test a low-tech energy saving action. As an experimental action it brought to the forefront the difference between everyday activities and living lab activities, enabling engagement with building users.

The paper describes the response to the experiment and is primarily based on interviews and participant observation after the experiment took place in July 2018. A group of seven engineers who had offices on the second floor of the building and two librarians located on the first floor took part. Interviewees are presented in the text below as Office 1 to 7, or Librarian 1 to 2.

Table. 1. Overview of ethnographic activities, time-frame and roles associated with the activity

Action	Role	Number of participants
ZEN partner workshop	ZEN partners, technical management Evenstad, Campus administration, ZEN researchers	Ca. 50 people
Living lab week 05.03-08.03.2018 Lectures, workshops and four interviews	Campus administration, scientific personnel, students, technical management, ZEN researchers	Ca. 27 people
Questionnaire	Campus administration, scientific personnel, students, technical management, ZEN researchers	17 people
Meeting 22.05.2018	Campus administration, technical management, Statsbygg, ZEN researchers	12 people
Workshop with site visit in the old administration building 23.05.2018	Campus administration, scientific personnel, technical management, ZEN researchers	10 people
Experiment in the old administration building 01.07 - 01.08.2018	Technical management, scientific personnel and others with offices in the building	Ca. 20 people
Interviews: skype and face to face November 2018	Scientific personnel with offices in the building	9 people (Offices 1-7 and Librarian 1-2)
Participant observation 12.- 16.11. 2018	Office in the old administration building	Informal meetings, coffee breaks, lunch, 2-5 participants

4. Experimental impact, building problems and the role of ZEN

The pragmatic aim behind the experiment was achieved, 12 000 kWt (or 12 MWt) were saved, during the four-week period. There was approximately 12,000 kWt greater energy consumption in the building in August compared with July. This is due in part to the shutdown of the ventilation system, but it is also due to higher activity in the building in August. This is regarded as a success and Statsbygg plans to apply the same low-tech method in other buildings that it manages[2]. However, the focus of the paper is the building user's response to the experiment and not on the amount of energy saved. This section is divided into three parts, starting with the impact of the experiment on building users, then moving on to problems with the old administration building and concluding with ZEN's connection to Campus Evenstad.

The impact: The experiment at Evenstad took place during the summer when the old administration building is largely empty, the main summer holiday in Norway is traditionally in July. We proposed that building users did not use their offices during the four-week period the heating and ventilation was shut down, but we did not ban them from using their offices. Temporary offices in the new zero-emission administration building were made available if they needed an office. Only Office 6 and Librarian 2 were at work during the four-week period. This is a period when campus buildings require cooling. Office 6 who chose to use his own office and not the temporary office spaces, struggled with the building temperature. The summer in 2018 was the hottest ever recorded and it is therefore unclear if the temperature was due to the experiment or the weather conditions. When possible, he worked from home.

[2] The application of the strategy has not been discussed with Statsbygg, but the implication is that Statsbygg is responsible for the management of a number of public buildings that are not in full use during holiday periods and weekends. Looking into the possibilities for shutting down HVAC systems has therefore been proposed. Other issues into addition to energy savings would have to be considered if this low-tech action is to be applied in other buildings. These include the impact on air quality due to the potential increase in air particles that may have implications for the health of building users, and wellbeing and functionality for building users. Not everyone is able to have holidays at the same time of year.

Librarian 2 claimed to be happy with the experiment, expressing satisfaction with the freedom to open the windows, something she is not usually encouraged to do by technical management. In addition, she stated that it was "wonderfully quiet" without the noise from the ventilation systems. The other seven building users were either on holiday or doing fieldwork.

The building: Prior to the experiment the building users were sceptical. They maintained that the energy saving benefits would not weigh up for the inconvenience that they would experience. Any energy savings made during the shutdown benefit the university centrally, not Campus Evenstad and not the building users. They would be helping technical management and the university, but what was in it for them? After the experiment, the seven building users who were away during the four-week period stated that they had not been inconvenienced, but when told about the energy savings the building users still could not see any benefits, Office 2 stated,

> "The university likes to appear as sustainable… but the wallet comes before sustainability. The whole Evenstad concept, which equals minimal emissions, the solar panels and zero emission buildings, is about a signal effect."

The experiment although less inconvenient than expected only supplied intangible results and the building users who took part in the preliminary workshop stated that they wanted tangible results, in the form of building improvements when they agreed to the experiment. They hoped that the experiment would highlight functional issues associated with the building. Particularly the problems with the second floor south facing offices and the window systems. Office windows have external sunscreens installed but when the sunscreens are lowered, it is not possible to open the windows more than two centimetres. When the sun is shining the offices become very warm and the ventilation system does not have enough cooling capacity. Opening the window would allow natural ventilation. Building users must choose between keeping the sun out of the office and ventilating using the window. There is agreement among all the office users that the sun creates a difficult working environment,

> Office 6 "There is a great difference between summer and winter. I can regulate the temperature myself in the winter. In the summer I can regulate early in the morning until the sun starts burning through the window. I had a thermometer in the office (August) and around lunch time it's about 30 degrees. The solution during the summer is to go home, but it is often not possible to go home. We have tried to create an air-flow by opening doors. I often leave the window open when I go home, in the morning I close it and lower the sun screening. Birds have come into the office twice."

The example shows that the building users apply various strategies to dealing with the problem of overheated offices and experience a variety of inconveniences. Despite the problems they are not interested in moving to offices in other buildings, not even during the experiment. This is because of two main aspects; the social environment is considered good and they have individual offices. Office 3 stated, "it's not too bad here. The climate is one thing, but we have become a small enclave." The group of engineers with offices on the floor work within the same field and none of the building users was interested in sharing an office or working in an open landscape. They moved into the old administration building two years ago, previously they were in an off-campus laboratory building. Their current offices are an improvement and despite periodically having overheated offices, not having a modern coffee machine or comfortable sofas like the ones in the zero-emission administration building, they like where they are.

The problems with the windows are well-known on campus, the building's previous users experience the same problems. During the workshop in May two of the building users proposed installing roller blinds on the inside of the window as an immediate solution to the problem, but nothing changed in the four-month period after the experiment. The technical management team stated that improving the window systems were on "the "to do" list of measures on campus, but low down on the list.

ZEN's relevance: The ZEN Centre's main activity on Campus Evenstad is the testing and introduction of zero emission technology, examples are a CHP biogas burner, battery systems for energy storage and vehicle to grid storage systems. These technical innovations have a wider potential in other

neighbourhoods. The experiment offered the opportunity to ask building users what they knew about ZEN, its activities on campus and the technologies. Half the interviewees said that they knew very little about ZEN, two stated that involvement in the ZEN Centre takes place on a leadership level, and one that this was also the case with the ZEB Centre. The ZEN Centre is not the first research centre to be active on Campus Evenstad. The Research Centre for Zero Emission Buildings (ZEB) was involved with the design, development and building of the new campus administration building, and installing of the biogas burner. Few users or groups on campus are involved in the planning or development of buildings and technology, the process is top down. Librarian 1 "The leadership talks about it when they talk about Evenstad. We (the employees) don't care about it so much."

However, building users are in general positive to being part of ZEN. Although there is the lack of detailed knowledge, and some confusion about what the technology is useful for. Building users are proud that being a zero emission neighbourhood is part of Evenstad's profile.

> Office 5 – "I hadn't noticed ZEN or the technology. Now that we have the CHP system I thought that power cuts would not be a problem (the biogas burner will only supply heat, not electricity). But the chip burner and solar production are a plus. Its renewable, a plus plus really."

However, the lack of connectivity between users and ZEN on campus, when combined with a faith in the sustainable potential associated with zero emission technology, causes a deeper criticism of the activity on campus, because ZEN cannot simply be written off as irrelevant for them or uninteresting. Disappointment is expressed because ZEN and Statsbygg have not placed more emphasis on involving students or staff. The building physics and energy management associated with ZEN on campus is not part of the subject matter that students and staff from the Faculty of Applied Ecology, Agricultural Sciences and Biotechnology at Evenstad usually working on, but as Office 1 pointed out

> "The two things complement each other. Here on campus we could produce food and deal with waste products for a zero-emission neighbourhood……. I have never been involved in any brainstorming. It is very technical and outside our field, but ecosystem services are within it. There ought to be some kind of collaboration."

5. Discussion: The third stage – intangible results

The paper presents the different phases of a ZEN living lab, starting with the in-depth qualitative phase, where information necessary to develop and activate the second experimental stage was gathered. The second stage focused on the experiment and the building user's response to it. This final section represents the third phase, a discussion of the results from the experiment.

The ZEN living lab on Campus Evenstad is a technology and innovation based living lab. The practical aim was to enable the campus's technical management to reduce campus energy use and to highlight the energy costs associated with different buildings on campus. This was achieved, but when faced with this goal and the resulting energy savings the building users asked, "What's in it for us?" They required more tangible results and in a living lab whose aims are associated with products and solutions, the building user's expectation that rational choice be involved should not come as a surprise [14]. Building users asked for building improvements, tangible results, these are associated with building efficiency, but although the experiment helped to highlight the well-known problems with the indoor climate, changes have not been made. A reason for the lack of improvements may be because the building users like their offices and would not willing move from them. The problems on sunny days are out-weighed for by a good social environment and the "luxury" of individual offices. This limits their bargaining power.

6. Conclusions

The paper asks, what are the implications for users when engaging with experiments. Living labs are a useful format for demonstration. In a ZEN living lab, the focus is on securing engagement with the development of zero emission technologies or neighbourhoods, the challenge is to connect ZEN aims with the aims of the user groups associated with pilot neighbourhood. Outside the ZEN partner group

and stakeholders involved in the development of zero emission technology and buildings, interest in the zero emissions is limited. Therefore, within the social and technical context supporting the living labs there is a danger of the process being primarily top-down. The experiment did raise awareness about energy use in buildings and the role of the ZEN Centre on campus. However, faith in both the technology and centre activities may be challenged if the engagement with living labs is not combined with tangible results for building users. A living lab can raise awareness among user groups affected by the sustainable transitions planned by ZEN, and it can offer insight in how user groups would like to be involved. At Evenstad some interest is already in place and has the potential to be built upon. Not involving a broad group of users is a missed opportunity in the work towards sustainable transitions.

The social and physical place provided by Campus Evenstad is associated with its own set of challenges and needs. Following on from the experiment at Evenstad, the question is how the actions in one context be upscaled or translated so that they can be applied in other pilot locations? In addition, can we make sure that the results are tangible for users outside the main ZEN stakeholder groups? Finally, an issue arose about the role of the ventilation system in the experiment, after tentative results were presented to representatives from the construction industry in a blog text [14]. It was proposed that greater focus should have been on the air quality. The existence of particles within the air circulated could have been measured before and after the experiment, and the impact on users studied. This suggests that a broader interdisciplinary focus within the engineering team is useful when planning the technology and innovation inspired experiments in living labs.

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