



Research Centre on
ZERO EMISSION
NEIGHBOURHOODS
IN SMART CITIES



USER INVOLVEMENT IN ZEN

A reflection on the user perspective in ZEN

ZEN MEMO 64 – 2025



Marianne Skaar, Lars Arne Bø and Judith Thomsen | SINTEF



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User involvement in ZEN – A reflection on the user perspective in ZEN

Keywords: user perspective, participation, living labs

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Preface

Acknowledgements

This memo 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, Trøndelag county, Norwegian Directorate for Public Construction and Property Management, Norwegian Water Resources and Energy Directorate, Norwegian Building Authority, ByBo, Elverum Tomteselskap, TOBB, Snøhetta, AFRY, Asplan Viak, Multiconsult, Civitas, FutureBuilt, Heidelberg Materials, Skanska, GK, NTE, Smart Grid Services Cluster, Statkraft Varme, Fornybar Norge 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, Mære agricultural school, Ydalir in Elverum, Campus Evenstad, Ny by-ny flyplass Bodø, and Zero Village Bergen.

The ZEN Research Centre is a eight year project ending in 2025, 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.



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FME ZEN (page)

Abstract

This memo is a reflection on the user perspective in FME ZEN.

The FME Research Centre on Zero Emission Neighbourhoods in Smart Cities (ZEN) has chosen Living Labs to address user engagement and as a framework for the organisation of user involvement in pilot projects. Work on user involvement in ZEN has also been carried out outside the activities in the Living Labs, mostly on methods of user involvement, rather than testing them on end users.

A brief overview is presented of selected publications in ZEN on user involvement where the "users" are not necessarily directly involved or represented. The common theme for these publications is *methods for citizen participation*, and *challenges with stakeholder engagement* in developing zero emission neighbourhoods. Key aspects to improve for increased user involvement in FME ZEN include:

- Providing methods for how to include the end user perspective when the end users are not yet present
- Early involvement in neighbourhood development project
- Collaboration and shared vision among the stakeholders
- Continuous stakeholder involvement

Further, user participation in a selection of ZEN pilots is discussed: Ydalir, Evenstad, Furuset, Gløshaugen, Lø and Mære. Publications on user involvement in these pilots are presented, and additional information was acquired from interviews with researchers and partners involved in the pilots. Based on the findings from the interviews and the presented publications, the following three themes are identified for discussion: (1) The struggle of engaging the end user, (2) Enthusiastic users of the technology, and (3) Complex planning- and development processes make user involvement challenging.

The "middle actors", such as operating staff, is reported by researchers in the Living Labs as an especially interesting user group to work with, as they have intimate knowledge on both the end user and the technological infrastructure. Local initiatives driven by enthusiastic and innovative operational staff and property managers have realized a combination of technologies and the interoperability of solutions which had not been tested elsewhere before.

The memo concludes that the work in ZEN has mainly been concentrated on technological solutions for environmental sustainability. These solutions are often invisible for the user, not directly impacting people's everyday lives, making them hard to relate to. When technology is presented as the major solution, the need for behaviour change is under-communicated and may seem less important, leading people to continue their usual practices, assuming technology will compensate for emissions. Research based on the data from the Living Labs shows the need for a closer link between social sustainability and technological innovation. Bridging the gap between the social and technical context has been proven difficult within the frame of FME ZEN. The nature of the FME scheme under which ZEN was filed is, by description, not a social science-related program. Initially, this topic was not given much emphasis. In retrospect, we can question whether the centre should have addressed the social aspects of sustainability to a greater degree in order to succeed with zero emission neighbourhoods.

Inclusivity of perspectives from all stakeholders can enhance the robustness of research, give an understanding of social structures and processes, as well as benefit planning with observations by people closest to the phenomena in question.

Norwegian abstract

Dette notatet er en refleksjon over brukerperspektivet i FME ZEN.

Forskningssenteret for nullutslippsområder i smarte byer (FME ZEN) har valgt Living Labs som en tilnærming til brukermedvirkning og som en ramme for å organisere brukerinvolvering i pilotprosjekter. Arbeid med brukerinvolvering i ZEN har også blitt utført utenfor aktivitetene i Living Labs, hovedsakelig med fokus på metoder for brukerinvolvering, heller enn å teste dem på sluttbrukere.

Vi presenterer en oversikt av utvalgte publikasjoner i ZEN om brukerinvolvering der "brukerne" ikke nødvendigvis er direkte involvert eller representert. Felles for disse publikasjonene er at de tar for seg **metoder for brukerperspektiv og utfordringer med å engasjere ulike brukere** (stakeholders) i utviklingen av nullutslippsområder. Nøkkelaspekter som kan forbedres for økt brukerinvolvering i FME ZEN inkluderer:

- Presentere metoder for hvordan man kan inkludere sluttbrukerperspektivet når sluttbrukerne ennå ikke er til stede
- Tidlig involvering i nabolagsutviklingsprosjekter
- Samarbeid og felles visjon blant brukere (stakeholders)
- Kontinuerlig involvering av brukere (stakeholders)

Videre diskuteres brukerdeltakelse i et utvalg av ZEN-piloter: Ydalir, Evenstad, Furuset, Gløshaugen, Lø og Mære. Publikasjoner om brukerinvolvering i disse pilotene blir presentert. Ytterligere informasjon er hentet fra intervjuer med forskere og partnere involvert i pilotene. Basert på funnene fra intervjuene og publikasjonene, identifiseres følgende tre tema til videre diskusjon: (1) Utfordringen med å engasjere sluttbrukeren, (2) Entusiastiske brukere av teknologien, og (3) Komplekse planleggings- og utviklingsprosesser gjør brukerinvolvering utfordrende.

"Mellomaktører", slik som driftsansatte, trekkes frem av forskere i Living Labs som en spesielt interessant brukergruppe å arbeide med, siden de har inngående kunnskap både om sluttbrukeren og teknologisk infrastruktur. Innovative og entusiastiske driftsansatte og eiendomsforvaltere har tatt initiativ til å teste kombinasjoner av nye teknologier som ikke tidligere har vært testet andre steder.

Notatet konkluderer med at arbeidet i ZEN hovedsakelig har vært konsentrert rundt teknologiske løsninger for bærekraft. Disse løsningene er ofte usynlige for brukeren, uten å påvirke folks hverdagsliv direkte, noe som gjør det vanskelig å relatere seg til. Når teknologi presenteres som den viktigste løsningen, underkommuniseres behovet for atferdsendring, noe som kan føre til at folk fremholder sine vanlige praksiser i den tro at teknologien vil kompensere for utslipp. Forskningen i Living Labs viser behovet for en tettere kobling mellom sosial bærekraft og teknologisk innovasjon. Det har vist seg vanskelig å bygge bro mellom den sosiale- og den tekniske konteksten innenfor rammene av FME ZEN. ZEN har vært finansiert innenfor det tekniske- og ikke det samfunnsvitenskapelige programmet for FME-ordningen. I ettertid kan vi stille spørsmål ved om senteret i større grad burde ha adressert de sosiale aspektene ved bærekraft for å lykkes med bærekraftige nabolag med null utslipp av drivhusgasser.

Contents

| | |
|--|----|
| Preface..... | 3 |
| Abstract | 4 |
| Norwegian abstract..... | 5 |
| 1. Background | 8 |
| 1.1 Who are the users in ZEN?..... | 8 |
| 1.2 ZEN Pilots..... | 9 |
| 1.3 Data | 10 |
| 2. Publications on methods and stakeholder involvement in ZEN..... | 11 |
| 2.1 Publications on methods for user involvement..... | 11 |
| 2.2 Publications on involvement of stakeholders in the planning process | 12 |
| 2.3 Reflections on literature in ZEN..... | 13 |
| 3. User involvement in ZEN pilots and Living Labs | 14 |
| 3.1 Ydalir..... | 14 |
| 3.2 Evenstad | 15 |
| 3.3 Furuset..... | 16 |
| 3.4 Gløshaugen..... | 17 |
| 3.5 Lø | 17 |
| 3.6 Mære..... | 18 |
| 4. Discussion | 18 |
| 4.1 The struggle of engaging the end user..... | 18 |
| 4.2 Enthusiastic users of the technology | 19 |
| 4.3 Complex planning- and development processes makes user involvement challenging | 20 |
| 5. Concluding reflections | 20 |
| 6. References..... | 21 |

1. Background

The Norwegian Research Council finances the Centres for Environment-friendly Energy Research (FME). These centres carry out long-term research targeted towards renewable energy, energy efficiency, carbon capture and storage, and social science aspects of energy research. The FME scheme is designed to foster innovation and value creation by supporting collaborations between research groups, trade and industry, and public administration (The Research Council of Norway, n.d.). The Norwegian Research Council has appointed both Technological FMEs (11 projects) and FMEs within social science (2 projects). ZEN is classified within the Technological FMEs.

In the technological FME's, it is still asked for a cross-disciplinary approach, including social science perspectives. For example, the predecessor of ZEN, the FME ZEB (<http://www.zeb.no>), dedicated a specific work package to the use and operation of zero-emission buildings, with a clear allocation of monetary and personnel resources to this topic. In the ZEN Centre, the user's perspective received a more diffuse focus, being part of the work package on pilot projects and Living Labs, and task X.2 as a cross-cutting task on user involvement in ZEN. The resources allocated to these tasks were minor compared to the rest of the centre, resulting in limited personnel and time.

The responsible for the overarching task X.2, participated in the leader group's meetings but did not seem to have significant involvement or influence on the other activities of the centre, apart from WP6, pilots, and Living Labs. User involvement in ZEN primarily occurred within the context of Living Labs. Over the eight years of the centre, commonly 1-2 researchers conducted these Living Labs, with a total of five Living Labs experiments executed.

1.1 Who are the users in ZEN?

The scope of this Memo is to have a closer look at the user involvement in FME ZEN. Our question has been: *How were the users involved and what did we learn about their perspective on ZEN?*

In ZEN, the user involvement has been organised in Living Labs in a selection of the pilot projects. The target group were people affected by the suggested changes implied by ZEN, within the geographically defined area of the pilot (Woods, Berker, Baer & Bø, 2019, p. 5):

"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."

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.

(Woods, Berker, Baer & Bø, 2019)

1.2 ZEN Pilots

The ZEN Research Centre has ten (11 including Lø) pilot projects across Norway. These test areas aim to reduce their greenhouse gas emissions towards zero over their life cycle. Serving as innovation hubs, they provide a space for testing new solutions for developing zero emission neighbourhoods. The pilot projects reflect the interdisciplinarity of the centre, bringing together building professionals, property developers, public authorities, energy companies, building owners and users, and of course our researchers.

The ZEN pilots include both new and well-established areas that will be upgraded and developed further. These projects involve over 30.000 people and cover more than 1 million square meters. The variety among the projects includes:

- 2 residential areas with community infrastructure: Zero Village Bergen and Ydalir
- 5 large multifunctional areas (both new and redevelopment) with dwellings, commercial buildings and transport infrastructure: Bodø, Nyhavna, Fornebu, Sluppen and Furuset
- 3 campus areas: Campus Gløshaugen, Campus Evenstad and Mære agricultural school
- 1 kindergarten. In this report, we have also included Lø in Steinkjer, which did not last as a ZEN Pilot over the 8 years.

The ZEN pilot projects are in different stages, from early planning phase where we can influence the result, to already build areas where we can test our methods. An overview of the pilots can be found at <https://fmezen.com/category/pilot-projects/>.

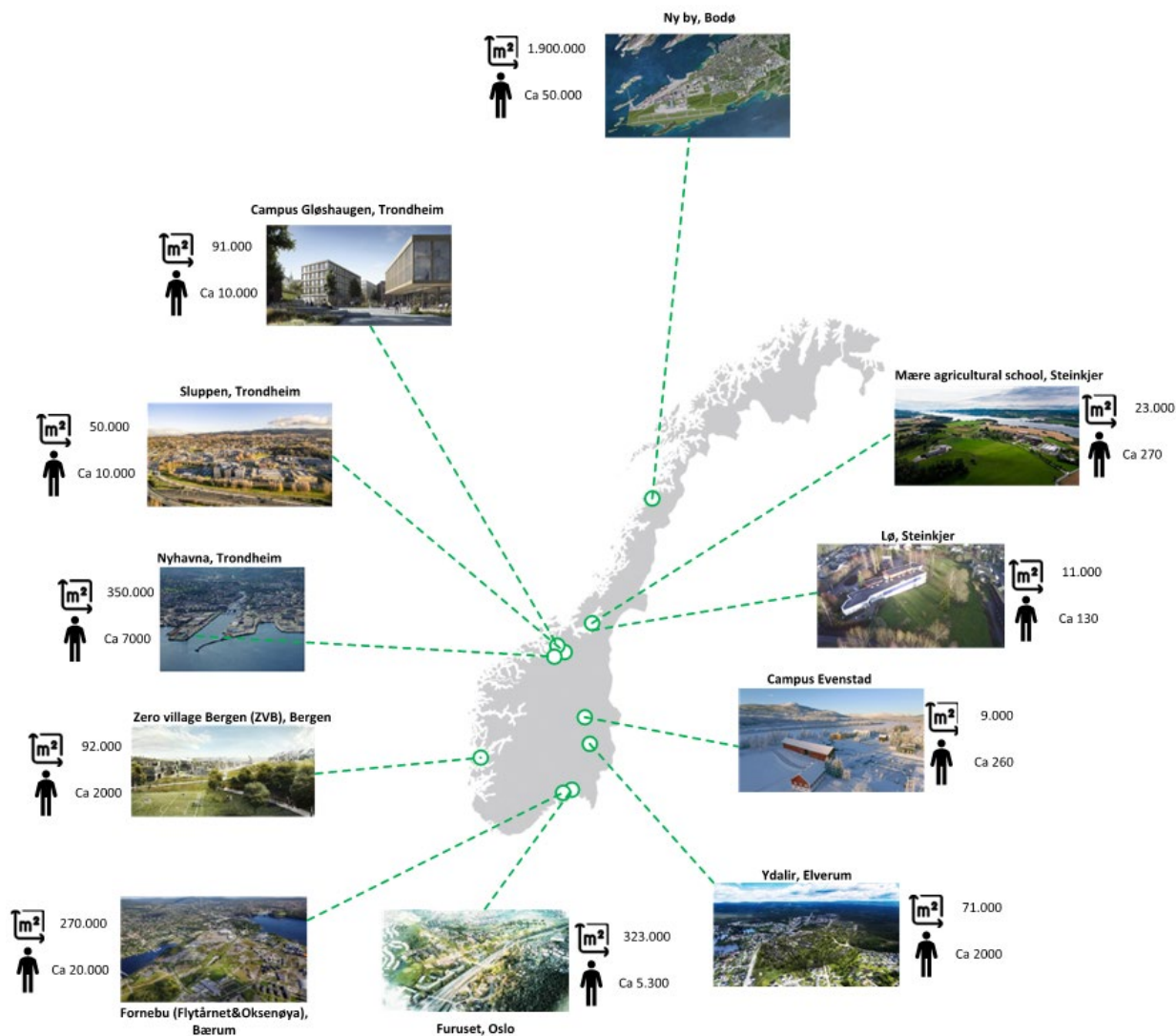


Figure 1: Locations of ZEN Pilot Projects

1.3 Data

This memo is based on a selection of reports and articles published within ZEN, along with information from interviews conducted with seven informants involved in ZEN pilots.

Document collection

We reviewed the list of publications in ZEN and identified those regarding different perspectives on user involvement. Short summaries of the selected publications are provided, with references to the original publications for further reading.

Interviews

We conducted five interviews with seven informants from research and practice to gain more in-depth information about user involvement in the pilots. The informants were chosen for their key positions in ZEN, either as contacts between research and pilots, responsible for implementation of the pilots, or for user involvement in the Living Labs.

The informants have been involved in the Ydalir, Evenstad, Furuset, Gløshaugen, Lø, and Mære pilots:

- Two researchers involved in the ZEN Living Labs
- One researcher involved in the ZEN pilots at Lø, Mære, and Gløshaugen
- One representative from ZEN partner Elverum in Ydalir
- Three representatives from Campus Evenstad/Statsbygg
- Interviews conducted as a part of the pilot project report “Insights into ZEN pilot projects: An overview and experience summary” (Thomsen et al. 2024) have been used as additional information

2. Publications on methods and stakeholder involvement in ZEN

This chapter presents a brief overview of selected publications on user involvement where the "users" are not necessarily directly involved or represented. There are several articles and reports on various methods for user involvement (2.1) and publications on involvement of stakeholders during the planning process (2.2). Publications more directly related to user involvement in the pilots and the Living labs are presented in chapter 3.

2.1 Publications on methods for user involvement

Tools for Stakeholder Engagement in Zero Emission Neighbourhood Developments. Mapping of tools in use in Trondheim, Steinkjer, Elverum and Bodø, ZEN Report no. 13 (Baer, 2018).

People play a key role in zero emission neighbourhoods. They are the ones designing and creating the neighbourhood, transforming and building it and finally using it when living and working there. People play different roles in that process – such as project owners, architects, construction workers, neighbours, and users. The report presents tools in use for stakeholder engagement in the four ZEN pilot projects in Trondheim, Elverum, Steinkjer, and Sluppen. Baer writes in the report that "A special focus in future work will be on the involvement of citizens and end users in the ZEN development".

A New Perspective on Participation Processes in Sustainable Urban Development, ZEN Report no. 25 (Baer, Nielsen, Gohari, Bø & Junker, 2020)

The report examines how the methodology *design thinking* can be used to identify new solutions for citizen participation. The urban development project "New city - new airport" in Bodø municipality is one of the pilot projects in the FME ZEN. Bodø municipality co-hosted the international planning conference ISOCARP in the fall of 2018 in Bodø. This conference was chosen as a framework for conducting a workshop on "Reframing citizen participation", seeking new ideas from international, national, and local actors to address challenges in user involvement. Employing design thinking and storytelling in the workshop setup fostered multifaceted knowledge, and one of the key results was a prototype for structuring participation in municipal processes.

Integrating User Needs in Sustainable Neighbourhood Transition of the Smart City – Expanding Knowledge and Insight among Professional Stakeholders, REAL CORP 2021 (Baer & Ekambaram, 2021)

This paper looks at how capacity building and social learning among professional stakeholders (such as developers, landowners, planners, civil servants) can contribute to development of more citizen-centred solutions within neighbourhood developments. A Market Preference Tool (MPT) is developed based on a workshop concept for detecting market preferences through insight in citizen needs. A practical guidance for using the tool is presented in the paper.

Planning for sharing neighbourhoods – Negotiating sustainable transition with adaptive governance models, *IOP Conf. Series* (Baer & Lindkvist, 2022)

This paper analyses how sharing could be implemented as a guiding principle in neighbourhood developments. A "ladder of adaptation" as adaptive governance model is presented which facilitates collaboration and co-creation between stakeholders, and establishment of permanent structures to enable sharing in the neighbourhoods. The study concludes that the approach is applicable to other new planned development but may have some limitations when it comes to existing neighbourhoods with existing buildings and infrastructure.

ZEN Case: Bodø Storstue. Kartlegging av BREEM Communities-emner innenfor brukervedvirkning og steds kvalitet, ZEN Memo no. 51 (Rokseth & Baer, 2024)

This memo is about spatial qualities and user participation in the Bodø Storstue project. Results from a survey of BREEAM Communities topics within user participation and spatial qualities is presented, and a comparison between BREEAM Communities and key performance indicators in ZEN is provided.

2.2 Publications on involvement of stakeholders in the planning process**The role of Eco-villages in reaching Zero Emission Neighbourhood (ZEN) goals, ZEN Memo no. 29 (Chaudry and Brattebø, 2020).**

This memo provides a literature study on eco-villages and analyses these communities based on seven key performance indicators established by the ZEN Research Centre. It also raises the question of whether compensating for emissions is sufficient to achieve the goal of zero emissions. The memo suggests that eco-villages can overcome barriers related to embodied emissions, mobility, and the unpredictability of user behaviour that current ZEN pilot projects face, presenting a potential point of collaboration and learning for the ZEN Research Centre. Beyond ecological sustainability, eco-villages are also seen to ease many social issues by decreasing loneliness, increasing autonomy of the elderly, inclusion of traditionally marginalised communities etc. The memo further highlights that the early planning stage of any neighbourhood development project must include the people who are going to occupy the neighbourhood. The ZEN Centre should at the early planning stages of its projects also involve the people who will occupy the space, and existing eco-villages/co-housing serve as a great learning platform.

Energy Master Planning in Ydalir on neighbourhood level: learnings on stakeholders and constraints from the Norwegian case of Ydalir, *IOP Conf. Ser.* (Baer and Haase, 2020).

Energy planning on the building level is characterized by a limited number of stakeholders and a clear ambition setting, but this situation changes when expanding to a neighbourhood level. The Ydalir case has shown that a collaborative masterplan development can help to strengthen the commitment to the project and lowering uncertainty at an early phase of development. Regarding energy, these general measures are identified within the masterplan to gain for the ambition.

Process guide for ZEN, ZEN Report no. 70 (Rokseth, Vergerio & Bø, 2024)

The main goal of this report is to provide guidance to the parties involved in ZEN (including leading organizations, project owners, developers, project delivery teams, etc.) who are tasked with executing projects within a zero-emission neighbourhood (ZEN). It also highlights the roles of local authorities in shaping ZEN ambitions through strategic planning. The report presents an overview of the key topics to

be considered during the various phases of planning, facilitating, and evaluating a ZEN, with a primary focus on the phases involving strategic planning and zoning plans in a project.

Barriers and good practices in the planning and building process, ZEN Report no. 54 (Vergerio & Knotten, 2024)

This report asks how we can ensure good processes before, during and after the realization of a zero-emission area. In the fragmented and project-based Architecture, Engineering and Construction industry the adoption of tools is under its full potential because of technical, but also non-technical reasons. Most importantly, collaboration is still hindered, since diverse actors are coming together for a limited amount of time, with their own cultures, practices, and objectives. Lack of stakeholders' collaboration and commitment, insufficient organizational processes, and unsupportive development frameworks are reasons for failure in reaching energy master plan goals at the neighbourhood level more than lack of technologies.

Nyhavna– a harbour area on its way to climate neutrality. Empirical insights and learnings for different stakeholders, *Net-Zero Future 2024 conference proceedings* (Skaar, Bø & Thomsen 2024).

The paper investigates the transformation process of an urban harbour area, Nyhavna, in Trondheim, Norway, with a focus on converting it into a neighbourhood reducing its carbon emissions towards zero. Interviews with seven informants of different stakeholder groups were conducted, public text documents were analysed, and participative observation in meetings was carried out. The study highlights several challenges experienced by the informants: Continuous stakeholder involvement is challenging and must be planned for; various planning documents and the ownership structure of a neighbourhood can impose barriers to ambitious goals, the hierarchy of goals must be clearly defined, and the roles of stakeholders and their interplay should be clarified.

From Social Barriers to Transformative Planning in Energy Transitions: Learning from Norwegian Planners' Perspectives, *Urban Planning* (Loewen, 2024)

This article investigates social barriers in Norwegian urban energy projects from the planner's perspective. Four categories of social barriers are identified: the understanding of a shared vision amongst stakeholders, lowered ambitions over the course of a project, lack of user involvement, and structural constraints to planning. A framework for a deeper understanding of social barriers for planning researchers, practitioners, and policymakers is proposed.

2.3 Reflections on literature in ZEN

The common theme for the publications on user involvement in FME ZEN is **methods for citizen participation**, and challenges with **stakeholder engagement** in developing zero emission neighbourhoods.

Key aspects to improve for increased user involvement in FME ZEN include:

1. **End user perspective:** Provide methods for how to include the end user perspective when the end users are not yet present. The methodology of design thinking is used to identify new solutions for citizen participation (Baer, Nielsen, Gohari, Bø & Junker, 2020)
2. **Early Involvement:** The early planning stage of any neighbourhood development project must include the people who are going to occupy the neighbourhood (Rokseth, Vergerio & Bø, 2024)
3. **Collaboration and Shared Vision:** Collaboration is often hindered due to diverse actors coming together for a limited amount of time, with their own cultures, practices, and objectives.

A collaborative masterplan development can help to strengthen the commitment to the project and lower uncertainty at an early phase of development (Baer & Haase, 2020). There are also social barriers related to the understanding of a shared vision amongst stakeholders, which also could stem from a lack of user involvement (Loewen, 2024).

4. **Continuous Stakeholder Involvement:** Continuous stakeholder involvement is challenging and must be planned for (Skaar, Bø & Thomsen, 2024). This is particularly important when expanding from building level to a neighbourhood level (Baer & Haase, 2020).

3. User involvement in ZEN pilots and Living Labs

Much of the end user involvement in ZEN has taken place in the Living Labs. Living Labs are user centred initiatives where knowledge production involves individuals or user groups affected by sustainable transitions. In this chapter we take a closer look on user participation in a selection of ZEN pilots: Ydalir, Evenstad, Furuset, Gløshaugen, Lø and Mære. We have gathered publications where the user perspective is presented, and additional information was acquired from interviews with researchers and partners involved in the pilots. An overview of the activities and outcomes of the ZEN Living Labs can be found in **Insights into ZEN pilot projects: An overview and experience summary, ZEN Report** (Thomsen et al., 2024).

3.1 Ydalir

The ZEN pilot Ydalir is a newly planned development zone situated approximately 1.5-2 km northeast of the center of Elverum, Innlandet. Currently, it has been built a new school (6,000 m² accommodating 350 pupils) and a kindergarten (1,700 m² for 120 children). There are also planned around 800 residential units. The development of Ydalir is expected to span 10-15 years, with an estimated completion between 2035 and 2040.

In the article "**Homelife in a Norwegian forest: a rural approach to the sustainable transition**", **Woods and Berker (2022)** explore the relationship between local and universal expectations for sustainable lifestyles and the feasibility of proposed changes in the ZEN pilot of Ydalir. Their findings reveal a broader, more inclusive understanding of sustainability among the inhabitants in Elverum, compared to the primarily technical and environmental focus of the ZEN concept. Woods and Berker suggest that prioritizing social sustainability over technical innovation may better encourage sustainable practices in rural communities.

In the article "**From Science to Sales: Changing Representations of Zero Emission Housing**", **Henriksen (2023)** looks at how the ZEN concept is fitted to the local housing marked in Elverum. A disparity between the project's initial technological focus and the social qualities anticipated to appeal to potential residents in Ydalir is highlighted. The analysis shows that "*social qualities, rather than technology, provide more suitable entry points in the efforts to make the ZEN concept attractive in the local market in the case of Ydalir. (...) The process of making a ZEN pilot project attractive in a local market entails more than simply extracting selling points from the ZEN centre's vision and definition guidelines. (...) A stronger connection between the social and technological attributes of the neighborhood is desirable. This connection should be reflected in both the research agenda and the representations of the neighbourhood.*" (p. 608).

The memo "Deling i ZEN områder [Sharing practices in ZEN areas]" (Baer, Bø, Gorantonaki & Qui, 2024) reports results from a **workshop exploring possible sharing solutions in Ydalir** (Elverum). The

workshop was organized with various stakeholders, including landowners/developers, the municipality (administration and project development), volunteer organizations, school staff, maintenance services, and mobility solution providers. Participants identified several sharing solutions for the future neighbourhood, such as mobility, common areas, equipment, and community resources. Due to the complexity of the area, which involves multiple owners, it is essential for different actors to take responsibility and develop a committed network of landowners, developers, consumers, managers, and the local community to facilitate sharing in the neighbourhood. Establishing a user-friendly interface is crucial for creating awareness and encouraging engagement. Developers play a central role in implementing sharing solutions at their construction sites. Consequently, the Elverum Land Development Company scheduled separate follow-up meetings with all the developers.

According to our informant from Ydalir, there has been a noticeable shift toward a greater understanding of the user's perspective over time in FME ZEN: *"ZEN came straight from ZEB, and the technical solutions were the main focus. Over time, the user perspective and the creation of good living environments gained more attention. We build for people, and it must be facilitated so that people can change behaviours and live more environmentally friendly. Some of the researchers in ZEN highlighted this perspective."* Our representative from Ydalir also emphasize that the market perspective is important in such development: *"you can market a vegan soup or a tomato soup—both are the same but will likely appeal to different groups"*.

A significant challenge in this pilot has been engaging future inhabitants of Ydalir as a target group due to the long timeframe. This has also posed difficulties in securing commitments from developers, such as committing to building a shared parking garage.

3.2 Evenstad

The ZEN pilot project at Evenstad was a part of the previous Research Centre on Zero Emission Buildings (FME ZEB). The administration and teaching building, opened in January 2017, became the country's first ZEB-COM building, achieving zero greenhouse gas emissions over its lifecycle. Located in Stor-Elvdal municipality, Norway, the site comprises approximately 10,000 m² of total floor area spread across 22 buildings. The campus is owned, developed, and operated by Statsbygg. The end-users at Campus Evenstad include around 70 employees (academic staff, operators, and administrative personnel) and about 250 students.

Statsbygg's operational staff at Evenstad have shown great commitment and enthusiasm in their work with ZEN. As a pilot project, they have had the opportunity to test new technical solutions that would otherwise be inaccessible. Being part of ZEN has also enabled them to fix and continuously improve technical solutions when issues arise: *"If a problem arises, we have access to the means, knowledge, and capacity to solve it!"*. The ZEN-case approach has allowed partners to pursue their needs and interests, following a bottom-up approach.

One of our informants states that *"advanced solutions can also create advanced problems"*. A lesson learned from Statsbygg is that the latest technology quickly becomes outdated, particularly in the case of batteries, and upgrading and maintenance can be costly. Operating at a pilot level means that while many individual technological solutions have been tested, integrating them into a cohesive system and ensuring they function as intended can be challenging. Statsbygg is currently developing a technology strategy aimed at the "golden middle way"—not outdated, but also not overly advanced. They recognize

that low-tech solutions can address many challenges and consider the end user: *"Various suppliers often emphasize how easy everyday life will be. What they forget is how difficult things become when it doesn't work! If you have a touch screen that doesn't work, then nothing in the menu works"*. Another informant points out that *"sometimes it is easier just to be able to open the window"*.

When it comes to the students at Evenstad, the operating personnel state that the students and employees as "end users" have not been particularly involved in the ZEN activity at the campus: *"We have not been good enough to share what we have been working on with the students and staff. It is very dependent on engaged people; we need someone at the college who sees the value of it. At the beginning, we had a very engaged professor, but when this person quit, the engagement faded away"*. Researchers in the Living Lab also experienced difficulties recruiting students and academic staff in the workshops, resulting in the engaged operating personnel becoming the main participants in the Living Lab activities. Together, they organized a low-tech intervention by turning off the ventilation system in the old administration building for four weeks during the summer. Through this experiment, other building occupants also became engaged in the Living Lab activity. The findings from this intervention are reported in the article **"Identifying and addressing reverse salient in infrastructural change. The case of a small zero emission campus in Southern Norway."** (Berker & Woods, 2020). This article also highlights the involvement of "middle actors", the on-site facility management team, playing an important part in infrastructural transformations. This is a group with knowledge both about the technological infrastructure and who also deals with the users.

Campus Evenstad is also used as a case in the article **"Smart energy prosumers in Norway: Critical reflections on implications for participation and everyday life"** (Korsnes & Throndsen, 2021). This article provides insights about the end users at Campus Evenstad, and points to the differing perceptions of what a Zero Emission Neighbourhood should imply:

"(lack of) engagement and participation are not necessarily the barriers hindering the successful implementation sustainable solutions in Norway. Rather, we could say that local inhabitants are supportive and want to contribute, but this engagement is not catered to by the relatively narrow, technical, efficiency optimised scopes of many smart technology development projects. In the Evenstad case, for instance, the local participants had imagined an eco system consisting of reusing rainwater, growing local vegetables and reusing sewage for local heat production. None of these aspects were of any interest to the academic and industry partners of the zero-emission neighbourhoods research centre that initiated the project with Campus Evenstad, who had entirely different solutions in mind." (Korsnes & Throndsen 2021: 7).

3.3 Furuset

Furuset is a suburb with 2,800 homes built in the 1970s, housing approximately 3,800 inhabitants from 140 nations. The main ZEN focus on Furuset has been to construct a seasonal thermal energy storage facility, which will utilize surplus heat from the Klemetsrud waste incineration plant during the summer. This will be made available at Furuset by connecting the area to the city's primary district heating network.

The researchers in ZEN engaged in conversations with youth and elderly in the district, but did not find anyone interested enough to spend more of their time on it. Attempts to establish a Living Lab through contacts with the library and a city district center did not progress. Our informant states, *"It was impossible to establish a Living Lab at Furuset"*. Residents in the area were unaware of ZEN and showed

little interest even after being introduced to the pilot area plans. The district heating network system, being an underground technology, is not visible to the general public and does not affect electricity prices for residents, making it hard for them to relate to it.

3.4 Gløshaugen

The Norwegian University of Science and Technology (NTNU) is consolidating from dispersed locations to one central campus at Gløshaugen. This transition requires approximately 92,000 m² of new buildings and the upgrade of 45,000 m² of existing buildings. NTNU had ambitious environmental goals for the new campus, including a commitment to achieving zero emissions. Significant cuts from central authorities have led to a reduction in the environmental ambitions and consequently also Gløshaugen as ZEN pilot.

One of the Living Lab activities carried out in this pilot involved creating reuse zones for old furniture and inventory from the university in collaboration with the facility management team. The researchers in the Living lab experienced engagement and enthusiasm among the students and employees visiting the reuse zones. The attitude towards reducing the consumption of furniture and inventory was positive. The Living Lab activity, while more symbolic than directly impactful on the planning of the project at Gløshaugen, can still provide valuable information to the planning actors.

3.5 Lø

In this report, we have also included Lø in Steinkjer, which did not last as a ZEN Pilot over the 8 years. In spring 2017, Steinkjer Municipality joined as a ZEN partner and selected the former NRK site in Steinkjer as the pilot project. The plan was to merge two kindergartens from the Lø neighbourhood and relocate them to a renovated building. The goal was to transform the old NRK building into a six-department kindergarten. However, objections from kindergarten staff led to the halt of the renovation plans, resulting in the demolition of the NRK building and the cancellation of the pilot project in Lø in 2018.

The article "**Citizen Participation in Steinkjer: Stories about the 'Old NRK Building at Lø'**", (Woods & Berker, 2020) analyses the process that led to the cancellation of this pilot. The engagement in ZEN within the municipality was rooted in the planning department. Representatives from the nursery, as future occupants of the building at Lø, felt that their needs and wishes were not heard. They perceived the plans for renovating the old NRK building as something *"forced upon 'from above'"* (Woods & Berker, 2020). *"[t]he nursery representatives finally felt that user needs were in focus"* when the old NRK building was decided to be demolished (ibid, p. 1). The end user perspective at Lø provides important learnings about the process: *"Analysing the stories that are told about Lø can help us to understand what kind of support is needed in the early stages of a project. This case highlights the importance of the early establishment of forums for engagement and information exchange where new solutions appear realistic and relevant for the citizens and the local context."* (ibid, p. 7)

In the case of Lø, the potential positive aspects of the plans for the area were not clear to the end users. One of our informants involved in Lø stated that there is generally a need for translation between the technical issues and the users in ZEN, exemplified by the challenges in the pilot at Lø: *"[The researchers in ZEN] have talked a lot about 'ZEN', 'zero emission' and 'here you have the lifecycle module A1-A3'... We should probably talk much more about what the actual purpose of ZEN is - about the climate crisis and the need for good neighbourhoods to live in, and that ZEN should be an answer to both problems."*

There has been a very technical focus and little focus on good neighbourhoods." The informant also points to the building level as a starting point for calculations instead of the neighbourhood level, as ZEN is a follow up of the former FME Zero Emission Building: *"all the concepts, systems, and frameworks have been taken from the building level with the attempt to transfer them to a neighbourhood level, at least for the greenhouse gas calculations"*. The neighbourhood perspective was also neglected at Lø, with attention focused on the renovation of the old NRK building.

3.6 Mære

After the cancellation of the pilot project in Lø in 2018, Mære was chosen as a new ZEN pilot. Mære is an agricultural school in Steinkjer municipality owned by Trøndelag County Municipality. The school employs 70 staff and educates 200 students in agriculture, forestry, local food production, and climate/energy initiatives in agriculture. Photovoltaics have been integrated into the roofs of two buildings—the calf barn and a dormitory. Additionally, a dormitory has been constructed as a passive house, and a stable has been built as a zero-emissions building (ZEB-O).

The contact persons from the county municipality and the agricultural school at Mære are key personnel for running the pilot project. The students and other staff at the school are minimally affected by the energy management system and have not been directly involved in the ZEN work. According to our informant, the research at Mære has been very technical and not very "hands-on". The climate gas calculations are in an Excel sheet, which is not very pedagogical in its current format for teaching purposes. The "users" have been the operating personnel and employees in the county municipality, utilizing the tools, methods, and research expertise within ZEN in their efforts to make Mære a "zero-emission farm" as a model for Norwegian farming. Mære has not been involved in the Living lab activities.

The end users, as in the people living and working at the school, have also to a little degree been included in the calculations. For example, the emissions from driving tractor within the farm operation are included, but not the emissions from the students and employees transport to and from the school.

4. Discussion

Based on the findings from the interviews and the presented publications on user involvement in ZEN, the following three themes is identified for further discussion: (1) The struggle of engaging the end user, (2) Enthusiastic users of the technology, and (3) Complex planning- and development processes makes user involvement challenging.

4.1 The struggle of engaging the end user

The researchers in the Living Labs experienced difficulties finding and recruiting end users to the activities in the Living Labs, which is a known challenge in social science research. Since many of the ZEN pilots involving residents are in early planning stages, such as Bodø, Fornebu, and Elverum, it is not unexpected that creating significant engagement can be challenging. Norwegian planning practices often tend to fulfil only the minimum requirements for participation set by the Planning and Building Act (PBL) (Rambøll, 2014). Significant engagement often arises when construction is underway, or just before, especially when activities directly affect users/residents. In projects with long timeframes, the

communities or neighbourhoods are not always established, making it also difficult to identify who the end user will be.

In the case of Lø, the representatives for the nursery were directly affected by the plans for the pilot project. In this case, the problem was not the lack of engagement from the end users, rather that they felt the plans did not involve their perspective sufficiently. They experienced that the idea of renovating the existing “old NRK-building” on-site to a ZEB-standard building appeared more important than the needs of the nursery as future occupant (Woods & Berker, 2020). Analysing and following the process, as seen in projects like Lø provides insights into why things may not proceed as planned and highlights challenges.

The end users were difficult to engage also in some of the already operating pilots. In general, the researchers in the Living Labs experienced little general knowledge about ZEN among end users (or potential end users) that have not been directly involved in the pilots. After informing potential participants for the Living Labs in the local communities about ZEN, it was still difficult to find people interested enough to spend time on activities in the ZEN Living Labs. This applies in particular for the pilots where the technical infrastructure is invisible and not obvious affecting people's everyday life, as in Furuset and Evenstad.

It appears that the plans for Ydalir have engaged at least parts of the community in Elverum, likely due to a holistic transformation of the neighbourhood that is easier for end users to relate to, compared to previous examples, where ZEN appeared more as an invisible technological approach. During the project phase in Ydalir, a school and a nursery have been built, making the place actively used. The case of Ydalir also exemplifies that once the action will affect the end users' daily lives directly, engagement is less difficult. An example is that the original plan for reducing personal car use in Ydalir, which became a discussion topic among the general citizens of Elverum. The reduction of parking spaces was not widely supported when it came to their own places of residence. As discussed in Woods & Berker (2022), private car use is central to the everyday practice of homelife of many people living in Elverum since public transport is limited in the rural surrounding areas. Additionally, existing social values and ideas of how to live “the good life in a small town” are closely linked to social sustainability and provides a starting point for change of practice towards sustainable communities (Woods & Berker, 2022).

Communication about what ZEN is and what it implies for the general citizen was likely not sufficiently exploited. The general public is anticipated to be less interested in ZEN solutions than the involved stakeholders, including researchers. Korsnes & Throndsen (2021) point to the expectations of a more holistic perspective on a “zero emission neighbourhood”, Woods & Beker (2022) propose social sustainability as a starting point, and Henriksen (2023) highlights the need for a closer link between social sustainability and technological innovation. A popular translation, explanation, and illustration of the benefits of ZEN solutions for society, nature, and people would probably have achieved a greater level of public interest.

4.2 Enthusiastic users of the technology

In this memo, we include a comprehensive understanding of "users," not just end users or potential end users. Regarding other "users", such as those tasked with finding technological solutions in the various pilots, as well as the municipalities and other partners in ZEN, participation has been both rewarding and educational. Their roles have varied, but all have shared a desire to contribute to new technologies

and solutions for achieving zero-emission areas. These users have been engaged through meetings, workshops, ZEN conferences, and various ZEN case studies, involving far more participants than the initial partners.

The ZEN partners, including users of the technology, project partners, and research experts within ZEN, appear very enthusiastic. For many of them, joining the ZEN research centre was an opportunity to further develop technological solutions that contribute to reducing emissions. Pilots where there have been coincident interests between the partners has been more successful, like at Evenstad where there was a match between the partners and researchers' interests. For the researchers in the Living Labs, the operating personnel has been an interesting group to work with. They know both the end users and the technological infrastructure. These "middle actors" plays an important role in infrastructural transformations (Berker & Woods, 2020).

Project participants report that they have been relatively free to initiate projects in "ZEN-cases", giving a low threshold for partners to initiate projects that is of interest for them, as the case of the operating personnel in Evenstad. The ZEN Innovation report for 2023 (Collins, Aakervik & Kvellheim, 2023) also confirms that the ZEN-case-approach in organizing project have supported upon the partner's needs.

4.3 Complex planning- and development processes makes user involvement challenging

Transitioning from building-level projects as in FME ZEB to neighbourhood development in FME ZEN was a learning process for both partners and researchers involved. A significant change is longer and much more complex planning- and development process of neighbourhoods, compared to a single building. Consequently, there is also a greater challenge to ensure a continuous user involvement at all levels throughout a long-time process. An understanding of the target group and their associated needs is crucial for planning a neighbourhood that meets needs and expectations. This context is crucial to assess from an early planning stage. The development in many of the pilots has a long timeframe, the community or neighbourhoods are not always yet established, which means we don't necessarily know who the end user is. These challenges are discussed in several research papers as presented in chapter 2.

Within ZEN, there were discussions on how to address the planning process and user involvement. These topics were not weighted as much in the initial phase of the centre as towards the end. To begin with, it was decided to incorporate these elements into the categories of urban form (previously spatial qualities) and mobility, assuming that process and involvement were naturally aligned with the early planning phases of these categories. However, in hindsight, it has become evident that process and user involvement cannot be confined to a few categories of the ZEN ambition but should be treated as overarching topics across all ZEN categories. Focus on both is crucial in all aspects of planning ZEN and throughout its entire timeline. In recent years, there has been a greater emphasis on the process (Rokseth, Vergerio & Bø, 2024). The work with the pilot areas and the approach to planning a ZEN neighbourhood has, over the years, highlighted the importance of the planning process and user perspective as crucial elements in realizing ZEN or comparable ambitions.

5. Concluding reflections

We started off to summarize how users have been involved in ZEN. During the writing process, we found that it is likewise interesting to reflect on the role the users are given in projects with a high focus on technological solutions. Behaviour change is a major driver for achieving a societal transition to a

low-carbon society. The work in ZEN has mainly concentrated on technological solutions for environmental sustainability. These solutions are often invisible for the user, not directly impacting people's everyday lives, making them hard to relate to. When technology is presented as the major solution, the need for behaviour change is under-communicated and may seem less important, leading people to continue their usual practices, assuming technology will compensate for emissions.

Research based on the data from the Living Labs shows the need for a closer link between social sustainability and technological innovation (Henriksen, 2023; Woods & Berker, 2022). Several international studies highlight benefits and challenges in cross-disciplinary energy research combining technology and social topics. Common challenges are for instance different research traditions, including various methodologies and a lack of mutual understanding of the usefulness of the approaches (e.g. Sovacool et al., 2015; Mallaband et al., 2017).

Bridging the gap between the social and technical context has been proven difficult within the frame of FME ZEN. The nature of the FME scheme under which ZEN was filed is, by description, not a social science-related program. Initially, this topic was not given much emphasis. In retrospect, we can question whether the centre should have addressed the social aspects of sustainability to a greater degree in order to succeed with zero emission neighbourhoods. Ultimately, it is the people who use buildings and neighbourhoods. A benefit could have been to foster a closer collaboration between technological- and social science FMEs, e.g. the social science FME Include – Research centre for socially inclusive energy transitions (University of Oslo, n.d.) addresses issues very relevant to ZEN.

The “middle actors”, such as operating staff, is reported by researchers in the Living Labs as an especially interesting user group to work with, as they have intimate knowledge on both the end user and the technological infrastructure (Berker & Woods, 2020). Local initiatives driven by innovative operational staff and property managers have realized a combination of technologies and the interoperability of solutions which had not been tested elsewhere before. The Evenstad pilot is a good example, where the enthusiasm among those involved also fostered pride and strengthened the identity of both Statsbygg and Evenstad College as pioneering organizations. The pilot projects clearly demonstrate what passionate individuals can achieve within their organization.

In conclusion, we would like to emphasise the benefits of encompassing diverse types of research approaches and viewpoints to the topic of zero emission neighbourhood planning. To succeed, there is a need to include perspectives from all stakeholders: practice, research, users and as well, learnings from national and international regions. Inclusivity of perspectives can enhance the robustness of research, give an understanding of social structures and processes, as well as benefit planning with observations by people closest to the phenomena in question.

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