Research Centre on
ZERO EMISSION
NEIGHBOURHOODS
IN SMART CITIES

NTNU SINTEF

ZEN PILOT PROJECTS

MAPPING OF THE PILOT PROJECTS WITHIN THE RESEARCH CENTRE ON ZERO EMISSION NEIGHBOURHOODS IN SMART CITIES

ZEN REPORT No. 10 – 2018

Daniela Baer and Inger Andresen | SINTEF / NTNU

Research Centre on
ZERO EMISSION
NEIGHBOURHOODS
IN SMART CITIES

ZEN Report No. 10
Daniela Baer (SINTEF Building and Infrastructure) and Inger Andresen (NTNU)
ZEN PILOT PROJECTS
Mapping of the pilot projects within the research centre on ZERO emission neighbourhoods in smart cities
Keywords: zero emission neighbourhood, pilot projects, living labs, sustainable urban development, neighbourhood, transformation
ISBN 978-82-536-1601-8
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, Trøndelag county, Norwegian Directorate for Public Construction and Property Management, Norwegian Water Resources and Energy Directorate, Norwegian Building Authority, ByBo, Elverum Tomteselskap, TOBB, Snøhetta, Tegn_3 , Asplan Viak, Multiconsult, Sweco, Civitas, FutureBuilt, Hunton, Moelven, Norcem, Skanska, GK, Caverion, Nord-Trøndelag Elektrisitetsverk (NTE), 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 m^2 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

Denne rapporten vil gi leseren en oversikt over de åtte pilotprosjektene i ZEN Forskningssenter, med fokus på utfordringene som ligger i å utvikle og transformere pilotprosjektene til nullutslippsområder.

Målet med forskningssenteret Zero Emission Neighborhoods er å utvikle produkter og løsninger som vil føre til realisering av bærekraftige nabolag med null klimagassutslipp. Disse løsningene blir testet i åtte pilotprosjekter i norske kommuner. Når vi søker etter de beste løsningene, er det viktig å ha kartlagt pilotprosjektene med tanke på de utfordringene de står overfor med tanke på å oppnå bærekraftige nabolag med null utslipp av klimagasser. Denne rapporten vil derfor fungere som en introduksjon til de åtte pilotprosjektene og skal hjelpe ZEN-partnerne til å utvikle en felles forståelse for pilotprosjektene og deres utfordringer som grunnlag for videre forskning og samarbeid.

Rapporten starter med en kort introduksjon av forskningssenteret og en arbeidsdefinisjon av hva som legges i Zero Emission Neighborhood (ZEN). Hvert av de åtte pilotprosjektene er beskrevet i detalj med deres individuelle egenskaper som plassering, interessenter, mål, tiltak, status for prosjektutvikling og utfordringer. Utfordringene ble identifisert gjennom kvalitative intervjuer med de involverte aktørene i pilotprosjektene, mange av dem er ZEN partnere. Disse intervjuene ble gjennomført i 2017.

En systematisk dokumentasjon av prosessen og utfordringene med å utvikle ZENs vil bidra til å identifisere suksessfaktorer og beste praksis for å planlegge og utvikle ZEN. Dette gjør det mulig for de involverte partnerne å lære fra de første pilotprosjektene og overføre løsninger til andre byutviklingsprosjekt senere. Denne rapporten danner grunnlaget for videre oppfølging, dokumentasjon og analyse.

Summary

This report on the pilot projects of the Research Centre on Zero Emission Neighbourhoods in Smart Cities (ZEN Centre) will give the reader an overview of eight pilot projects of the Centre, focusing on the challenges to develop or transform the pilot areas into Zero Emission Neighbourhoods.

The objective of the ZEN Centre is to develop products and solutions that will lead to the realization of sustainable neighbourhoods with zero greenhouse gas emissions. These solutions will be tested in the eight real life pilot projects in Norwegian municipalities. When searching for the best solutions, we first need to map the pilot projects and the challenges they are facing on the way to become sustainable zero emission neighbourhoods. This report will therefore serve as an introduction to the eight pilot projects to help the ZEN partners to develop an understanding for the pilot projects and their challenges, as a base for further research and cooperation.

This report will start with a short introduction of the Research Centre and present a working definition for a Zero Emission Neighbourhood (ZEN). Each of the eight pilot projects are described in detail by their individual characteristics regarding location, stakeholders, goals, measures, status of project development, and challenges. Challenges were identified through qualitative interviews with stakeholders of the pilot projects. These interviews were conducted in 2017.

A systematic documentation of the process and challenges to develop ZENs will help to identify the success factors and best practices that are needed for planning and developing ZENs. This enables the involved partners to learn from the first pilot projects, and to transfer solutions to other neighbourhood developments. This report provides a foundation for further follow-up, documentation, and analysis.

Key words: zero emission neighbourhood, pilot projects, living labs, sustainable urban development, neighbourhood, transformation.

Contents

1. Introduction

1.1 Objective

The mapping of the ZEN pilot projects will serve as a basis for planning of the ZEN activities within the projects and will provide input to the research in the other work packages (WPs) of ZEN. In particular, it offers useful input to the definition work in WP1.
The pilot project mapping focuses on a short description of each pilot project including location, stakeholders, goals, measures, status of project development, and challenges. This is necessary in order to compare the projects, identify (common) problems, and thereby lay the basis for further analyses and the development of processes, activities, methods, and technical solutions for the realization of ZEN. Furthermore, the mapping offers partners the opportunity to learn from the experiences of others.

1.2 The ZEN Centre

The Research Centre on Zero Emission Neighbourhoods in Smart Cities (ZEN Centre) was established in spring 2017 at the Norwegian University of Science and Technology (NTNU) in Trondheim. Research partners NTNU and SINTEF are working with 31 public and private partners to enable the transition to a low-carbon society. The main objective is to develop products and solutions that will lead to the realization of sustainable neighbourhoods that have zero greenhouse emissions gas emissions related to their production, operation and transformation.

The centre is organized in six work packages (WP). WP 6 focuses on pilot projects for Zero Emission Neighbourhood (ZEN) concepts and the implementation of living lab methodology within the pilot projects. The participating pilot projects are Ydalir in Elverum, Furuset in Oslo, NyBy in Bodø, Knowledge Axis with the NTNU Campus and Sluppen in Trondheim, Zero Village Bergen, NRK site in Steinkjer, and Campus Evenstad. The pilot projects will serve as innovation hubs for co-creation between researchers and building professionals, property developers, municipalities, energy companies, building owners, and users. The ZEN Centre will develop and test the solutions in real-life contexts and include a broad group of relevant stakeholders, and living lab methodology is therefore particularly relevant. The pilot projects will also function as lighthouses of inspiration, supporting the development and dissemination of ZEN-related knowledge.

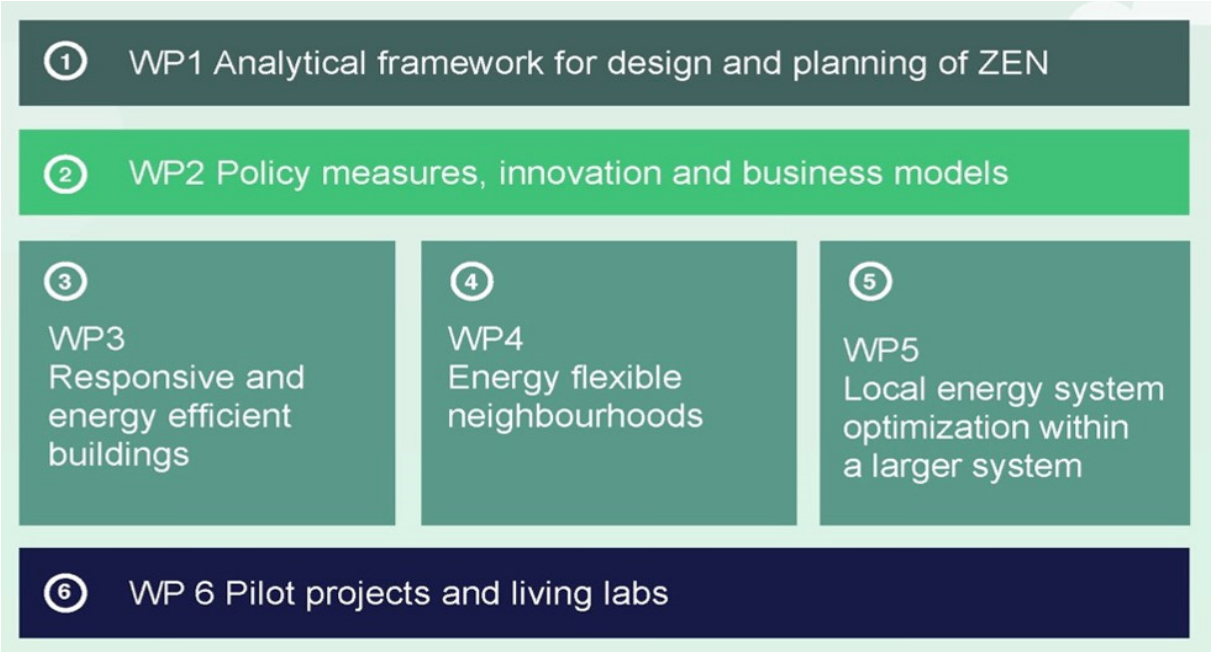

Figure 1. Work packages within the ZEN Centre

1.3 Definition of a Zero Emission Neighbourhood

The definition of a Zero Emission Neighbourhood is a separate task within the ZEN Centre, and the definition work will be an ongoing process throughout the eight-year programme period, taking into account the different specifications and solutions being tested in the work packages and pilot projects. The following is a simplified definition, formulated in May 2018 (Andresen, 2018):

A zero-emission area aims to reduce its direct and indirect greenhouse gas emissions to zero within a given period of time. Focus is placed on the following seven main areas (criteria):

A. Reduction of greenhouse gas emissions to zero, seen in a lifecycle perspective

Through the planning, engineering and operation of buildings and related infrastructure elements, the area will aim to achieve net zero emissions of greenhouse gases over the lifetime. The standard NS-EN 15978 "Sustainability of Construction Work- Assessment of Buildings Environmental Performance - Calculation Method" and the proposed new standard NS 3720 "Method for Greenhouse Gas Calculations for Buildings", defines a set of lifespan modules; products, implementation phase, usage phase, end of life cycle, and advantages and disadvantages beyond the system boundary. A given ZEN project should have a defined ambition level regarding which of these lifecycle modules are included, as well as what building components and infrastructure elements are included. It is up to the owner of a ZEN project to decide such an ambition level, but this should be unambiguously defined according to the module principle in the standard NS 3451 “Table of Building Elements”. In the ZEN Centre, further work is being carried out with clarifications as to what should be the recommended minimum ambition level for ZEN pilot projects. Work is also being done to clarify how to calculate CO_2

emissions from local renewable energy generation, and the ZEN Centre is not currently bound to the methodology for emission calculations in the Standards NS-EN 15978 and NS 3720.

B. Energy efficiency and renewable energy

The first strategy to employ is to reduce the need for energy as much as possible. The most environmentally friendly energy is, as is known, the one you do not use. This is also in line with national and international objectives, ref. EU's Strategic Energy Technology Plan (SET-Plan). Secondly, one should cover the remaining energy needs with renewable energy. Local available renewable energy in the area should be seen in conjunction with the surrounding energy system, avoiding sub-optimization and exploiting all available resources in the best possible way. The utilization of potentially available surplus heat in the area, as well as the exchange of energy between buildings and the surrounding energy system, is central.

C. Flexibility and Power

Reduction of peak load requirements, smart management of the energy flow in the area, and exchange with the surrounding energy system can yield significant gains in terms of both costs and greenhouse gas emissions. The individual buildings must be viewed in connection with surrounding buildings and energy supply systems in order to find the best overall solution. This involves systems for controlling energy demand and production, as well as exchange of energy between buildings, energy systems, energy storage, and transport.

D. Mobility

Through the design of the area and the connection to surrounding areas, functions and infrastructure, the ZEN area must focus on sustainable transport solutions. Currently, the ZEN Centre has chosen to base its mobility criteria mainly on criteria in BREEAM Communities, focusing on low-emission transport solutions and access to public transport. In addition, emissions from transport are also taken into consideration in criterion A.

E. Spatial Qualities

A ZEN area should also be perceived as a good place to be. If the area offers good qualities and services, this will have indirect impacts on greenhouse gas emissions, as it will limit the need for transportation out of the area. The ZEN Centre has currently chosen to focus on three criteria related to spatial qualities: user involvement, accessibility to service functions and recreation areas, and public spaces. These are closely linked to criteria in BREEAM Communities (Demographic needs, delivery of services, facilities and amenities and public space).

F. Economics

To get an indication of economic sustainability, ZEN wishes to focus on life cycle system costs (LCC).

G. Innovation

The last area we want a special focus on, is innovation. This area has not been developed in detail yet, but we are seeing that ZEN areas use innovative processes that utilize new forms of cooperation between the involved players, which provide the basis for innovative solutions.

In the ZEN Research Centre, a neighbourhood is defined as a group of interconnected buildings with associated infrastructure [1)], located within a confined geographical area [2)]. In this context, **pilot projects** are geographically limited areas in Norway where new solutions for the construction, operation and use of buildings are developed and tested to reduce the total greenhouse gas emissions to zero on a neighbourhood scale. ZEN pilot projects will function as role models, inspiring others to build zero-emission neighbourhoods and offering suggestions as to how to achieve the best possible results.

Stakeholders are defined as individuals, groups, or organizations from different disciplines. They have different needs, responsibilities, and resources, and are involved in the development of a ZEN or are influenced by its activities.

1.4 Methodology

The sources used for data collection during the mapping of the pilot project include research from the former FME Centre on Zero Emission Buildings (FME ZEB Centre) and the research project "Planning Instruments for Smart Energy Communities" (PI-SEC). The PI-SEC project aims to deliver efficient planning instruments for integrated energy design at the neighbourhood scale and is a collaboration between NTNU and SINTEF (2016-2019). PI-SEC focuses on the pilot projects Furuset in Oslo and Zero Village Bergen. The ZEN pilot projects in Bergen and Evenstad were pilot projects within the FME ZEB Centre.

In addition, the mapping is based on 33 qualitative interviews with stakeholders of seven pilot projects within the ZEN Centre. Interviews were conducted either as individual interviews, or as group interviews and conducted in 2017. The interviews followed a semi-structured interview guide and were transcribed and analyzed with the help of a qualitative content analysis methodology (Mayring, 2000).

1) Buildings can be of different types, e.g. new, existing, retrofitted or a combination. Infrastructure includes grids and technologies for exchange, generation and storage of electricity and heat. Infrastructure may also include grids and technologies for water, sewage, waste, mobility and ICT.

2) The area has a defined physical boundary to external grids (electricity and heat, and if included, water, sewage, waste, mobility and ICT). However, the system boundary for analysis of energy facilities serving the neighbourhood is not necessarily the same as the geographical area.

2. Pilot Projects of the ZEN Centre

The eight pilot projects[1] within the ZEN Centre have different characteristics with regard to their size, measures planned, and their development status.

The following table gives a short overview of the projects and their main characteristics. The eight pilot projects will be described with regard to their measures, status, challenges and risks, the stakeholders involved, and the characteristics of the locality.

	City population (1.1.2017)	Project owner	Area size in m^2	Planned/Existing function	Construction	Status/Phase
Elverum - Ydalir	14 877	Public (Municipality)	430 000	Residential area with a school and kindergarten (planned)	New construction: 1 000 dwellings (ca. 100 000 m^2), a school and a kindergarten	Implementation
Oslo - Furuset	666 759	Public (Municipality)	870 000	Multifunctional local centre with 1 400 dwellings and 3 800 inhabitants, 213 100 m^2 (existing)	Retro-fitting/upgrading and new construction: 1 700 – 2 300 dwellings and 2 000 – 3 400 work places (up to 160000 m^2)	Implementation and Operation
Bergen - ZVB	278 556	Private (Developer)	378 000	Residential area with a kindergarten and additional services (planned)	New construction, 720 dwellings (92 000 m^2), a kindergarten and additional service functions	Planning
Trondheim – NTNU Campus	190 464	Public (NTNU/ Municipality)	339 031	University Campus (existing)	Retro-fitting and new construction (ca. 136 000 m^2)	Planning and Operation
Trondheim -Sluppen	190 464	Public / Private	275 000	Multifunctional local centre with a mobility hub (planned)	Retro-fitting and new construction	Planning and Operation
Steinkjer – Former NRK site	12 744	Public (Municipality)	11 113	Kindergarten and dwellings (planned)	Re-use and new construction of 10-12 dwellings	Planning
Evenstad - Campus	2 530 (Municipality)	Public (University)	61 000	University campus (existing)	Building stock in use: 10 000 m^2, no further construction planned	Operation
Bodø – New City – New Airport	51 002	Public (Municipality)	3 400 000	Multifunctional city centre extension with residential and business areas (planned)	Re-use and new construction: 2 800 dwellings in the first construction stage	Planning

Figure 2. Eight pilot projects at a glance

[1] During 2018, an additional pilot area was added to the ZEN Centre; including two pilot projects at Fornebu, Bærum. These projects have not been included in the report.

Ydalir in Elverum, Hedmark

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

Location: The size of the area is approx. 430 000 m^2, and it is located 1.5 km to the northeast of the town center. It is currently in use as a gravel depot, and this activity will continue in some areas until 2019, when all the buildings connected to the depot will be demolished. Surrounding the site are existing residential areas, small commercial sites and park areas – including a ski jump.
The main **stakeholder** is the project owner Elverum land development agency [Elverum Tomteselskap], a semi-public organization that aims to enable population growth in Elverum by developing land for housing and businesses at a reasonable price. 80% of the land in Ydalir is owned by this development agency. Two private landowners count for the remaining 20% of the area. Other stakeholders involved are Elverum municipality, seven local private developers, consultant agencies, the transportation agency Hedmark Trafikk, the energy utility company Eidsiva that will deliver district heating and grid connection, and the waste management company SØIR IKS.
The **goal** of the project is to plan and develop a major neighbourhood development in a new way and to reduce the mobile and stationary energy demand and greenhouse gas emissions. Ydalir is also regarded as an environmental forerunner project for the city of Elverum.
Project goals will be achieved through the implementation of **measures** associated with five thematic areas:

- A planning and design process that transfers the methodology of "Integrated (Energy) Design" from building to neighbourhood level (Asplan Viak, Elverum Vekst, 2016). The masterplan for Ydalir is developed in cooperation with the involved stakeholders.
- Minimizing the demand for energy within the building stock and basing energy production on local sources (such as solar, groundwater, biofuels, district heating). Energy storage in batteries or within the bedrock is a possibility (not yet decided).
- The building materials should have a long lifespan, include recirculated materials, and have a low carbon footprint. The preferred building materials are locally sourced wood or recycled materials. In general, the amount of building materials should be reduced and optimized.
- The traffic infrastructure should enable and encourage residents to use public transport or individual transport by foot or bicycle. Investment in good public transport with four bus departures per hour, good walking and cycling paths, and a restricted car policy, with communal parking spaces some distance from the houses, making transport alternatives with low emissions more attractive.
- The planning of a public space which supports an emission-friendly lifestyle.

Status: Between autumn 2016 and autumn 2017 a masterplan for the neighbourhood was developed in cooperation between the project owner and the other involved stakeholders (see above). Five workshops over the period of six months were dedicated to different aspects of the project

development. These included topics such as aims and vision, energy, building and infrastructure, user and quality aspects, and transportation. These were concluded with a summarizing workshop in April 2017. The first construction in the area - the school – is planned with BREAAM Very Good standard. The construction of the school in a central position of Ydalir started at the beginning of 2018 and will be completed in 2019, with the first pupils starting school in autumn 2019. After signing an intention agreement for the development of the area in 2016, the contractual negotiations between the landowners and several private developers started in spring 2017. The construction of the first residential buildings is planned to start in 2019.

Based on eight qualitative interviews with Elverum municipality, the local energy utility company and private developer, 6 major **challenges and risks** have been identified in the planning process so far:

1. Setting of appropriate system boundaries: The combined heat and power (CHP) unit is planned to be installed in the district heating plant a few kilometers away from the area, due to practical and economic reasons.
2. Planning of an energy system based on several energy sources (solar, ground heat, district heating based on biofuels) which are combined in an appropriate way without being too complicated.
3. A predictable sequence of construction and timeframe. The timing of the development of the construction sites in the coming 10-15 years is important as the ongoing construction could influence the attractiveness of the neighbourhood.
4. Demand for housing and political commitment (Risk): The size of the Ydalir project covers the estimated demand for housing in Elverum for the coming 10-15 years. The recent designation of another building zone in the eastern part of the city could jeopardize the implementation of the project within the contemplated timeframe.
5. Continuation in process management (Risk): The land development agency in Elverum is the project owner, and normally their responsibility ends when selling the plots. The further management of the process has not yet been designated.
6. Disagreement among the private landowners could jeopardize the project goals (Risk).

Figure 3. Planned construction in Ydalir. Illustration: tegn_3

Figure 4. Public space in Ydalir. Illustration: Plan 1

2.1 Furuset in Oslo

The Furuset project aims to combine the physical upgrading of the neighbourhood centre of Furuset from the 1970's with high environmental ambitions. The renewal includes the infrastructure taking into consideration energy, waste and water, traffic, green landscaping and social issues, the extension of the number of residential units and work places, and the development of an attractive urban space. The exact number of the planned 1 700 – 2 300 housing units and 2 000 – 3 400 work places depends on the realization of a lid covering the E6 highway, which was controversial when discussed during the planning phase, and a final decision has not yet been made.

Location: Furuset is a multi-functional local neighbourhood centre in the eastern part of Oslo. The refurbishment area incorporates about 3 800 residential units (90% are in apartment blocks) and 1 500 workplaces. Furuset has good transport connections including two metro stations, four bus lines, and a close proximity to the E6 highway. The local centre offers a broad range of shopping and service facilities. An ice stadium, a school, a library, and a kindergarten complement the social infrastructure in the neighbourhood.

The main **stakeholders** involved are the municipality with several departments, the administration of the city district Alna, and the FutureBuilt Programme. The planning department was the leading actor during the planning phase. The Department of Climate in Oslo municipality [Klimaetaten] took the leadership in 2016. Several consultant agencies participated in different stages of the process. Other stakeholders involved are 12 housing cooperatives, private landowners, the transportation agency Ruter, and the energy utility company Hafslund. Furuset lies within Hafslund's (now Fortum) concession area for district heating.

The overall **goal** – to develop a climate-friendly and attractive neighbourhood - incorporates several sub-goals such as the creation of attractive urban spaces, strengthening of the green infrastructure with blue-green connections, a broad and varied supply of residential units, and a well-functioning traffic hub. These goals are facilitated by the area regulation adopted in 2016 (Oslo Kommune, 2014a). In addition, the development of a micro energy system aims to establish a local energy system with zero greenhouse gas emissions.

In addition to the area regulation, a separate action plan describes the planned **measures** (Oslo Kommune, 2014b):

- Investment in social infrastructure with the construction of the Verdensparken skole (World Park School) and the nursing home Furuset Hagelandsby.
- Creation of a mobility centre and attractive urban spaces in a central location at Trygve Lie's place.
- Development of a micro energy system: The establishment of a common hydronic energy system which utilizes – among other things – the surplus heat of the local ice stadium. This system will guarantee an environmentally friendly, economically feasible and flexible system that will gradually be extended during the forth-coming years.
- Climate friendly construction of buildings: Energy consumption in buildings should be reduced and optimized by applying a predefined greenhouse gas (GHG) accounting method in the

planning and utility phase. The municipality has this focus when developing public-owned estates such as schools and nursing homes.

Status: The planning for the re-development started already in 2007, when Furuset became part of the "Groruddalssatsingen" (until 2013). This initiative combines local (city) and national (state) interests that focus on urban improvements on a neighbourhood level in Oslo. A broad and cross-cutting participation process hosted by Oslo municipality's planning department started in 2009. This process included citizens and ensured that the ideas and resident needs in this multi-cultural neighbourhood were integrated into plans for the future. The Oslo City Council adopted the area regulation plan in November 2016 as well as the action plan, and the implementation phase could thereby start.
During preceding years, relevant projects were implemented, such as the re-design of a green area known as the "Verdensparken" and the construction of an apartment building in Ulsholtveien 31 to the passive house standard. This building combines energy supply from a heat pump, solar heating, grey water recycling, and photovoltaics.

It is also essential that Furuset is a lighthouse project within the FutureBuilt Programme. The FutureBuilt programme is a public partnership among different stakeholders in the Oslo area that runs between 2010 and 2020. The aim is to cut emissions in the 50 participating projects by 50% compared to current standards. The Futurebuilt programme has functioned as a bridge builder between the different stakeholders and carried some of the coordination of the Furuset development.

Based on findings from the PI-SEC project (Nielsen et al., 2016) and three additional qualitative interviews with Oslo municipality, six major **challenges and risks** in the planning process have so far been identified:

1. Evaluation and consideration of alternative energy system solutions: The design and planning process of the local energy system is dominated by a few stakeholders, and therefore a limited number of alternatives is considered. This is linked to the concession as well as the high public stakeholder presence and lack of incentives to include more energy stakeholders. Furthermore, the in-house municipal capacity on energy in urban planning is unexplored.
2. Conflict related to the plan for a 'highway lid' over E6: This structural measure would make the area more attractive, quieter, and add more space for buildings. It is desired by the municipality and the residents. Due to financial considerations, the National Road Administration has so far rejected this measure.
3. Pressure to speed-up construction activities: There is a mismatch between the urgent need for more housing in Oslo and the perceived slow process from planning to implementation in Furuset.
4. Knowledge transfer: The planning and design of the neighbourhood, and in particular the micro energy system, need a fast and current knowledge transfer. There is a particular need for knowledge within the field of legal/juridical questions and the application of an integrated planning approach that connects the different technological solutions.
5. Acceptance of physical measures among the residents (Risk): The construction phase, providing a connection between two central roads (as part of the re-modelling of the transportation system) was delayed due to protests from residents. This emphasizes the importance of communication

and the involvement of residents during both the planning and implementation phases. (Challenge/risk)

6. Low interest from private stakeholders (Risk): Due to the relatively low real-estate prices in the neighbourhood, the interest of private stakeholders in the construction of residential and commercial buildings is limited. This can jeopardize the estimated construction scope and the time frame. The development of the sites owned by private landowners is crucial for the establishment of a comprehensive energy system.

Figure 5. Planned construction in Furuset. Illustration: a-lab

Figure 6. Planned central street in Furuset. Illustration: Planning Department Oslo Municipality

2.2 New City - New Airport in Bodø, Nordland

Bodø's former civil and military airport is planned to be replaced by a smaller civil airport, located 900m southwest of the existing one. The transformation area is approx. 5 600 000 m^2 and is located in close proximity to the city center. An area of 2 200 000 m^2 will be used for the civil airport development. The remaining 3 400 000 m^2 – the same size as the current city center - is dedicated to expanding the existing city center and will include residential and business areas, as well as a logistic hub (flight, railway, shipping) close to the airport. The planned multifunctional urban area will be developed within the next 60 to 80 years.

Location: The site is located south of the city center, within walking distance to the center. The area lies on a peninsula and is surrounded on three sides by water. A residential area with detached houses to the north forms a small belt between the old airport and the city center. A commercial area with a shopping center connects to the residential area to the east. A green zone with a camping ground and a low-density residential area borders the site to the north-east.

The **stakeholders** involved are the project group from Bodø municipality, with a project manager and members from different departments (e.g. city planning and environment). The defense department, for the military airport and AVINOR for the public airport, are both represented. The National Road Authority, responsible for the interregional street system, is also involved in the early planning stages. Bodø municipality established several platforms for consultation of stakeholders and especially citizens, as e.g. a city lab, the Bodø ByLab.

The **goal** of the 'New City – New Airport' project is to develop a dense, mixed-used urban neighbourhood, which is environmental friendly and citizen-centered. The environmental goals are to minimize the neighbourhood energy demand and greenhouse gas emissions. Buildings are planned built according to the ZEB standard. The neighbourhood development is expected to function as a catalyst for the business sector in Bodø, which is mainly characterized by the construction and consultant sectors, the IT sector, and an export sector based on agricultural products and food. The municipality has imbedded the project in a broader vision, which is to become the world's smartest city (Bodø Kommune, 2015). 'New City – New airport' is planned as a citizen-centered development with a strong focus on citizen participation in the planning process.

The goals are planned met using **the following measures**:

- Development of a design and planning toolbox to integrate energy and emission aspects into the planning process and the evaluation of different option based on scenarios.
- Integration of citizens in the planning process, e.g. through the living lab methodology: The application of co-creation processes in collaboration with citizens, the research and the business sector.
- Knowledge transfer by building up national and international networks with business and research partners as well as other cities and through participation in several research projects.
- Development of knowledge and gaining experience by designing and constructing two public schools according to ZEB-standard in the near future.
- Creating a local network of partners.

Status: The planning for 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 regarding the adequacy of re-use options along with a mixed-used city expansion

and a focus on transport hub development. Parallel to that, the planning for the new civil airport was conducted by Avinor in close cooperation with the local and regional municipalities and the government. 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 for the second part of the 2020's. The civic airport will be in use until 2024, the preceding years will be dedicated to the design and planning process. The public planning process for the area is expected to be completed in 2022.

Based on three qualitative interviews with stakeholders within Bodø Municipality and the local energy utility company, ten major **challenges and risks** have been identified in the planning process so far:

1. Steering of the project development: Most of the former airport area is owned by the military and will be sold in the near future. The interview partners see the establishment of a real estate corporation [eiendomselskap] as the project developer as a priority. The ownership - and thereby influence and steering opportunities – is seen as an important factor if the local authorities are to realize the goals to establish a ZEN.
2. Setting appropriate system boundaries with regard to the scope of activities that are included in the calculations and evaluation by ZEN. The greenhouse gas emissions generated by the use of data, business and industrial activities within the neighbourhood are of particular interest.
3. Data synchronization for scenario-based planning: The planning authorities need an evaluation tool for planning alternatives with regard to e.g. energy, emissions, and transport. Most of the data required for the calculations already exists in the municipality, but due to the existence of different data systems in the several departments, the alignment between them is time- and cost-intensive.
4. Coherent development of the area: The re-location of the airport to the southern part of the site will create a medium-term brownfield between the new airport and the city center. The challenge is to develop the whole site – the airport, the city, and the brownfield - at the same time and create functional connectivity between them despite the long timeframe for the development (60 to 80 years). The brownfield's geographical location and the development sequence are important factors for a successful development.
5. Re-use of existing buildings and infrastructure vs. demolition: The former unique use of the buildings and infrastructure for military and airport poses challenges with regard to re-use with other functions. Little is currently known about the alternatives for re-use vs. the demolition of buildings and infrastructure with regard to emission assessment and user demands.
6. Flexibility for adaptation: A challenge is to create a planning framework that sets high environmental standards and is simultaneously capable of adapting to new circumstances (e.g. technology, population and business sector growth and digitalization) over the long development period. The allocation of the technical infrastructure at an early stage of the site development and the construction phase of the new civil airport could be barriers to later adaptation.
7. Commitment to the project and its ambitions: To develop a neighbourhood with ambitions higher than existing laws and regulations requires political commitment and resolve among the involved partners to follow these ambitions.

8. Organization and cooperation: The uniqueness of the project and its ambitions need an integrated and interdisciplinary approach, which requires new forms of process organization as well as cooperation and communication between the stakeholders.
9. Time pressure (Risk): The civil airport's recently renewed taxiway has an estimated lifespan until 2024, when the new airport is planned to be completed. The construction of the new airport has to start already in 2019 to be in line with the schedule. This short timeframe places pressure on the planning and design process for this part of the area.
10. Uncertainty about deposits on the site and environment-friendly cleaning and decontamination methods (Risk): Military use has had an impact on the site, but little is known about the condition. Contamination could be a challenge with regard to costs and the tight time schedule. The adaption of environment-friendly cleaning and decontamination methods with low greenhouse emissions is desired by the municipality.

Figure 7. Aerial view of the planned development. Illustration: Bodø Municipality

2.3 Knowledge Axis with NTNU Campus Project in Trondheim, Trøndelag

The Knowledge Axis is a north-south bound route in Trondheim that includes a high concentration of knowledge-intensive institutions involved in research, education, business and public sectors. NTNU is one of the primary actors along the axis, and the re-location of the social sciences campus currently found at Dragvoll to the Gløshaugen Campus will strengthen this position. The relocation encompasses a spatial demand of 136 000 m^2 of floor area and, after the completion in 2025, 17 000 additional users. In total, more than 36 300 students and 7 550 employees will use the campus on a regular basis.

Location: The Knowledge Axis is a north-south bound route that passes through the city center, the harbor in the north, and the area surrounding the main radial highway Elgesetergate to the south. The NTNU Gløshaugen Campus is centrally located within the Knowledge Axis, see figure 8. The ZEN pilot project Sluppen is located south of the NTNU campus. A residential area lies to the east of the campus, and to the west lies a multi-functional neighbourhood that includes the St. Olav Hospital. About 10 000 people live within the campus area (NTNU, 2016). NTNU holds concessions for heating and electricity on the Gløshaugen Campus.

The two main **stakeholders** are Trondheim municipality and the project owner NTNU, which have established a project organization for the campus development that is part of the NTNU administration. Other stakeholders are the Trøndelag regional municipality and the Norwegian Directorate of Public Construction and Property [Statsbygg]. A smaller part of the Campus, Elgesetergate 10, is owned by Statsbygg and will in the near future be developed as a new education and service center. The student organization SiT is an important actor with regard to student involvement and on-campus service supply for students.

The main **goal** of the campus consolidation project is to develop a campus, which provides the best environment for excellent research, education, dissemination and innovation (NTNU, 2011). The vision report for NTNU (2014:88) describes the option to expand the vision of zero energy building "to a campus perspective, which means that all activity on and adjacent to the campus will be at a net zero energy level in 2060".

The main **measure** to meet the goals is the application of a detailed project plan and relevant quality principles (NTNU, 2016):

- Development of a vision, quality principles, and the identification of the appropriate construction area; Phase 1 "Vision" (2016)
- Development of a master plan, design concepts, and the detailed planning of the units and the academic communities; Phase 2 "Definition" (2017)
- Development of a program for space use and functionalities, for the design and for the construction; Phase 3 "Design" (2018-2020)
- Development of quality assuring solutions, rules for use and the localization of users; Phase 4 "Construction" (2021-2025)
- Evaluation and adaptation; Phase 5 "Use" (from 2025)
- Application of six quality principles to ensure that the new campus has the required quality characteristics. The principles are unifying, urban, network of hubs, effective, sustainable and living laboratory. These principles shall be applied to all phases of the project development.

Status: After the development of vision and quality principles, the Elgeseter district west of the campus was selected as a possible location for the consolidation in 2016 (Phase 1). 2017 was dedicated to the definition phase, which contains masterplan development, concepts for design, and the detailed planning for the localization of the units and the academic communities. Three alternative concepts for construction west of the Gløshaugen Campus were presented in August 2017 and constituted the basis for further discussion. 2018 and 2019 are dedicated to the design phase and the planning and construction of the first building at Elgesetergate 10 and the ZEB-office building "Flexible lab". The main construction phase is expected to start in 2020, with an estimated start for the operation phase of the first buildings in 2025.

Based on seven qualitative interviews with different departments at NTNU and Trondheim Municipality, six **challenges and risks** have been identified in the planning process so far:

1. Anchoring of ambitions: The goals in relation to the campus project are described in several leading documents (Trondheim Kommune, 2012, Trondheim Kommune, NTNU, 2014, NTNU, 2014), but the scale of the project, the time pressure, and conflicting goals are perceived as obstacles to the high ambitions. In addition, the two main partners, NTNU and Trondheim Municipality, are huge organizations where responsibilities are distributed among several departments and employees. This can result in a lack of ownership and accountability when following the ambitions related to the establishment of a ZEN.
2. Competence for an integrated approach: The broad level of professional and organizational challenges to establish a ZEN sets high requirements for the steering of the project development with regard to interdisciplinary teamwork and the application of an integrated approach.
3. Appropriate involvement of available knowledge: The involved partners distribute the knowledge to develop a ZEN, but due to the size of the involved partner organizations, it is difficult to integrate it properly in the development.
4. Involvement of citizens: The project owner NTNU naturally focuses on the involvement of their own users - students and employees. The involvement of citizens and especially the closest neighbours, is not so obvious. There is already a resistance from neighbours and from the politicians against the planned construction. Other important groups who need to be involved are the business sector and landowners, especially those located close to the campus.
5. Conflict of goals: Some interview partners describe the possibility that the goal to develop a campus that provides the best environment for research, education, dissemination and innovation should be prioritized before the goal to develop a ZEN.
6. Several landowners (Risk): Several landowners have stakes in the campus area and the possible construction area in the Elgeseter district. Disagreement among landowners could jeopardize project development. An open question from the project owner is to identify the appropriate owners for the buildings with regard to the management of the energy system.
7. Financing (Risk): The financing of the project is not yet guaranteed and is among other things dependent on the sale of the Dragvoll Campus. If this area is regulated for another purpose, such as housing, a higher market price could be realized.

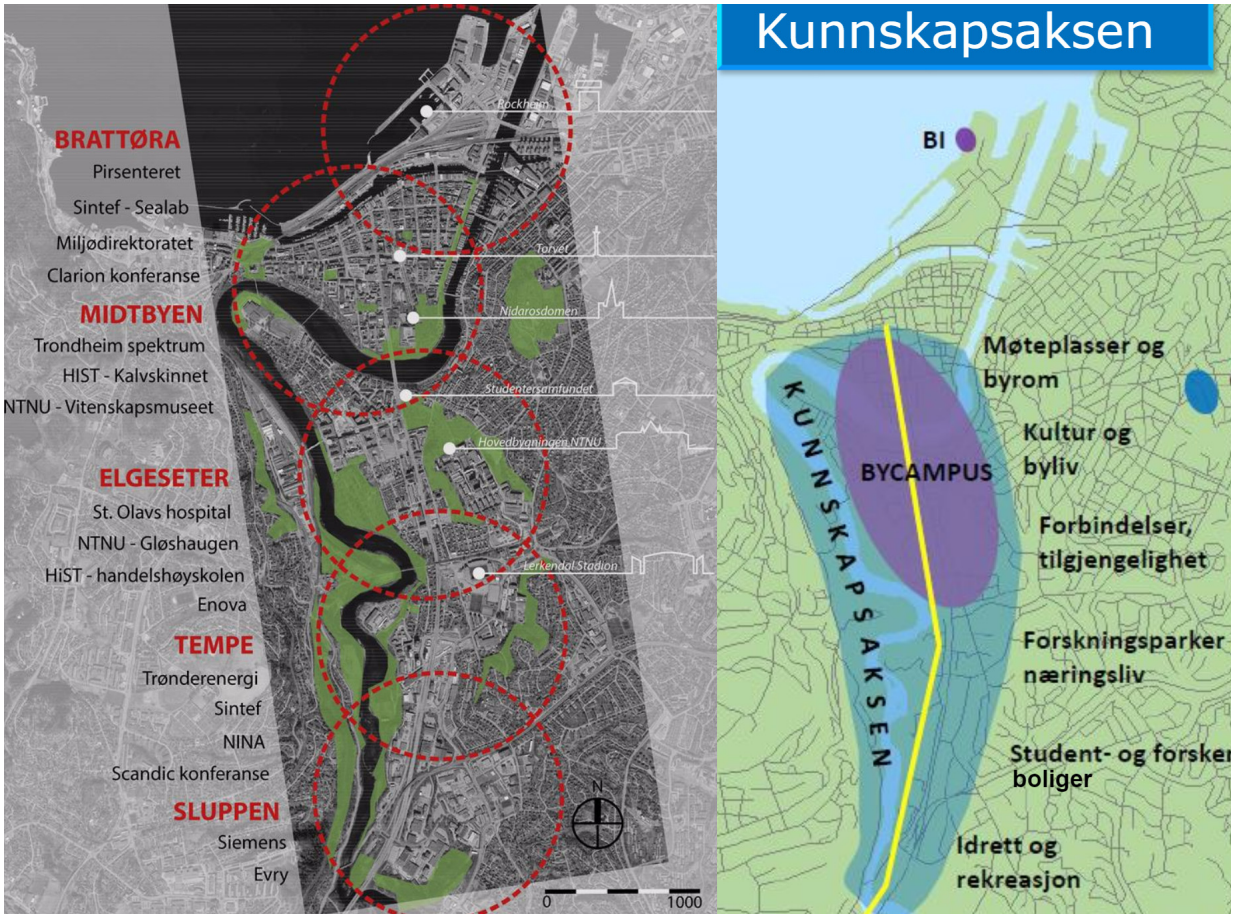

Figure 8. Knowledge Axis with its prominent institutions and functions. Illustration: Trondheim Municipality

Figure 9. Illustration for construction west of the campus. Illustration: Koht Architects

2.4 Knowledge Axis with Sluppen in Trondheim, Trøndelag

Sluppen is a mainly commercial area that is planned to be transformed into a multi-functional neighbourhood with a mobility in its center. The actual planning includes offices and residential buildings, a mobility hub, and social infrastructure such as a school, and residential buildings. Trondheim municipality is planning the renovation and building of two schools, a multifunctional hall and a new health care building on site.

Location: Sluppen is located 3.5 km from the city centre on the southern edge of the knowledge axis in Trondheim. The Knowledge Axis is a north-south bound stretch in Trondheim with a high concentration of knowledge-intensive institutions in research, education, business and public sector. Today, office buildings, logistics and storage companies with a low density characterize the area. Surrounded by industrial and commercial uses to the north, a residential area to the east, the area borders on green space and the river Nidelven to the west and south.

Stakeholders involved are Trondheim municipality with the planning and real estate department. The main private landowner is R. Kjeldsberg AS which owns nearly half of the area with 130 00 m^2. Other private landowners are Statsbygg, Trondos, KLP Eiendom og Norske Shell. Other stakeholders involved are the National Road Administration, Sør-Trøndelag County, Miljøpakken and Siemens. Trondheim municipality hosts the Forum Sluppen, a cooperation platform between the main stakeholders in the area, funded by the Ministry of Local Development and Modernization.

The **goal** is to transform the area into a new attractive and distinctive city district, with good living conditions for its users. Sluppen shall be developed as a climate-neutral neighbourhood with innovative solutions for the mobility sector.

The goal is planned to be met by the following **measures**:

- Transformation into a multifunctional local center with high density
- A mobility hub located central in the neighbourhood, an effective street system, and prioritization of sustainable mobility solutions
- Minimization of negative environmental impacts with e.g. a lid over the highway E6
- Creation of good living conditions by creating an urban character, accessibility, a blue green infrastructure and the active use of landmarks to strengthen a local identity.

Status: The municipality has started with the development of a planning strategy, which is planned to be completed in autumn 2018 and followed by a municipal sub-plan for the area. The planning for the re-development and building of the Nidarvoll and Sunnland schools, the multifunctional hall, and the health care building are planned to start in autumn 2018, and the school is to be opened in 2022. The private developer Kjeldsberg has already developed two office buildings with higher environmental standards than the actual building requirements in the neighbourhood. A third office building is under development.

Challenges and Risks:

1. Uncertainty and lack of motivation for transformation (risk): Sluppen was dedicated as a local center in the land use element of the municipal master plan from 2013. For a transition from a

business area into a multifunctional neighbourhood with a mobility hub, additional measures are necessary but not yet formalized into binding planning documents as e.g. the National Transportation plan. As long as these measures are not adopted, several private stakeholders are not interested in change, especially as many of them are satisfied with the current situation.

2. Establishment of common goals among stakeholders (risk): A common goal for transformation of the neighbourhood among a wide range of stakeholders is necessary to implement necessary measures for transformation, especially when infrastructure measures and land use transformation are intertwined. For the planning and establishment of a new transportation system, public stakeholders such as Trondheim municipality, the county, and the national Road Authority have to coordinate their work in line with the development goals and to secure the financing of the investments. As long as the new planning regulations are not adopted, private landowners are free to build according to old regulations. Not following future development goals and requirements could jeopardize planning goals on the neighbourhood level.
3. Develop single building projects within a neighbourhood: To develop a well-functioning neighbourhood and to reach the ZEN goals, single building developments must be developed in line with goals on the neighbourhood level. Individual characteristics, such as the location of the building and its entrances on the site or accessibility are important factors to consider.
4. Involvement of stakeholders and existing users into the transformation: The challenge is to transform a business area into a multifunctional area without losing the opportunity to offer areas for existing users, especially businesses, as they are important for economic capability of the city. The involvement of existing commercial users into further planning and transformation is necessary.
5. Anchoring of ambitions: To define and set necessary requirements for ZEN in underlying planning documents, especially early planning documents such as the planning strategy and the municipal sub-plan.
6. Flexibility and timeframe: As the timeframe for development of the whole neighbourhood is long and technical standards, regulations and planning goals will change over time, flexibility in planning and design is necessary.
7. Steering of the process, continuity and resources: As the neighbourhood is developed over a long timeframe, continuity in steering and engagement of stakeholders in the process is crucial. Trondheim municipality is perceived as possible steering organization, while it is perceived as crucial that enough resources are allocated for that task.
8. Commitment for the project (risk): Without a strong commitment for the project and its goals - especially from the public and the political and administrative levels of Trondheim – the transformation goal is at risk.
9. Cooperation among stakeholders: The development goals can only be realized through good cooperation between the involved stakeholders, including both the public-private level and the public level. This includes cooperation between the several involved public institutions as well as establishing well-functioning cooperation within Trondheim municipality (among different departments). Within Trondheim municipality, much of the knowledge necessary to develop a ZEN is available. The challenge is to integrate the right persons at the right time into the planning and development processes.

Figure 10. Aerial view of Sluppen, from east. Photo: R. Kjeldsberg

Figure 11. Illustration of the planned development at Sluppen. Illustration: Rambøll AS, SAAHA AS and Agraff Architects

2.5 Zero Village Bergen, Hordaland

The Zero Village Bergen project encompasses the development of a new neighbourhood on the outskirts of Bergen. The planning consists of approximately 720 dwellings (92 000 m^2), divided between terraced houses (68% of total floor area) and apartment blocks (25%). 7% of the floor area is dedicated to non-residential purposes such as offices, shops and a kindergarten. In addition, a common parking garage using mainly wood as building material, is planned (Sartori et al., 2016).

Location: The area is located 16 km south of Bergen center in proximity to Flesland international airport and the business area of Sandsli/Kokstad with about 15 000 workplaces. The closest center is Blomsterdalen, at a distance of 750 m. A forest and a lake, as well as a residential area and a road, surround the area. The planned development area is currently in use as a greenfield with some semi-detached houses. The closest public transportation hub is the light rail, 1.5 km to the north, but there is a bus stop on the site with bus frequency approx. every 15 minutes.

The main **stakeholder** in the ZVB project is the private developer ByBo, a Bergen based company that focuses on the development of low-energy and environment-friendly buildings and neighbourhoods. Several private companies, such as Norconsult, Multiconsult and Snøhetta, and researchers from the ZEB Centre have been involved in the planning phase, as well as Bergen Municipality and the local energy utility company BKK.

The **goal** is to construct residential buildings within a neighbourhood with net zero greenhouse gas emissions during the operation phase of the buildings on an annual basis (ZEB-O Standard[2]).

The goal is planned to be met by applying the following **measures**:

- Minimize energy demand through energy efficient buildings. Application of local renewable energy systems based on building-integrated photovoltaics and possibly also solar thermal systems.
- Stepwise development of the area in combination with a gradual rise in ambitions with regard to building standards (from ZEB-O÷EQ[3] at an early stage to ZEB-COM[4] at the final stage).
- Development of a transport infrastructure based on a broad network of walking and bicycle paths, charging stations for electrical bikes, a car pool for electric cars, and an electric bus that connects the neighbourhood to the nearby train station.
- Creation of an attractive public space, which encourages an emission-friendly lifestyle: e.g. shared space, community gardens, a market place in a central position within the neighbourhood, and playgrounds.

Status: The regulation process for the area started in 2011, but due to the planned extension of the nearby Flesland airport, the plans for the ZVB needed to be adapted. New noise analyses were conducted and as a result, buildings had to be placed in a different order due to building restrictions in some parts

[2] ZEB-O: Emissions related to all operational energy "O" shall be compensated for with renewable energy generation.
[3] ZEB-O÷EQ: Emissions related to all energy use in operation "O" except energy use for equipment/appliances (EQ) shall be compensated with renewable energy generation.
[4] ZEB-COM: Emissions related to all operational energy "O" use plus embodied emissions from the materials "M" plus emissions related to the construction phase "C" shall be compensated with renewable energy generation.

of the site. The municipality is developing a zoning plan for the area of Ytrebygda with a new road infrastructure, a business area, and the ZVB residential area. Objections from the regional governor with regard to the distance between the ZVB residential area and the closest local center and the public railway system have been raised since 2010 and have not yet been resolved.

Based on a literature study of publications from the ZEB Centre and PI-SEC work (Sartori, 2016, Nielsen et al. 2016), six major **challenges and risks** have been identified in the planning process so far:

1. Time pressure: Ongoing construction around the area, such as the regional road Hjellestadvegen, requires a decision about the connection of the ZVB development area to the technical infrastructure. A later connection to the infrastructure network will result in higher project costs.
2. Uncertainty and risk: High uncertainty about the acceptance of the project by the authorities, the time pressure, and the assumed cost increases, heighten the risk for hindering project implementation. The risk is mainly carried by one private developer, and the risk of project cancellation is therefore present.
3. Limited knowledge and understanding about ZEN ambitions and embedded requirements on the executing level in the construction phase of the neighbourhood.
4. Conflict of goals (Risk): The ZVB project refers differently to goals for emission reduction and densification than those of the public actors and therefore offers room for disagreement between the involved partners.
5. Political commitment (Risk): Disagreement between the local and regional authorities about the evaluation of the project with regard to planning regulations could jeopardize the implementation of the project. The associated time lag will cause increased costs and uncertainty for the private developer.
6. Costs to develop alternative solutions (Risk): The development of alternative solutions (e.g. wood as construction material for the parking garage) is cost-intensive, and the approval of funding proposals is perceived as low. Due to the described uncertainty and risk, the ability of the private developer to bear the costs is limited.

Figure 12. View of the planned neighbourhood from the recreation area. Illustration: Snøhetta/Mir

Figure 13. Aerial view of the planned development. Illustration: Snøhetta/Mir

2.6 Lø - former NRK site in Steinkjer, Trøndelag

In Steinkjer, the ZEN pilot project is planned in the area of Lø as a development of a site with an existing office building, with the establishment of a kindergarten and 10 to 12 residential units.

Location: The site is about 11 113 m^2 and located 1.5 km south-west from the city centre. Surrounded by a school and several detached houses, the area is a typical suburban residential area. The site lies outside the concession area for district heating.

Involved Stakeholders: The project owner is Steinkjer municipality with the department of social development as the responsible unit. The plan is that the public-owned land development agency Steinkjerbygg will develop the site in cooperation with private contractors. The local energy agency NTE and a network of regional IT start-ups, the Smart Grid Cluster, are participating in the discussion about the future development of the site.

The **goal** of the project is to develop a kindergarten and a residential area that provides a good environment for the users and is accepted by them. The project has the ambition to establish a ZEN.

The goal is planned to be fulfilled by the following **measures**:

- Exchange of energy between the buildings and a common energy central with solar energy and wastewater heat as energy sources.
- Use of the regulation framework for public acquisitions as a tool to require high standards during the construction process with regard to ZEN.
- Early and open dialogue with potential project partners.

Status: The site was in use until autumn 2017 by the Norwegian broadcasting company NRK. It then became the property of Steinkjer municipality. The work with the zoning plan has recently started, and the planned kindergarten should be taken into use in the autumn 2019, at the earliest. A recently conducted preliminary analysis by the ZEN Centre showed that, with regard to the greenhouse gas emissions, the re-use of the NRK building will probably result in lower greenhouse gas emissions than a demolition and new construction (Skeie et al., 2017). Consultation with the future users of the kindergarten started in autumn 2017 to assess their demand regarding the usability of the kindergarten building and outdoor area.

Based on two qualitative interviews, eight major **challenges and risks** have been identified in the planning process so far:

1. Setting of appropriate system boundary: Besides the buildings, transport, waste management, and water usage are indicated as factors within the scope of a ZEN.
2. Conflict of goals: The main goal is to develop the site appropriate to its functions. The prospective users should perceive the appearance of the buildings and their uses as positive. This goal is prioritized in the context of concurrent environmental, economic and social goals.
3. Costs: Uncertainty about the prospect that technical solutions to achieve ZEN ambitions could make costs escalate and therefore result in a more expensive project development compared to a standard one.
4. Social sustainability: The expected higher costs could trickle down to the real estate prices and make the buildings affordable only for a smaller part of the population. On the other hand, a

social intermix in the planned area and broad acceptance of the project among citizens is important to ensure its transferability.

5. Transferability to other neighbourhoods: The challenge is the development of appropriate solutions and good results that are transferable to other neighbourhoods and positively perceived by a broad section of the population.
6. Common goals: To set common goals and create a common understanding among the involved project partners.
7. Anchoring of ambitions: To identify and set necessary requirements for ZEN in underlying planning documents for the area and within the public tendering procedure.
8. Knowledge transfer: The complexity of the pilot project and lack of experience with ZEN are seen as obstacles to develop and transfer knowledge within local institutions. The need for knowledge is foreseen particularly within the fields of technology, legal/juridical questions, and process management.

Figure 14. Aerial view of the former NRK site. Photo: Steinkjer Avisa.

Figure 15. Illustration of the planned development. Illustration: Terje Grønmo Architects

2.7 Campus Evenstad in Stor-Elvdal Municipality, Hedmark

The Department of Applied Ecology and Agriculture of the Inland Norway University of Applied Sciences (Høgskolen i Innlandet) is located at Campus Evenstad. It is located in a rural area in Stor-Elvdal municipality. The campus accounts for 61 000 m^2 of land with 17 buildings (10 000 m^2 of heated floor area) with different uses: administration, education, sport, student housing, and building operation. The construction of a new administration and education building between 2015 and 2016 with ZEB-COM standard and a heated floor area of 1 141m^2 was one of the ZEB Centre's nine pilot projects.

Location: The campus is located in a rural area in the village of Evenstad, 70 km north of the city of Elverum and 20 km south of Koppang, a regional service center. Surrounded by farmland and the river Glomma to the west, there are few other buildings in the area.

Involved stakeholders: The Campus is owned by the Norwegian state with Statsbygg as the public owner and responsible for the administration of the real estate. The Inland Norway University rents the area from Statsbygg. The student organization Studentsamskipnaden owns the two dormitory buildings on campus which are built with the passive house standard and include in total 117 residential units for students.

The **goal** is to develop a ZEN with regard to campus operation. This goal incorporates the optimization of energy production, management, and use. Campus Evenstad aims to be a regional energy hub and a demonstration plant for renewable energy - the Campus Evenstad Energy Centre (CEEC) (Statsbygg, 2017).

The goal will be achieved using the following **measures**:

- Development of a smart energy management system to reduce the peaks in energy consumption and thereby the load on the electricity grid. The aim is to increase the amount of self-produced and self-consumed energy.
- Optimize the interplay between different electricity (solar cells, CHP, net) and heat (CHP, solar collectors, bio-based and electric boiler) sources.
- Energy storage in batteries in a network of buildings with variable power requirements during the day, week, and year.
- Application of the living lab methodology to engage campus users in activities which minimize energy consumption and greenhouse gas emissions.

Status: The new construction of the ZEB-COM building on the campus was completed in December 2016 and handed over to Statsbygg after a six-month probationary period. The demand for heat on the campus is covered by on-site heat production through the newly established CHP plant, and about one-third of the electricity demand is covered by this.

Challenges:

1. Legislation: Another landowner owns part of the Campus. The existing regulation framework therefore limits the establishment and operation of a comprehensive energy system with just one interface to the electricity grid owner.

Figure 16. Aerial view of campus Evenstad with its main buildings. Photo: Statsbygg

Figure 17. New administration building. Illustration: Ola Roald Arkitektur

3. Conclusion

3.1 Differences between ZEN pilot projects

The pilot areas are different with respect to size, typologies, and context, and they are at different stages of development. Some of the main differences between the pilot areas include the following:

- The ZEN pilot areas comprise both new developments and existing neighbourhoods.
- The ZEN pilot areas vary in size, from a small university campus (Campus Evenstad) to a large area development ('New City – New Airport' in Bodø).
- Each ZEN pilot area is at a different stage within the ZEN phases, ranging from the strategic planning, through implementation, to operational phase, see Figure 18.
- Each ZEN pilot project has a different timeframe for development, ranging from 8 to 100 years.
- Each ZEN pilot area has different functional requirements and building typologies: residential, schools, offices, commercial, educational, etc.
- Each ZEN pilot area has different stakeholders and users.
- Each ZEN pilot area is placed at a different geographical location within the regional context of the city or region, which implies various links to the existing infrastructure, the surrounding neighbourhoods, and the city or local centers.
- Each ZEN pilot has a different thematic scope in general and with regard to the connection to the ZEN Centre, varying from focusing mostly on energy infrastructure (Evenstad and Furuset) to more holistic neighbourhood developments including e.g. new construction of buildings and technical infrastructure at Sluppen in Trondheim and 'New City – New Airport' in Bodø.

Three main factors explain the differences between the ZEN pilot projects:

1. Firstly, each of the pilot projects are situated in different local **contexts**, which is a set of conditions of a specific geographic area – in our case the area of the ZEN pilot project. These conditions can be physical, such as the local climate or the condition of the ground, or social, such as the local political and planning system, local culture, innovation regime, and existing use of the pilot area.
2. Secondly, **individual pilot project specifications** explain most of the differences. These include:
   - Thematic scope (i.e. energy system or holistic neighbourhood development)
   - Time frame
   - Size of project
   - Function[5] of the neighbourhood and building typologies (residential, commercial, recreational, etc.)

[5] The function of an area describes its reason or purpose for being. In urban areas this relates to the purpose of a land use for i.e. residential areas, recreation, industry etc.

- Ownership (private/public)
- Stakeholders involved and affected from the project development

3. Thirdly, in addition to these two aspects, the **stage of development** of the ZEN pilot projects is an important factor that influences e.g. the opportunity for innovation and cooperation between stakeholders and the anchoring of ambitions in municipal planning documents. So far, have we identified three phases within a ZEN development, see Figure 18.

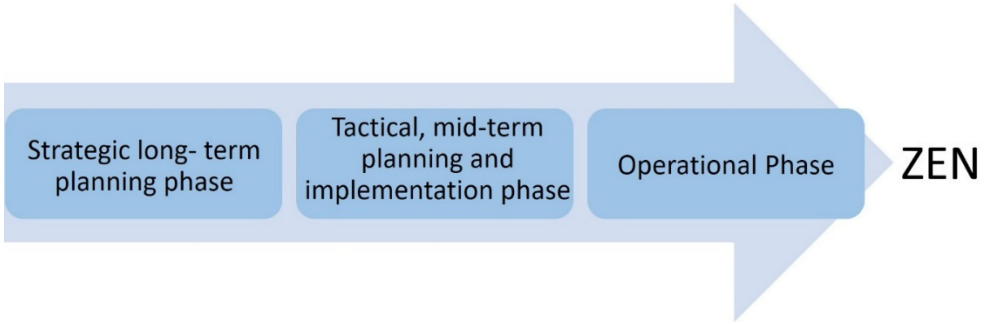

Figure 18. Phases of a ZEN development

At the beginning, the **strategic long-term planning phase** will identify the goals and ambitions for the ZEN development. In this phase, central planning documents, such as the municipal master plan with land use element [kommuneplan med arealdel] or the municipal sub-plan [kommunedelplan], are provided, and on a general level measures to fulfil the goals and ambitions are already identified.

In the **tactical, mid-term planning and implementation phase**, zoning plans [reguleringsplan] and development agreements [utbyggeravtale] are developed to specify the development goals developed in the previous phase. This phase is characterized by plenty of smaller projects – such as the development of buildings, estates, or the energy system - which can be developed simultaneously or sequenced. Planning and implementation in this phase are therefore dedicated to a more individual project level.

In the **operational phase**, the whole planned neighbourhood, or parts of it, are in use.

The interplay of these three factors explains the differences between the ZEN pilot projects which were documented in this report. Among other things, they influence the challenges perceived by the involved stakeholders.

3.2 Main Challenges in the ZEN pilots

In the series of interview in the pilot projects which were conducted during 2017, we identified a number of challenges on the development pathway to ZEN. The perceived challenges differ between the pilot projects and will most likely change during the further development of the projects. The challenges were presented in this report, but are further described and discussed in (Andresen, Baer 2018), and in (Baer, Nielsen, 2018) the latter having a focus on citizen participation.

It is important to note that in all of the pilot projects, the realization of technical solutions to develop and implement a ZEN were perceived as feasible. On the other hand, the creation of good cooperation and co-creation processes, the involvement of crucial stakeholders, and the generation of knowledge

transfer, were perceived as more challenging.

3.3 Summary

Within this report we have mapped eight pilot projects of the ZEN Centre in the year 2017, the first year of the ZEN Centre. As the report shows, each ZEN pilot project is different with regard to characteristics such as scope, status, location, goals, measures and challenges. The differences between the projects and the perceived challenges could be explained by the local context, individual pilot projects specifications, and the stage of development. However, the goal to cut climate gas emissions is unifying all the ZEN pilot projects.

Regarding their described individuality, each of the pilot projects have several specific opportunities to develop and implement solutions and innovations in order to become a ZEN. This individuality must be considered when developing solutions and innovations for ZEN. A multitude of innovations will be developed during the lifetime of the ZEN Centre. To foster collaboration within the ZEN Centre and ensure the implementation and transfer of solutions, we recommend to use this report as a starting point to familiarize with the ZEN pilot projects and their local contexts and individual project characteristics.

References

Andresen, I., 2018. Hva er et nullutslippsområde? Futurebuilt blog, [blog] 14 May. Available at: https://www.futurebuilt.no/Blogg#!/Blogg/Hva-er-et-nullutslippsomraade [Accessed 14 June 2018].

Andresen, I., Baer, D. (2017): ZEN pilot projects – plans and challenges. In: ZEN Annual Report 2017, [pdf]. Available at: https://fmezen.no/wp-content/uploads/2018/10/ZEN_annual_report_2017_Nett_og_trykk_oppdatert_LR.pdf [Accessed 15 May 2018].

Asplan Viak, Elverum Vekst, 2016. Ydalir – Det første ZEN-Prosjektet. Klimanøytral områdeutvikling. Søknad om støtte til konseptutredning – Prosjektbeskrivelse. [pdf] unpuplished.

Baer, D., Nielsen, B. (2018): Challenges and Best Practices for the planning of Zero Emission Neighborhoods and Smart Energy Communities – the case of seven Norwegian cities. 55. ISOCARP conference Bodø, Cool planning: Changing Climate and our urban future, [pdf]. Available at: https://isocarp.org/2018congress/ [Accessed 29 October 2018].

Bodø Kommune, 2015. Smart Bodø – Internt grunnlagsdokument for strategisk samfunnsplan. [online] Available at: http://einnsyn.bodo.kommune.no/eInnsyn-bodo/RegistryEntry/ShowDocumentFromDmb?registryEntryId=28492&documentId=40345 [Accessed 29 August 2017].

Mayring, P., 2000. Qualitative Content Analysis. [online] Forum Qualitative Research. Volume 1, No. 2, Art. 20. Available at: http://www.qualitative-research.net/index.php/fqs/article/view/1089/2385 [Accessed 15 January 2017].

Nielsen, B., Juhasz-Nagy, E., Wyckmans, A., Andersen, I. 2016. Planning Instruments for Smart Energy Communities. PI-SEC Report 2.1. [online] Available at: https://www.ntnu.edu/smartcities/pi-sec/publications [Accessed 3 May 2017].

NTNU, 2011: Kunnskap for en bedre verden. [online] Available at: https://www.ntnu.no/info/strategi_ntnu_bm.pdf [Accessed 16 March 2017].

NTNU, 2014: NTNU 2060. Visjoner for Campusutvikling. [online] Available at: https://www.ntnu.no/documents/36266287/38463652/NTNUvisjonsrapport.pdf/4b336a27-6ae7-4b8d-8c7a-3723d8a4216c [Accessed 16 March 2017].

NTNU, 2016: Lokalisering NTNU Campus Trondheim. NTNUs campusutvikling 2016-2025. Høringsversjon 8.Juli 2016. [online] Available at: https://www.ntnu.no/documents/1268425101/1269933790/NTNU+Lokalisering+NTNU+campus+Trondheim_utskriftsversjon.pdf/f175f92d-e72b-4642-a885-75aabaf28944 [Accessed 16 March 2017].

Oslo Kommune, 2014a. Områderegulering for klimaeffektiv byutvikling på Furuset. Planbeskrivelse. [online] Available at: https://www.futurebuilt.no/Forbildeprosjekter#!/Forbildeprosjekter/Furuset [Accessed 4 April 2017].

Oslo Kommune, 2014b. Handlingsplan Forbildeområde Furuset. Utkast desember 2014. [online] Available at: https://www.futurebuilt.no/Forbildeprosjekter#!/Forbildeprosjekter/Furuset [Accessed 4 April 2017].

Sartori, I., Merlet, S., Haug, T., Andresen, I., 2016: Zero Village Bergen. Aggregated Loads and PV generation profiles. ZEB project report 28. [online] Available at: https://www.zeb.no/index.php/no/news-and-events/257-zeb-project-report-zero-village-bergen-aggregated-loads-and-pv-generation-profiles [Accessed 16 March 2017].

Skeie, K., Skaar, C., Andresen, I. (2017). Energi og miljø vurdering av nybygg kontra riving i et ZEN livsløpsperspektiv. Internal ZEN memo. Unpublished.

Statsbygg, 2017. Campus Evenstad – Jakten på et nullutslippsbygg (ZEB-COM). [online] Available at: https://www.statsbygg.no/files/publikasjoner/rapporter/fou/CampusEvenstad-nullutslippsbygg.pdf [Accessed 27 March 2017].

Trondheim Kommune, 2012. Den kompakte Kunnskapsbyen. Byintegrert Campusutvikling i Trondheim. Rapport fra Dialogforum for helhetlig campus- og byutvikling i Trondheim. Mai 2012. [online] Available at: https://www.trondheim.kommune.no/globalassets/10-bilder-og-filer/07-kultur-og-naring/felles-kultur-og-naring/den-kompakte-kunnskapsbyen.pdf [Accessed 22 March 2017].

Trondheim Kommune, NTNU, 2014. Inspirerende & innovativ - felles masterplan for Trondheims bycampus. [online] Available at: https://www.trondheim.kommune.no/globalassets/10-bilder-og-filer/07-kultur-og-naring/felles-kultur-og-naring/inspirerende-og-innovativ---felles-masterplan-januar-2014.pdf [Accessed 22 March 2017].

VISION:

«Sustainable neighbourhoods with zero greenhouse gas emissions»

Research Centre on
ZERO EMISSION
NEIGHBOURHOODS
IN SMART CITIES

CENTRE FOR ENVIRONMENT-FRIENDLY ENERGY RESEARCH
The Research Council of Norway

NTNU

SINTEF

https://fmezen.no