Energy Master Planning on neighbourhood level: learnings on stakeholders and constraints from the Norwegian case of Ydalir

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Abstract. While energy planning on the building level is characterized by a limited number of stakeholders and a clear ambition setting, this situation changes when expanding to a neighbourhood level. Depending on the context of the neighbourhood, energy planning is challenged to align several stakeholders and define common ambitions and measures suitable to optimize the outcome of energy planning. In Norway, energy planning on neighbourhood level is a relatively new approach. We apply the Energy Master Planning (EMP) concept developed during the IEA EBC Annex 73 to describe the planning process within the Norwegian case study of Ydalir, which ambition is to become zero-emission. Through a qualitative research approach, we identify stakeholders involved, their role and impact, and indicate constraints on EMP implementation so far. We show how the concept of EMP must be further developed, to reply to evidence-based constraints in implementing and reaching for high ambitions in cutting down energy use and emission. This paper relates to the UN development goal 11 of Smart Cities and Communities.

1. Introduction

Reaching for the climate gas reduction goals of the Paris Agreement, stakeholders on all geographical and organizational levels from nations, regions, cities and communities are challenged. At the national level, the Energy Efficiency Directive has triggered numerous positive developments in the European Union member states by setting targets to incentivise and enable investment in energy efficiency programmes across all sectors. However, member states have yet to fully implement the directive, and additional support in building capacity and know-how is needed. A multitude of incentives and regulations are introduced on a national and regional level to foster the clean energy transition. The city and especially the neighbourhood level - are pointed out as one of the main important areas for change. This is due to the fact that cities consume ca. 80 % of the total energy and are accountable for ca. 75 % of global GHG emissions [1].

Urban planning aims to improve coherence in public action by transcending spatial sectoral boundaries [2]. Therefore, energy planning issues and experts has begun to enter typical urban planning areas since the 1990s, thereby challenge urban planners to integrate this new aspect into a holistic form of urban planning. Energy planning in general is defined as the process of finding solutions to the best mix of energy demand and supply in a given area [3]. Challenges in urban energy planning lies in its multi scales aspect (temporal and geographical), but also in the necessity to take into account the quantitative (economic, technical) but also qualitative environmental impact [4].

At an urban level, sustainable goals for energy and climate are written down in different political documents, all aiming for to fulfill the UN's sustainability goals by 2050. In Norway, municipalities and cities are obliged to develop local climate and energy plans to define their goals and ambitions through

by the national government [5]. Additionally, municipal implementation plans define the realization of these goals through diverse measures, mainly focusing on sectoral approaches as mobility or the building sector.

While municipal goals are set on regional and urban scales through climate and energy plans, goals for buildings and blocks of buildings are set by their individual owner. Setting energy and emission goals at the intermediate level between city and buildings is a new approach in Norway, and actually mainly developed through the research centre for Zero Emission Neighbourhoods in Smart Cities (ZEN), which is a frontrunner in developing this new research perspective in Norway. A Zero emission neighbourhood aims at reducing its direct and indirect green house gas emissions towards zero over its lifespan. At the time writing, a neighbourhood is defined within the ZEN centre as a group of interconnected buildings with associated infrastructure, located within a confined geographical area [6]. From a governance perspective, the neighbourhood level offers the appropriate arena for collaboration between different sectors and stakeholders in order to enable a holistic and inter-sectoral approach to energy planning as an integrative part of sustainable urban development [7].

1.1. Energy Master Planning (EMP) on neighbourhood level

The concept of energy master planning provides a roadmap for planning, designing, implementing and monitoring for an efficient, practical, cost effective and robust energy infrastructure system. EMP can be applied on different geographical levels as well as carried out in a hierarchic “top down” or in a “bottom up” process [7].

There are three main steps of EMP; (1) Setting of goals for energy performance, (2) Tactical mid-term planning phase consisting of the assessment of possible energy solutions, scenario analysis, the development of a comprehensive plan based on the analysis results and implementation, and (3) The operational phase, incorporating the measurement of goal achievement and verification [8; 12].

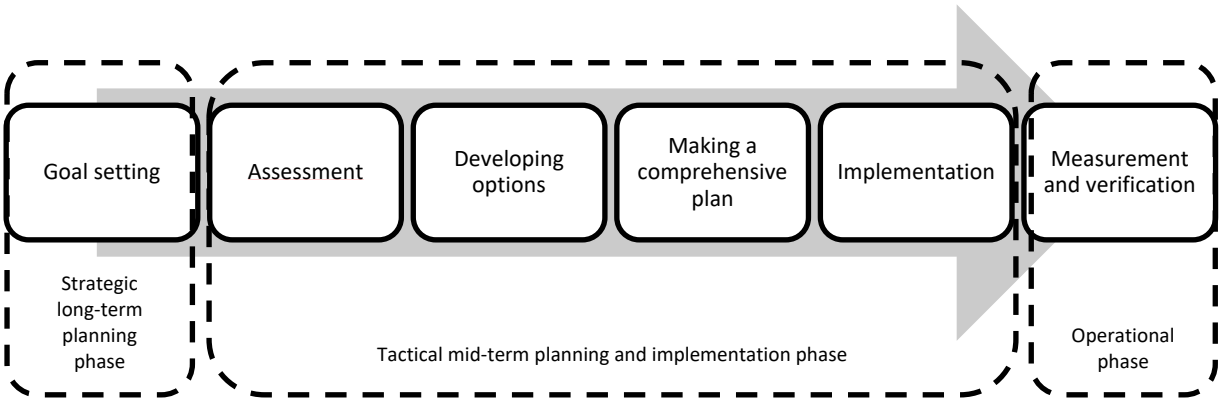

Figure 1. Different stages in Energy Master Planning (EMP)

1.2. Constraints of applying EMP and the role of stakeholders

However, when applying EMP on the neighbourhood level, it is crucial to understand the various constraints, formed by the stakeholders involved, in order to identify fields of action to improve processes for successful EMP implementation from planning to operation of the neighbourhood. EMP has to follow a holistic approach, incorporating thematic areas such as emission, sustainability and resilience, and must be applied inter-sectoral combining sectors as the built environment, mobility and citizen life. Through integrative energy design within EMP, multiple benefits can be realized.

The existence of a multi-stakeholder ecosystem with different stakeholders and their individual visions and interests, does form a wicked problem constellation for zero-emission development, and thereby challenges the deployment of higher energy ambitions [8]. Stakeholders thereby play a crucial role for EMP at neighbourhood level, especially as it is stated that it is not inadequate technological

solutions that are the main barrier for reaching energy goals, but lack of collaboration and commitment from the stakeholders involved, inefficient organizational processes, and an unsupportive framework for implementation [9,10, 11]. As there are several studies on identifying technical constraints [12], the studies on governance constraints are limited and challenged by the specific local context of each neighbourhood.

However, when looking into neighbourhood energy master planning, it is important to understand the motivation and the stakeholders, and the various constraints which frame the possibilities to implement a successful energy planning from the involved stakeholders' point of view. In order to be able to apply principles of a holistic approach to community energy planning and to provide the necessary methods and instruments to master planners, decision makers and stakeholders; it is essential to identify and frame the stakeholders and the constraints related to them that bound the options towards an optimized energy master planning solution.

2. Objectives and methodology

We describe how energy master planning is implemented on neighbourhood level and ask how the stakeholders and local context challenge the EMP process.

The case study is conducted in the neighbourhood of Ydalir in Norway, which have been committed to energy and emission ambitious plans. Ydalir is a pilot project within the ZEN centre as well. As energy planning of the neighbourhood has emerged in the last years in Norway, the case description will focus on an early phase of neighbourhood development.

This paper is based on document analysis, observation through participation in different workshops and meetings, as well as qualitative interviews with nine different local stakeholders (land development agency, municipality, landowners, housing developers and energy company) within the case of Ydalir, city of Elverum, Norway. We have chosen a qualitative research approach to take into consideration the new research field in Norway and the specific local context.

3. Results and discussion

3.1. Case description Ydalir, Elverum

The neighbourhood of Ydalir is a new development on a former sandpit, located in the mid-size town Elverum in the county Hedmark in Norway. It has a size of approx. 430 000 m^2, and it is located 1.5 km from the town center. 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 and a kindergarten, which were completed and opened in autumn 2019.

The main stakeholder is the project owner Elverum land development agency [Elverum tomteselskap] (ETS), a semi-public organization that aims to enable population growth in Elverum by developing land for housing and business at a reasonable price. At the beginning of the development in 2015, 80% of the land in Ydalir was owned by the land development agency. Since then, two plots are already sold to local housing developers. Two private landowners count for the remaining 20% of the area. Other stakeholders involved are Elverum municipality, seven local private developers which have signed intention agreements with the municipality, consultant agencies, and the local transportation agency, the local energy utility company, that will deliver district heating and grid connection, and the local waste management company.

3.2. EMP steps applied in Ydalir

So far, three phases of EMP have been implemented within the Ydalir case; goalsetting, assessment and development options and implementation. While two buildings are already completed and in use, the development of a comprehensive plan is under development. Table 1 lists and describes shortly the EMP phases implemented and their incorporated measures in a timeline from 2016 until today.

Table 1. EMP phases in Ydalir and the measures implemented

Phase of EMP	Measure of development	Timeline
Goalsetting	Masterplan development for Ydalir in a cooperative process including urban design, energy, material use, mobility, blue-green infrastructure and waste management	2016-2017
Implementation	Technical infrastructure implementation on neighbourhood level (e.g. way, sewage and district heating system)	2017- 2019
	Construction of first buildings in Ydalir: a school and kinder-garden, opened 08.2019	2018-2019
Assessment and Development Options	Analysis of potential energy system performance and scenarios for development	2019
	2 LCA analysis of emissions on neighbourhood scale	2019

Within the goalsetting phase, a masterplan for Ydalir was developed in a collaborative process facilitated by the project owner. The plan incorporates a wide range of stakeholders, as local housing developers, consultants, mobility and energy companies, Elverum municipality and researchers of the ZEN center. Five workshops over a 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. The project owner, ETS, invited deliberately a bit wide to the five workshops, in order to integrate as many stakeholders as possible in the masterplan development and create knowledge and commitment for further development. The result of this process is the masterplan, which shall ensure the realization of basic qualities within the areas of urban design, energy and material use, blue green infrastructures and waste management, while also being flexible enough to "open up the possibility to land owners and developers to provide individual solutions based on their expertise, creativity and ambition" [13].

The ambition for Ydalir is to become a ZEN, the amount of emissions through materials and energy used within the construction and operation phase of the neighbourhood shall be offset by locally produced energy [13].

With regard to energy, these general measures are identified within the masterplan to gain for the ambition:

- Buildings built after passive house standard or even better, and a high use of wood or other materials with low greenhouse gas emissions as building material,
- District heating based on bioenergy for residential buildings,
- Local electricity generation based on solar cells and bioenergy-based power/heat production.

Within the Assessment and Development Options phase, researchers from the ZEN centre conducted three studies in 2018 and 2019 to analyse future energy and emission performances.

Lund et al. (2019) applied a Lifecycle Assessment analysis (LCA) model for neighbourhood development based on a modular structure, integrating buildings, mobility, infrastructure, networks and on-site energy. The study reveals that regardless of which scenario considered, the Ydalir project does not achieve the ambitious goal of becoming a zero-emission neighbourhood, taking the existing planning status as basis for consideration [14].

A second LCA study by Yttersian et al. (2019), applying 'Område-LCA' as a tool, shows how significant the share of emissions from transportation are, contributing to more than 60 % of the total GHG emissions in Ydalir [15]. The identified impact of transportation on energy demand and emission has to be lowered through measures for cutting down transportation demand. One planned measure incorporated in the masterplan, is the reduction of parking lots on individual detached housing plots and establishing a joint parking space at a central area. However, the housing developers experienced a lack of interest from potential buyers due to limited individual parking space. Due to the influence of housing developers and landowners, the masterplan of Ydalir was reviewed and the parking regulations were watered down.

The study of Lien et al. (2019) shows that the existing planning of Ydalir will help to perform much better in terms of reducing emissions than building according to existing building regulations. Taking

into consideration buildings, infrastructure, energy demand and local energy production, the study also points out that the establishment of a local energy plant within the system boarders of Ydalir, can help achieving the zero-emission goal [16]. The local energy company is planning to establish a new Combined Heat Power Plant (CHP), but outside the neighbourhood of Ydalir. Applying the definition of the ZEN centre for a zero-emission neighbourhood, which demands the renewable energy production within the system boarder of the neighbourhood, Ydalir will not achieve the zero-emission goal. Taking into consideration the listed studies and experienced objections to the masterplan, the realization of the initial ambitious goals of the masterplan seems doubtable.

The construction of the first two buildings in Ydalir, a kindergarten and a school, is part of the implementation phase. Opened in August 2019, the school of 6.000 m^2 hosts 150 students and offers room for up to 350 students. Elverum municipality and the contractor won the national price for public procurement, as the project development process enabled good public-private collaboration from the beginning. Goals and plans for development where firstly created after a kick-off to ensure that all stakeholders started from the same point, also enabling energy issues to be incorporated from the beginning.

On the other hand, the technical and transport infrastructure for the whole neighbourhood was established parallel to the masterplan development. The ambitious concept of the neighbourhood is challenged as the infrastructure is built after prevailing concepts and standards, and thereby the opportunity to implement ideas for urban design developed under the masterplan as shared space are not implemented. This lowers the potential to exploit the full capacity of energy and emission reduction through urban design.

A comprehensive plan for future development, building on the latest conducted studies and analysis (s.a.), is not yet developed. The masterplan for Ydalir is the starting point for that plan, but needs specification and must be adopted to gain for the primarily ZEN ambition.

3.3. Stakeholders involved and constraints in EMP implementation

The description of the EMP phases applied in Ydalir, indicates already the role and impact stakeholders play in project development in general, and especially when it comes to the fulfilment of energy and emission goals. Table 2 lists the main stakeholders involved in the early phase of development in Ydalir. Each stakeholder and group of stakeholders is described shortly, and the constraints resulting from their role, stake and position within the project is listed.

Table 2. Main stakeholders involved in EMP and their particular constraints

Stake-holders	**Description**	**Constraints**
Land develop-ment Agency ETS	- Project owner - Leading planning and development process, especially masterplan development and implementation - Building infrastructure - Communication and marketing	- 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. - Missing tools to force developer to follow masterplan goals and ambitions, which are more ambitious than prevailing regulations (e.g. Planning and Building Act). - Setting of appropriate system boundaries: The CHP unit is planned to be installed in the district heating plant a few kilometres away from the area, due to practical and economic reasons. - Interest and need to develop and sell plots in Ydalir within a limited timeframe due to re-financing investments in (social) infrastructure. - Ability to facilitate a planning process for an energy system based on several energy sources (solar, ground heat, district heating based on biofuels) which are provided by different stakeholders (local energy company and developers), where sources are combined in an appropriate way without being too complicated.

Elverum municipality	- Formal planning institution - Owning and operation of Ydalir school and kindergarten - Contribution to infrastructure financing	- 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. - Limited timeframe to develop school and kindergarten due to political assignment and demand for both functions within the municipality.
Privat landowners	- Two private landowners, counting for 20% of area - One landowner is also developer and planning to develop the land self	- Diverse interests between existing landowners, with one being positive and the other critical to masterplan implementation. - Critical landowner's resistance problematic to realize holistic energy and urban design planning.
Housing developers	- Building houses in Ydalir - Diverse interests in ZEN goals, individual interests and visions	- Different visions regarding the goals of development and the implementation of the masterplan, e.g. parking space restriction in Ydalir. - Lack of knowledge to adapt new energy technologies in an appropriate way in the design of the building and the technological installation itself. - Lack of knowledge to conduct LCA of planned buildings.
Local Energy company	- Providing energy solutions as district heating - Advising developers in implementing energy solutions in buildings	- Uncertainty of planning for a local energy system with regard to housing developer's lack of commitment to ZEN.
ZEN research centre	- Providing knowledge to local stakeholders through i.e. scenario analysis of energy - Defining ZEN concept and system boarders	- Lack of indicators and guidance to identify appropriate areas for ZEN development. - ZEN definition under development during the lifetime of the centre, e.g. the system boarder restrictions are still discussed, but at the same used as guidance principles within the pilot projects.

3.4. Main barriers to energy-ambitious neighbourhood development related to stakeholders involved

There are several general factors particularly influencing the Ydalir development with regard to attaining high ambitions in cutting down energy and emissions. These factors do influence the stakeholders involved, but on the other hand, they could also be influenced by the stakeholders themselves.

Commitment to the project: The analysis has shown that commitment to the project depends on the individual stakeholders' visions and agendas. The collaborative development process of the masterplan was pointed out by the interviewees as an important step for knowledge and trust development besides the establishment of a common understanding and vision, thereby strengthening the commitment to the ambitious project goal. ETS got the co-funding for the masterplan development through Enova, the Norwegian environmental funding agency. Housing developers are indicated as crucial in this phase of development, as they have to commit to the general vision of Ydalir by developing an energy system and buildings with climate ambitions that go beyond existing regulations. The masterplan of Ydalir in its first version contained no parking lots for buildings, but the establishment of a car park. These ambitions were already lowered and parking spaces allowed, as housing developers feared lack of interest from buyers. The fear of higher development costs due to higher buildings standards is also expressed by housing developers, and could influence future commitment.

The timeline is always a factor influencing project development, but especially important as planning of the energy system and the management of the system, including reducing load on the system, is depending on the realisation of a minimum quantity of buildings and infrastructure within a limited timeframe. In this phase of development, windows of opportunities are open with regard to developing a holistic system. It is much more difficult to realise economies of scale for energy solutions if they are added step-wise to the neighbourhood system. The time of realisation of community services as the car

park is crucial for housing developers with regard to developing their own plots. Future buyers may not be interested to buy houses without own parking lots as long as the planned shared car park at a central position within Ydalir (s.a.) is not in place.

We have identified a lack of knowledge with regard to different thematic areas. On the one hand, interviewed stakeholders express that they do not have the knowledge needed to construct following higher ambitions than the prevailing building regulation TEK 17. On the other hand, there is a lack of knowledge about how to fulfil the ZEN ambition in the best manner within a collaborative holistic approach, especially with regard to the management of the process. The project owner, ETS, is managing the process of development in Ydalir in this early phase, but is normally no longer involved when infrastructure is established and the plots are sold. The long-term management of the development, including the implementation and operation phase, is not yet decided.

Last but not least, there is a lack of knowledge how to define the appropriate size and area for a ZEN development, as well as the design and location of amenities. At the early stage of neighbourhood development, tools are missing to evaluate primary plans for design of the neighbourhood that builds on LCA analysis of all sources for emissions as e.g. building materials, energy system, mobility. In the best case, these tools are used in a collaborative process including all stakeholders to define optimal development solutions and before fundamental decisions for further development are set.

Uncertainty is a factor in general for project development, but when it comes to ZEN developments, the uncertainty is particularly high. Ydalir has a stagnating population development, the risk of parallel designation of building land, and the focus on families and young agers as target group for development in Ydalir bears an uncertainty with regard to future demand for housing.

4. Conclusion

In our study on the neighbourhood of Ydalir, we have identified the involved stakeholders as well as stakeholders constraints with regard to EMP and its implementation. The type of stakeholders involved, how they communicate and how they are involved in the process, plays a crucial role. The main barriers identified have a strong impact on EMP, and are mainly influenced by the involved stakeholders themselves. 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. The realisation of this collaborative process was enabled through the initiative, and thereby commitment, of ETS. The external funding was crucial here, as financial resources for broad stakeholder engagement are often limited.

For the concept of EMP applied on the neighbourhood level with multiple stakeholders involved, we learned through the Ydalir case that there is a need to incorporate aspects of stakeholder management and engagement, process management and tools for the identification of the appropriate neighbourhood design. As there are today no tools or indicators available as well as a lacking interest from academic side to identify appropriate neighbourhood sizes, we recommend elaborating and identifying appropriate neighbourhoods within a multi-stakeholder approach by screening the whole city and/or region. In this selection process, factors as e.g. constraints with regard to available energy sources, possible stakeholders involved and their interests, location within the greater urban and regional infrastructure system has to be considered. We recommend a SWOT-analysis to assess development opportunities with regard to strengths, weaknesses, opportunities, and threats for neighbourhood development in general and specifically on realizing ambitious energy and emission goals.

As ZEN development is ambitious and demands a high level of commitment from the stakeholders, it is recommendable to identify feasible neighbourhoods to be successful forerunner projects. New approaches with regard to technical solutions as well as process management and stakeholder collaboration can be tested here, and gained knowledge and experience can be transferred to following neighbourhoods developments. Successful first ZEN developments are necessary to strengthen commitment and to tell the good stories. EMP needs not only to incorporate tools for neighbourhood selection, but as well the consideration of stakeholders that needs to be involved from an early stage with regard to their knowledge and experience.

Finally, we raised the question of leadership and process management for applying EMP at neighbourhood level. Our study showed that for Ydalir, a long-term management structure of the neighbourhood is not yet decided. The concept of EMP will be further strengthened by identifying good leadership and governance models for process management through all phases of development, including the operation phase of a neighbourhood.

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