Kristin Fjellheim • Selamawit Mamo Fufa

SINTEF NOTES 39

EE Settlement – Norwegian case studies





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Preface

This report has been written within the research project *EE Settlement – Embodied Energy, Costs and Traffic in Different Settlement Patterns*, which is financed by the Research Council of Norway within the BYFORSK programme. The project is a broad and interdisciplinary collaboration between SINTEF Community, Oslo Metropolitan University (OsloMet), the Norwegian Institute for Urban and Regional Research (NIBR) at OsloMet, Institute of Transport Economics (TØI), Kristiansand Municipality, National Association of Norwegian Architects - Norske Arkitekters Landsforbund (NAL) BYLIVsenteret initiative, and two partners from Vienna, Austria: Akaryon, and the Institute of Spatial Planning, Environmental Planning and Land Rearrangement (IRUB) at the University of Natural Resources and Life Sciences in Vienna (BOKU).

The authors would like to thank the project partners for their contributions. The authors would also like to thank Knut Felberg, Terje Lilletvedt and Erik Sandsmark from Kristiansand municipality for testing and providing feedback throughout the development of the EE Settlement tool. We also extend our thanks to all participants in the EE Settlement tool testing from Elverum, Bodø, Oslo, Trondheim, and Bergen municipalities.

Oslo, Norway
06.04.2021

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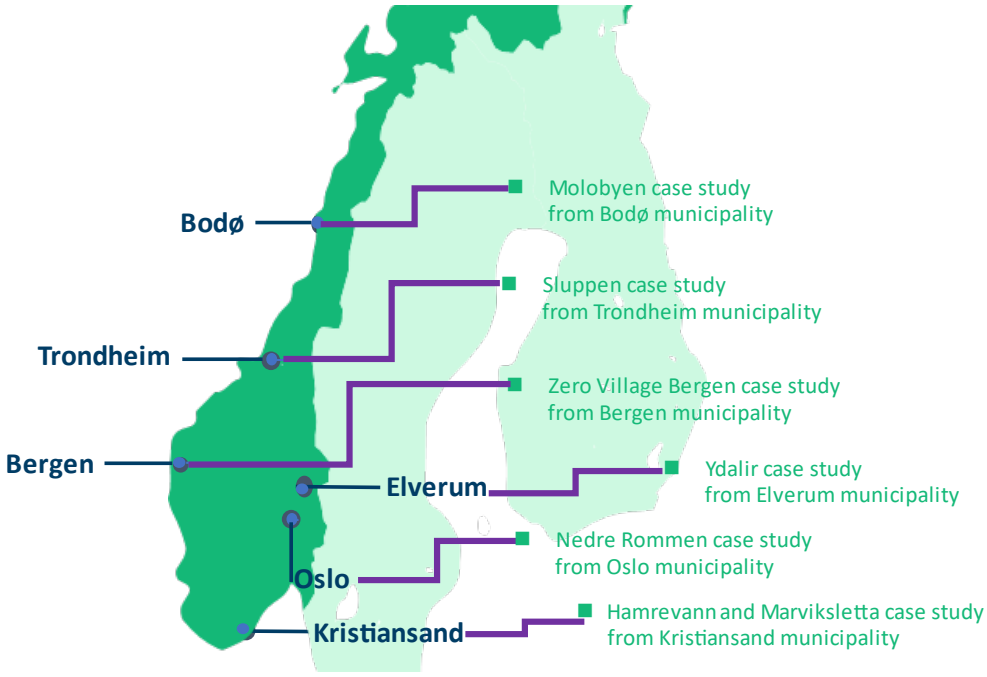
Abstract

The vision of the project *EE settlement – Embodied energy, costs and traffic in different settlement patterns* is to provide a decision support tool and a guideline which enable municipal planners and other stakeholders to assess the expected impacts of new developments in early planning stages. The main goal of performing case study tool testing is to get insight into how the tool performs when being used by the end-user. The tool testers from the municipalities will both give feedback on the tool functionality, user friendliness and how the tool can be practically applied as a decision support tool in the field of work.

For the Norwegian case studies seven locations in six different municipalities were selected as relevant based on certain selection criteria. These case studies are Hamrevann and Marviksletta in Kristiansand municipality, Zero Village Bergen in Bergen municipality, Ydalir in Elverum municipality, Sluppen in Trondheim municipality, Molobyen in Bodø municipality and Nedre Rommen in Oslo municipality.



There were three tool testing rounds where the first two focused on giving feedback to the tool and guideline development while the last round focused on tool functionality and how it could be used as a decision support tool. The test subjects gave feedback on the availability of information requirements for data input to the tool, on what type of decisions the tool could be used for and which criteria and aspects are important to evaluate when planning a new settlement area.

For further development of the tool and for future research focus the test subjects suggested:

- The tool could show some uncertainty values in order to give a range of emissions instead of one single number.
- Extending the tool to also evaluate transformation of areas.
- Several of the urban planners and developers saw the need for a "base case" or "reference scenario".
- In many of the early planning stages the development areas are quite large and very often divided into several sub-areas. It could be useful to have the possibility to input for each sub-area and add them together as needed as they usually follow different time schedule.

Contents

1 Introduction

This report will give an overview of the Norwegian case studies used for testing the EE settlement tool as a decision support tool for urban planners in the municipalities.

1.1 EE Settlement project

The project EE Settlement – Embodied Energy, Costs and Traffic in Different Settlement Patterns addresses the issues and challenges regarding new settlement areas. The main objective is to generate profound basic data on the embodied energy requirements of different dwelling types and settlement patterns, including associated outside facilities and infrastructure - such as roads and services (such as water, electricity, and sewage).

The vision for the project is to provide guidelines and tools for municipalities, regional and central authorities, as well as for professionals (e.g. architects and spatial planners) and the public, for assessing the consequences and impacts of different housing development options, taking into account energy need, environmental impact and costs over the lifecycle – not only for the buildings, but also for surroundings, infrastructure and transport.

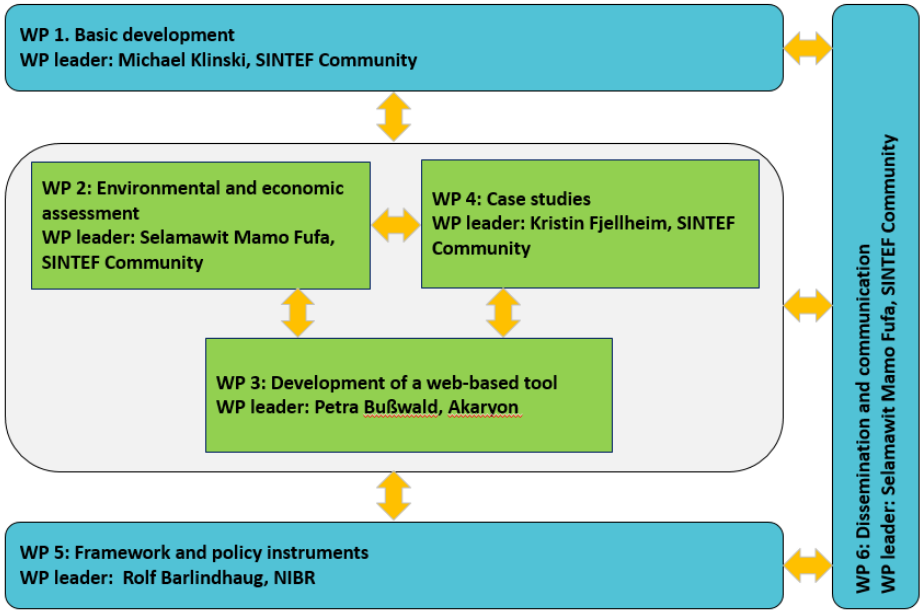


Figure 1-1. EE Settlement project organization plan (SINTEF)

The project is divided into six work packages (WP) that target the main research topics addressed in the project. The overall structure of the work packages, and the connection between them, is shown Figure 1-1.

This report is a deliverable from the Norwegian case study analysis performed under WP4. In WP4, the aim is:

- *Testing and quality assurance of the tool prototype developed in WP2 based on the feedback and inputs from tool testing results.*
- *Development of recommendations for the municipalities as useful input for the guideline and recommendations development under WP 5.*

1.2 Aim and scope of this report

This work includes testing tool prototype to evaluate case studies from Kristiansand municipality and developing recommendations (Task 4.1) and tool prototype testing to evaluate case studies from further municipalities or regions and developing recommendations based on the results based on the results (Task 4.2). The aim of this report

is to give an overview of the findings from testing of the functionality of the tool as a decision support tool in Norwegian case studies.

After this introduction chapter, Chapter 2 presents the case study selection criteria and an overview of the case studies (section 2.1) and the description of the procedure for EE Settlement tool testing in the case studies (Section 2.2). Chapters 3 to 8 presents each case studies with information on the project and the input data used in the tool testing part and a summary of the results for the case studies.

- Chapter 3: Case study Hamrevann, Kristiansand municipality
- Chapter 4: Case study Marviksletta, Kristiansand municipality
- Chapter 5: Case study Ydalir, Elverum municipality
- Chapter 6: Case study Zero Emission Village Bergen, Bergen municipality
- Chapter 7: Case study Nedre Rommen, Oslo municipality
- Chapter 8: Case study Sluppen, Trondheim municipality

Chapter 9 summarize the results and findings from all case studies with regards to the functionality of the tool and responses to the questions regarding the use as a decision support tool. It also gives limitations of the report and recommendations for further work.

2 Background

The main goal of performing case study tool testing is to get insight into how the tool performs when being used by the end-user. The tool testers from the municipalities will both give feedback on the tool functionality, user friendliness and how the tool can be practically applied as a decision support tool in the field of work.

2.1 Identifying user needs

In the early project phase, the needs of different users' group have been assessed through a workshop and interviews conducted in 2017-2018, in order to get input for the EE Settlement tool development (Venås & Mellegård 2018).

Participants in the workshop were representatives from municipalities, government agencies, research organizations, consultants and other interest groups. As municipalities are the main user group of the EE Settlement tool, a follow up group interview was conducted with two municipal and one county administrations. The main findings from the workshop and interviews show that:

- there is a clear need for a decision support tool, which is transparent (so that municipal professionals can understand the basis of the calculations in the tool (not being a "black box")), based on existing, acknowledged methodology (e.g. GHG emission calculations for buildings) and existing background data bases (from municipalities, national statistics from Statistics Norway or other governmental agencies).
- the need for having solid background information to make the best decisions in early planning stage of an area development or a zoning plan.
- a tool that could give answers to the environmental and economic consequences of a specific development alternative.
- a tool with a supplemental guide could not only be used to match the different area development patterns with the corresponding environmental impact, but also as empirical evidence or visualization when the municipal planners face public and private developers.
- a need for hard facts to convince politicians about the consequences of choosing the wrong development projects. The tool could be a potential constructive instrument in challenging zoning processes, especially where the (municipal or regional) strategy

of densification around the specified transport hubs is put aside for private development projects that appears attractive and "green", but that contributes to a more sprawled settlement.

It was also suggested to limit the scope of the tool to cover the needs in the early planning stage of a settlement. Good superior decisions in the early stage will give the municipalities and developers a good foundation for further optimizing the area in a later stage.

This background information was used as a basis in EE Settlement tool development.

2.2 Case study selection criteria

From 2020 there are 365 municipalities in Norway (Kommunesektorens organisasjon (KS), u.d.) with a wide variety in area size, population size, organisational complexity, settlement structure, environmental goals, and projects under planning. For the tool testing to be relevant the following was considered for the selection of the Norwegian case municipalities:

Prerequisites:

- The municipalities must have relevant challenges considered in this project and they must have a need for this tool.
- It is important that they have an actual housing development area/project under planning, where an evaluation of the development area in the tool could possibly contribute and provide important knowledge for the planners or decision-makers.
- Have willingness of sharing local data, statistics, and knowledge.
- There is a possibility in the municipality for both urban sprawl or more dense settlement. Rural municipalities that do not have relevant challenges are neglected.
- Municipalities experiencing growth in population, settlement and/or house construction are considered.

A variation between the cases for the following parameters:

- Population size
- Spatial archetypes (e.g. urban, suburban, rural etc.) and the degree of urbanisation. The extreme archetypes are not considered relevant. A distribution of cases in the range between the most rural and most urban settlements are encouraged, as these municipalities are considered to have most use for the tool.
- A variation of the dynamics in the urban region should be considered, like difference in the net commuter traffic etc. Difference in the centrality of the cases in their respective commuter regions are preferred.
- Having a distribution over the different provinces is important for the Austrian selection, as there are different legislations to consider. Some distribution is important for the Norwegian cases as well, to include several perspectives. A geographical distribution secures that the tool can be applied across regional borders.
- Size of the development area considered in the case, number of buildings etc.

Competence/interest:

- The last point is that municipalities preferably should already have some interest or competence in research activities or for example environmental impact, energy efficiency, green mobility, and sustainable communities.

In total throughout the project period there were 7 case studies that were selected as shown in Figure 2-1. All case studies, except Zero Village Bergen in Bergen municipality, are described in this report.

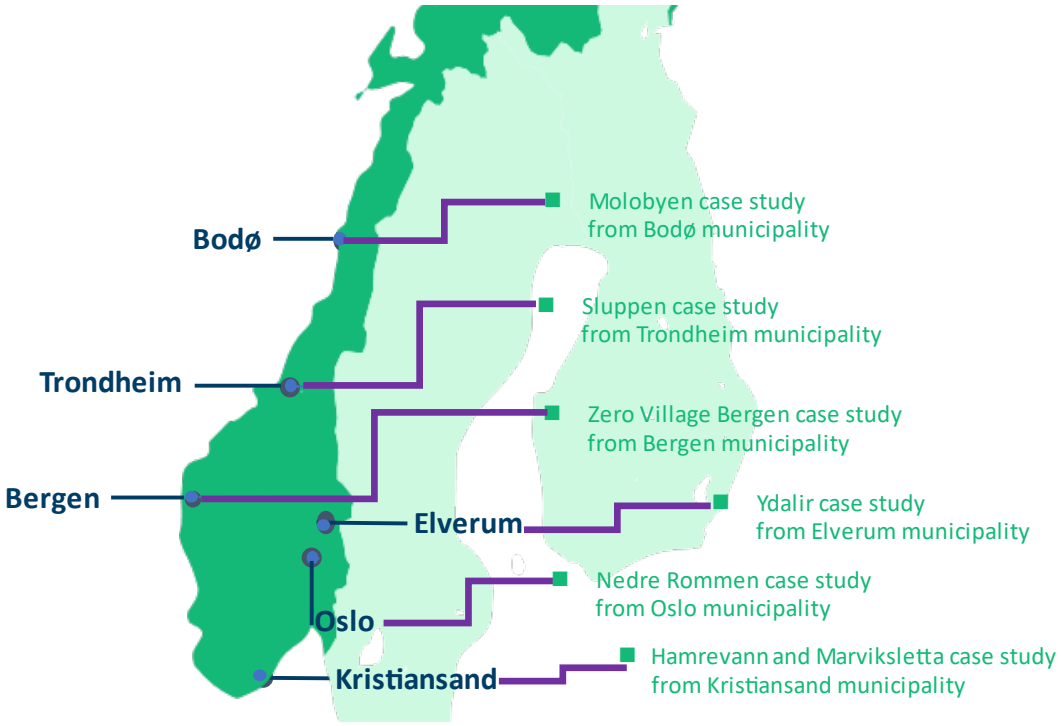


Figure 2-1. Map showing the selected Norwegian case studies

2.3 Tool testing

A series of tool testing followed by semi-structured qualitative interviews were performed using an interview guide shown in Appendix 1. The goal of the interviews of potential end users of EE Settlement tool was twofold:

1) Test the functionality of the tool and get feedback and input for finalising the tool (part of the EE Settlement project work)
2) Understand why and how a decision support tool could be applied by municipalities and for what decisions it could be helpful.

The interview was performed through two hours meeting which is divided into four parts (See Appendix 2 – meeting agenda):

- Short introduction of the project and tool (10 min)
- Tool testing (60min)
- Interview, in the form of discussion on tool functionality, application and recommendation (50 min)

The interviewees were given access to the tool before the meetings, and they have first looked into the tool on their own. The testing was with case studies in the interviewees' own municipality. The semi-structured interviews were performed at the end of the testing session. The duration of the interviews were around 20-40 minutes.

The tool testing has been an iterative process throughout the EE settlement project period to get feedback and input for the tool and methods developers along the way. There have been three main periods of testing as shown in Figure 2-2.

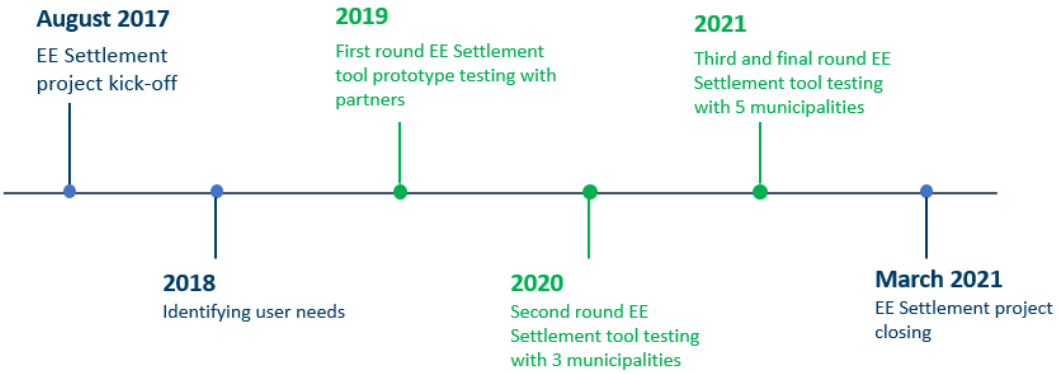


Figure 2-2. Tool testing timeline

Testing 2019

The first round of testing was conducted by the partners and advisory board members through a workshop arranged in August 2019. All participants were tested the tool prototype using Hamrevann as case study.

Testing 2020

The second round of testing was performed on three different case studies and municipalities with 6 interviewees participating:

1) municipal urban planner from a small-town municipality, Elverum, tested the tool using Ydalir as case study.
2) market manager for a large developer from Bergen tested the tool using Zero Emission Village Bergen as case study.
3) municipal urban planners from Kristiansand municipality tested the tool using Hamrevann and Marviksletta as case study.

Testing 2021

The third and final round of testing was performed on five different case studies and municipalities with 14 interviewees participating:

1) three municipal urban planners from Kristiansand municipality tested the tool using Hamrevann as a case study, mainly focusing making changes and updates from the previous test rounds.
2) municipal urban planner from Elverum municipality tested the tool using the case Ydalir mainly focusing on making changes and updates to the results from their first test round in 2020.
3) three municipal urban planners from Bodø municipality tested the tool using Molobyen as a case study.
4) two municipal urban planners from Oslo municipality tested the tool using Nedre Rommen as a case study.
5) fiver urban planners from Trondheim municipality tested the tool using the area Sluppen as a case study.

3 Case study 1: Hamrevann

Hamrevann is the main case study chosen in the EE Settlement project from the only Norwegian municipality in the project consortium, which is Kristiansand municipality. It has been used as a real-life example for testing the tool functionality throughout the development of the tool and has gone through three rounds of testing in 2019, 2020 and 2021.

3.1 Case description

Hamrevann is a lake about 12 km northeast of the city centre of Kristiansand, Norway. The 3627 acres surrounding the lake is planned as a future area for housing development, with the possibility of construction on 1765 acres of the land – potentially around 4100 dwellings. Today, the area is popular for hiking, and the aim is to strengthen the area as a high-quality living area, as well as being developed as a "central hiking area" for the inhabitants in the vicinity.

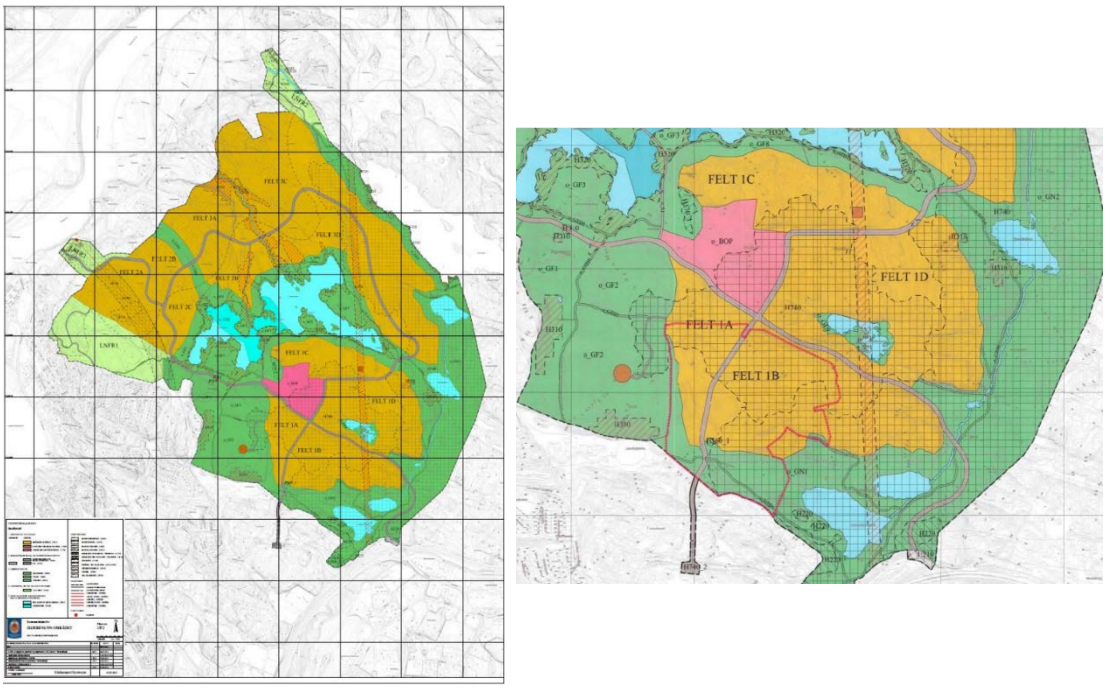


Figure 3-1. Area plan map showing the area from the municipal sub-plan (Kristiansand Municipality, 2016) and the specific area for this case "Felt 1A og 1B" (Kristiansand Municipality, 2019)

For the first part of the development, called "Felt 1A og 1B", there has been planned 300 dwellings, with the construction of 270 terraced houses and 30 apartments. Figure 3-1 shows the map of the entire area plan of Hamrevann and the case development area "Felt 1A og 1B". The zoning plan (with national zoning plan ID: 4204_1492) and the development area was finally approved by the municipal Council of Kristiansand in December 2019. The last objection in the zoning process, from the County Governor (of Agder), was withdrawn after negotiations together with the municipality and the developer – getting the final green light for construction in late May 2020, after 10 years of planning. At Hamrevann the settlement will be adapted to the landscape and the topography and the houses and apartments will be close to nature (Hamrevann, u.d.).

3.2 Input data

The first part of the development area in Hamrevann, area 1A and 1B, has been tested in the main test case throughout the project period and has gone through three rounds of testing (Figure 3-2). The first round of testing was performed together with one urban planner from Kristiansand municipality but the last round in 2021 was performed with three urban planners. For the first round of testing a set of input data was recorded in the EE settlement tool (Table 3-1). For the last round of testing in 2021 the input data was simplified to test the new and updated functionalities of the tool.

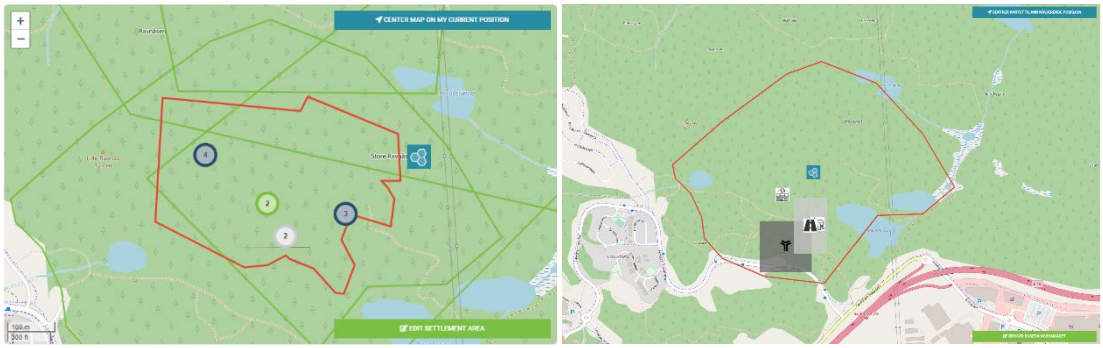


Figure 3-2. Screenshot of the settlement drawn in the tool in testing rounds in 2020 and 2021 for case Hamrevann

Table 3-1. Input data for first round of testing in 2020 for case Hamrevann based on documents related to the zoning plan

Buildings				
Number of dwellings	300	Apartment block – 7 floors Terraced house units Single family houses	25 208 67	3. planbeskrivelse
Number of buildings	120	Apartment block – 7 floors Terraced houses Single family houses	1 52 67	-
Average living area [m2]	136	Apartment block – 7 floors Terraced houses Single family houses	160 130 140	3. planbeskrivelse
Energy source	*Ground source heat pump*			Assumption
Infrastructure				
Collector road [m]		1000		Based on 1. plankart
Access roads [m]		1000		Assumption
Demography				
Total number of inhabitants	1110	Adults Children	600 510	Assuming high number of families with children (1,7 for each dwelling)
Edited mobility parameters (from the default values)				
Frequency public transport [no. of departures from closest stop(s) in morning peak hour]		4		3. planbeskrivelse
Driving distance to the main regional centre [km]		11,362		Suggestion in tool
Inhabitants main regional centre		64 057		SSB statistics (SSB, u.d.)
No. cars in the household		1		Assumption based on 1 parking lot per dwelling according to zoning plan
Private parking close to home		100%		
Distribution of car transport				
Gasoline [%]		35,04		SSB statistics (SSB, u.d.)
Diesel [%]		45,34		SSB statistics
Non-plug-in hybrid electric vehicles [%]		3,5		SSB statistics
Plug-in hybrid electric vehicles [%]		2,72		SSB statistics
Battery electric vehicles [%]		13,39		SSB statistics
Hydrogen [%]		0		SSB statistics
Gasoline [%]		35,04		SSB statistics

The parameters "Share of residents employed", "Gender (% of female population)", "Share of residents with driving license" and "Income per year" was not changed from the default (national average) values. There is no train/metro/tram within 1 km (thus assuming 0%).

The input data for round of testing in 2021 was mainly based on assumptions and simplifications on the number of buildings and infrastructure as the focus was on testing of new functionality. Most of the standard values in the tool were also kept regarding demography, mobility, and car transport.

Table 3-2. Input data for tool testing of case Hamrevann in 2021

Buildings		
Number of buildings	Single-family house (Type 111) 1-2 floors Apartment building (Type 132) 4-5 floors	100 10
Infrastructure		
	Urban centre road	1000 m
	Sidewalk/bike path (without road)	750 m

3.3 Results

Quick results from testing in 2021 gives the municipality an overview of the total GHG emissions from their settlement area and how much buildings, infrastructure and mobility contributes to these emissions. It also gives a comparison of the area sizes between the total plot size, the area for infrastructure and the area for buildings (Figure 3-3). The results were used only to test the functionality of the quick result part of the tool, not to get actual results, since the background data was not finalised and validated during the tool testing.

Figure 3-3. Quick results from the EE Settlement tool for Hamrevann Felt 1A and 1B

4 Case study 2: Marviksletta

The Marviksletta development area was only used for a comparative assessment with Hamrevann in the first round of testing. The aim is to see how the tool could be applied and how it works in a real-life planning challenge. However, the comparison between the settlements is highly fictional, which both are politically approved and under planning, so the only aim for the comparison is to get insights about the tool application and limitations.

4.1 Case description

Marviksletta is development area in central Kristiansand, in Lund, under 2 km from the city centre. The zoning plan that got the final approval 16.09.2015 (with national zoning plan ID: 4204_1363 (Marvika Utvikling AS, 2015)). According to the detailed description for the zoning plan, the residential part of the project consists of 515 apartments. In addition, the new building will house commercial interests, for office spaces or retail/shops, on the lower storeys. Previously, the area was used for industrial purposes, and the existing buildings were demolished in spring 2020.

According to the original plan, the non-residential purposes is covered in the two lower storeys. The area above the third storey will be dedicated to apartment dwellings, and some buildings will be fully dedicated for residential purposes from the ground floor. The building height varies from 4 to 7 floors.

4.2 Input data

Only 300 dwellings (of the 500 planned) are constructed for the case study within the tool model, so the number of dwellings is the same as for Hamrevann. The same average dwelling area is used for both case studies, and it is assumed that the same number of persons are living in the 300 dwellings. There is a large simplification in this approach: It only shows the evaluation in the EE Settlement tool if the 300 dwellings (in Hamrevann) had been constructed as apartments closer to the city centre. It does not take into consideration other factors like the preferences of the residents, the lower living area per inhabitant per m^2 closer to the city centre, different demography of the Lund area (Marviksletta) compared to the Hamrevann/Lauvåsen area and so on.

The buildings constructed in the fictional case study scenario are only apartment buildings, and 8 "Apartment Block - 7 floors" and 6 "Apartment Building - 4 floors" is assumed, imitating the mix of building heights that are planned in the real Marviksletta development. The commercial spaces that are planned for the real Marviksletta development is not considered in this study, since the EE Settlement tool only evaluates the impact that stems from the residential housing demand. Compared to the real development, where the planned residential living area is really around 46 350 m2, our fictional case only uses 40 800 m2 for living area purposes – so there is still room for more apartments (around 5 500 m2) within the total living area for residential purposes from the description in the zoning plan proposal.

As for the Hamrevann case study, the parameters "Share of residents employed", "Gender (% of female population)", "Share of residents with driving license" and "Income per year" was not changed from the default (national average) values. There is no train/metro/tram within 1 km (thus assuming 0%).

The following assumptions were taken into consideration based on the documents related to the zoning plan:

Table 4-1. Input data for testing in 2020 for case Marviksletta

Buildings				
Number of dwellings	300	Apartment building, 4 floors Apartment block, 7 floors	216 84	Assumption
Number of buildings	14	Apartment building, 4 floors Apartment block, 7 floors	6 8	Assumption
Average living area [m2]	136	Apartment building, 4 floors Apartment block, 7 floors	136 136	Only average value, same as Hamrevann
Energy source	*District heating*			Zoning plan (obligation)
Infrastructure				
Collector road [m]		350		Based on existing road
Access roads [m]		250		Assumption
Demography				
Total number of inhabitants	1110	Adults Children	600 510	Assuming high number of children families moving to Hamrevann (1,7 for each dwelling)
Edited mobility parameters (from the default values)				
Frequency public transport [no. of departures from closest stop(s) in morning peak hour]		6		Akt.no (public transport company)
Driving distance to the main regional centre [km]		2,3		Estimated with Google Maps
Inhabitants main regional centre		64 057		SSB statistics
No. cars in the household		1		Same as Hamrevann, there is planned parking cellars in the area
Private parking close to home		100%		
Distribution of car transport: Same as Hamrevann in Table 3.1				

4.3 Results

The main goal of the comparative assessment was to show how the tool could be used to identify differences between two different settlements as shown in Figure 4.1.

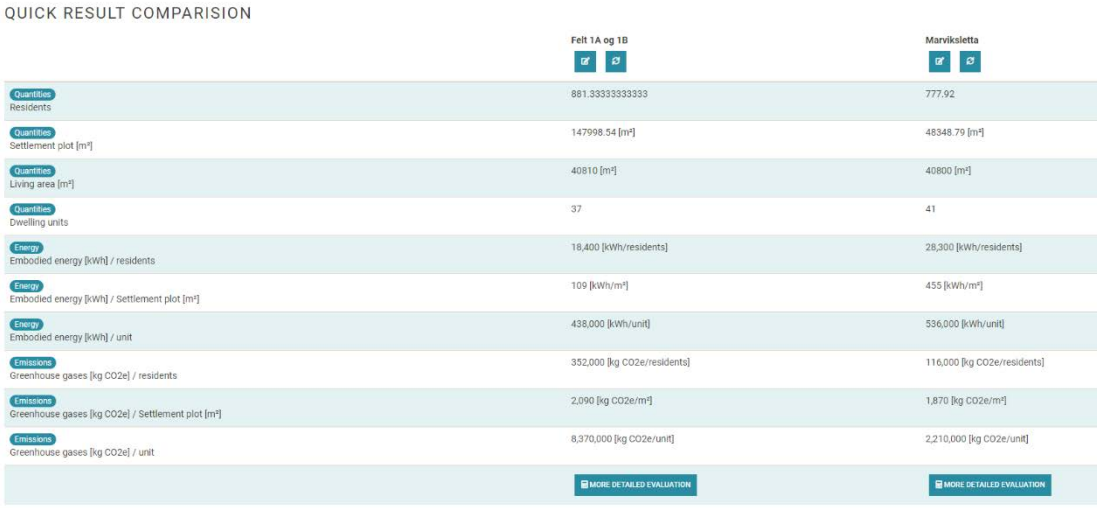


Figure 4-1. Quick results from the EE Settlement tool for comparison of Hamrevann Felt 1A and 1B with Marviksletta

5 Case study Ydalir, Elverum municipality

Ydalir development area in Elverum municipality was chosen as a case study through their work in the research centre on Zero Emission Neighbourhoods in smart cities (FME ZEN, 2017-2024). This case study has been through two rounds of testing, one in 2020 and one in 2021. For the first round of testing the data was input into the model to get the final results for the area. For the second round of testing these values were updated and changed and a copy of the settlement was created to test the difference between having passive housing vs. TEK 17 housing.

5.1 Case description

The Ydalir area is a large area of over 350 acres and the master plan of the area has a high focus on having a holistic view on the settlement with high environmental ambitions as they are a part of the FME ZEN. The entire area plan is regulated but each zone needs to also have a detailed zoning plan. Per today there are five detailed zoning plans that are approved, two that are under development and four-five that are on hold. The Figure 5-1 shows the area plan for Ydalir (Elverum Vekst, 2017).

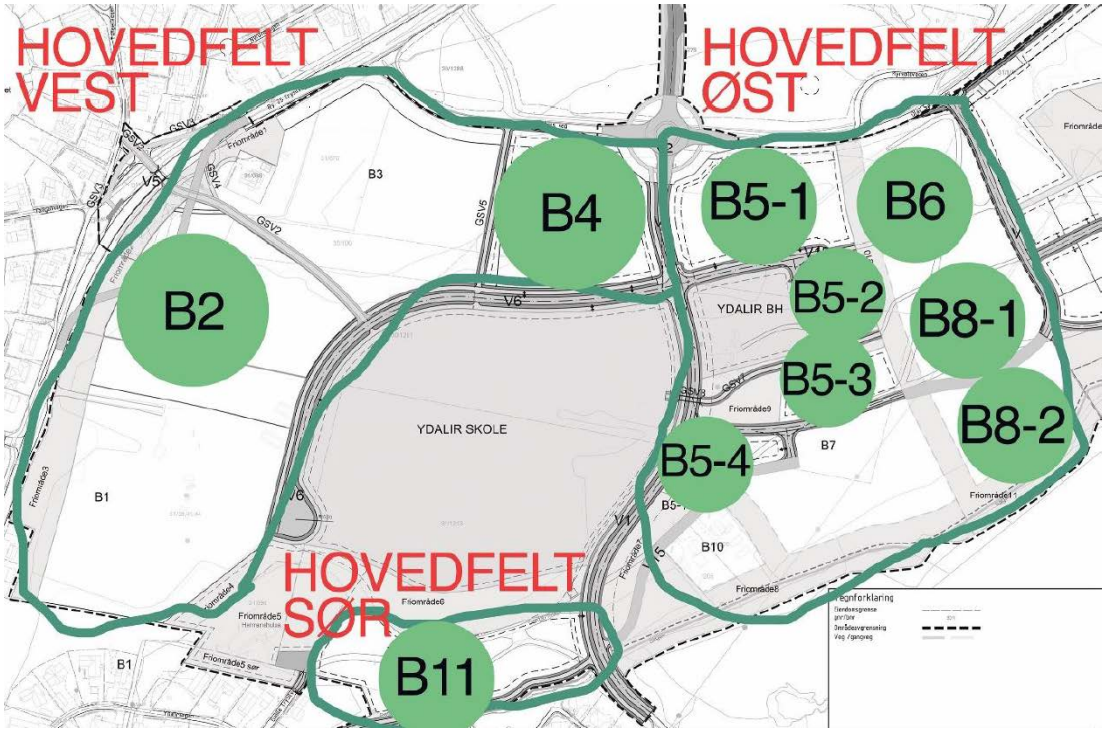


Figure 5-1. Area map over Ydalir case study from the master plan document

5.2 Input data

The areas used as input into the tool testing are area B3, B4, B5 and Muspelheim, Ydalirtoppen and Høyden. There are also added some estimations for the areas B2, B3 and B6. Information on schools and kindergartens are not included in the tool testing. The Figure 5-2 shows the map drawn out in the EE settlement tool with all corresponding housing and infrastructure elements.

Figure 5-2. Screenshot of the settlement drawn in the tool in testing rounds in 2020 and 2021 for case Ydalir

The input data values are shown in Table 5-1. Most of the standard values in the tool was kept except for the buildings part. Here there were some changes to different parameters within each building. Also, for the comparative study of Ydalir the settlement was copied so that in on settlement all buildings were passive house standards while for the comparative case study all buildings were TEK 17 standard.

Table 5-1. Input data for case study Ydalir, Elverum municipality

Buildings

Name	Type	Number of buildings
Flerfamilie Trysilhus	RH Row house (townhouse, terraced house) (Type 126) 2-3 floors	10
Rekkehus Trysilhus	RH Row house (townhouse, terraced house) (Type 126) 2-3 floors	6
Leilighetsbygg	AB Apartment building (Type 132) 4-5 floors	5
Kommunale enheter	RH Row house (townhouse, terraced house) (Type 126) 2-3 floors	2
Høyden	AB Apartment building (Type 132) 4-5 floors	4
Høyden	AB Apartment building (Type 132) 4-5 floors	2
Muspelheim	AB Apartment building (Type 132) 4-5 floors	1
Muspelheim	SFH Single-family house (Type 111) 1-2 floors	10
Ydalir park	RH Row house (townhouse, terraced house) (Type 126) 2-3 floors	12
Muspelheim	RH Row house (townhouse, terraced house) (Type 126) 2-3 floors	3
B6	RH Row house (townhouse, terraced house) (Type 126) 2-3 floors	20
B7	RH Row house (townhouse, terraced house) (Type 126) 2-3 floors	8
Ydalirtoppen	AB Apartment building (Type 132) 4-5 floors	4
B1 og 2	AB Apartment building (Type 132) 4-5 floors	20
Ydalir park	TB Tall apartment block (Type 133) 6-8 floors	3

Infrastructure

Name	Type	Length	Number of infrastructures
Overslag veger	Urban center road	1595 [m]	1
GS-veger ikke langs veg	Sidewalk/bike path (without road)	1400 [m]	1

Demography

	Buildings		Suggestion based on buildings/dwellings adde		
Building Type	**Number of buildings**	**Number of dwellings**	**Adults**	**Children**	**Total number of people**
SFH Single-family house (Type 111) 1-2 floors	10	10	20	20	**40**
TB Tall apartment block (Type 133) 6-8 floors	3	45	58	0	**58**
RH Row house (townhouse, terraced house) (Type 126) 2-3 floors	61	328	632	485	**1,117**
AB Apartment building (Type 132) 4-5 floors	36	538	1,021	384	**1,405**
Sum	**110**	**921**	**1,731**	**889**	**2,620**

5.3 Results

Results from the tool testing shows how it is possible to make comparison of the Ydalir case with passive houses and with TEK 17 houses alternatives. The results were used only to test the functionality of the comparison result part of the tool, not to get actual results, since the background data was not finalised and validated during the tool testing.

	Ydalir	Ydalir TEK17
Quantities Residents	2620.7	2620.7
Quantities Settlement plot [m²]	332,000 [m²]	332,000 [m²]
Quantities Living area [m²]	82,700 [m²]	82,700 [m²]
Quantities Dwelling units	146	146
Energy Embodied energy [kWh] / residents	4,810 [kWh/residents]	5,010 [kWh/residents]
Energy Embodied energy [kWh] / Settlement plot [m²]	37.9 [kWh/m²]	39.5 [kWh/m²]
Energy Embodied energy [kWh] / unit	86,300 [kWh/unit]	89,900 [kWh/unit]
Emissions Greenhouse gases [kg CO2e] / residents	10,800 [kg CO2e/residents]	10,700 [kg CO2e/residents]
Emissions Greenhouse gases [kg CO2e] / Settlement plot [m²]	84.9 [kg CO2e/m²]	84.6 [kg CO2e/m²]
Emissions Greenhouse gases [kg CO2e] / unit	193,000 [kg CO2e/unit]	193,000 [kg CO2e/unit]

Figure 5-3. Quick results from the EE Settlement tool for comparison of Ydalir with passive houses and Ydalir with TEK17 houses

6 Case study Molobyen, Bodø municipality

Bodø municipality was chosen as a case study through their work in the research centre on Zero Emission Neighbourhoods in smart cities (FME ZEN, 2017-2024). The first idea was to use the new city – new airport case, but when the interviewees started the testing, they realized it would be better to use a smaller area where they had more available information about the infrastructure. Therefore, the case Molobyen was chosen as the case study and was tested in 2021.

6.1 Case description

Molobyen is an area that is stretching from Molorota to the centre of Bodø city, they are currently working on the area plan which might be approved in 2021. The area marked as blue in the map in Figure 6-1 is the main development area, but they also see a possibility of expanding the area through filling of the area (Breivika utvikling Bodø AS, 2018). The total area is about 50 hectare and the plan is that it can be developed into 500-650 new dwellings as well as areas for business, offices, and other services.

Figure 6-1. Map over the development area for Molobyen

6.2 Input data

For the case study tool testing the focus was on the area that does not need filling (Figure 6-2).

Figure 6-2. Screenshot of the settlement drawn in the tool in testing for case Molobyen

The input data values are shown in Table 6-1. For the buildings part where the standard values were changed to passive houses and the energy source changed to district heating, in addition to some changes to parking cellar and other parameters. The plan for the apartments in the buildings is that they will be larger than the standard today, therefore there were also made changes to the living area per dwelling unit to a higher number, and consequently the number of dwelling units per building went down. For the infrastructure sidewalks was added to both sides of the roads. There were also added changes to the demography parameters where the total number of inhabitants was increased by 335.

Table 6-1. Input data for case study Molobyen, Bodø municipality

Buildings

Navn	Type	Antall bygninger
☐ Parkhusene	Boligblokk (type 132) 4-5 etasjer	4
☐ Molobyhusene	Boligblokk (type 133) 6-8 etasjer	6

Infrastructure

Navn	Type	Lengde	Antall infrastrukturer
☐ Gate 1	Samlevei Sa2 - Standardbredde: 6,00 (m)	240 [m]	1
☐ Gate 3	Adkomstvei A2 - Standardbredde: 4,5 (m)	200 [m]	1

Demography

	Bygg		Forslag basert på bygninger / boliger lagt til			Brukerinput for mobilitetsberegninger			
Bygningstype	Antall bygninger	Antall boliger	Voksne	Barn	Totalt antall personer	Voksne	Barn	Totalt antall personer	Alternativt forslag vs. brukerinp
Boligblokk (type 133) 6-8 etasjer	6	582	814	0	814	828	277	1,105	-291
Boligblokk (type 132) 4-5 etasjer	4	64	96	0	96	70	70	140	-44
Sum	10	646	910	0	910	898	347	1,245	-335

6.3 Results

The results show that a large amount of the total plot area is not utilized, however as this was only a test and they did not include all the buildings and infrastructure that is planned for the area. This shows that the tool is most useful when all background data is added as the results when only adding sections of the plot area can be misleading.

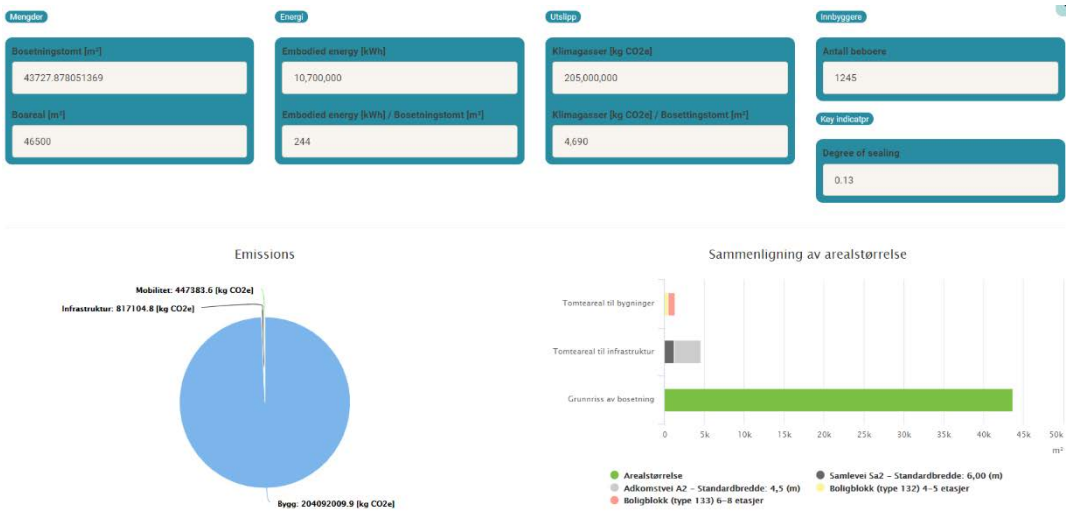


Figure 6-3. Quick results from the EE Settlement tool for the case Molobyen, Bodø municipality

7 Case study Nedre Rommen, Oslo municipality

Nedre Rommen is an area in Oslo municipality that is in the early stages of the planning program phase and there is no zoning plan in place yet. It was tested in 2021.This case study is the earliest planning stages that the tool is being tested on for the Norwegian case studies.

7.1 Case description

Nedre Rommen today is a large industry and logistics area with the potential of city development through area changes and transformation (see also map of the area in Figure 7-1). The plan program aims at setting overall city plan framework for future zoning plans. The recommended area plan will give 700 000 square meters of new buildings with about 5500 dwellings (Oslo kommune plan- og bygningsetaten, 2019).

Figure 7-1. Map of the area of case Nedre Rommen

As the area is in early planning phases there is only ideas on what type of building typologies there will be in the area. The areal is also very large so only a small fraction is used in the case study tool testing.

7.2 Input data

The Figure 7-2 shows the map drawn out in the EE settlement tool with all corresponding housing and infrastructure elements. Only a couple of buildings and infrastructure was added to the settlement mainly to test the functionality of the tool. Since the area is in early planning phase the area was also created as two scenarios: one with apartment buildings and one with office buildings. This makes it possible for comparative assessment in early stages between two types of regulations.

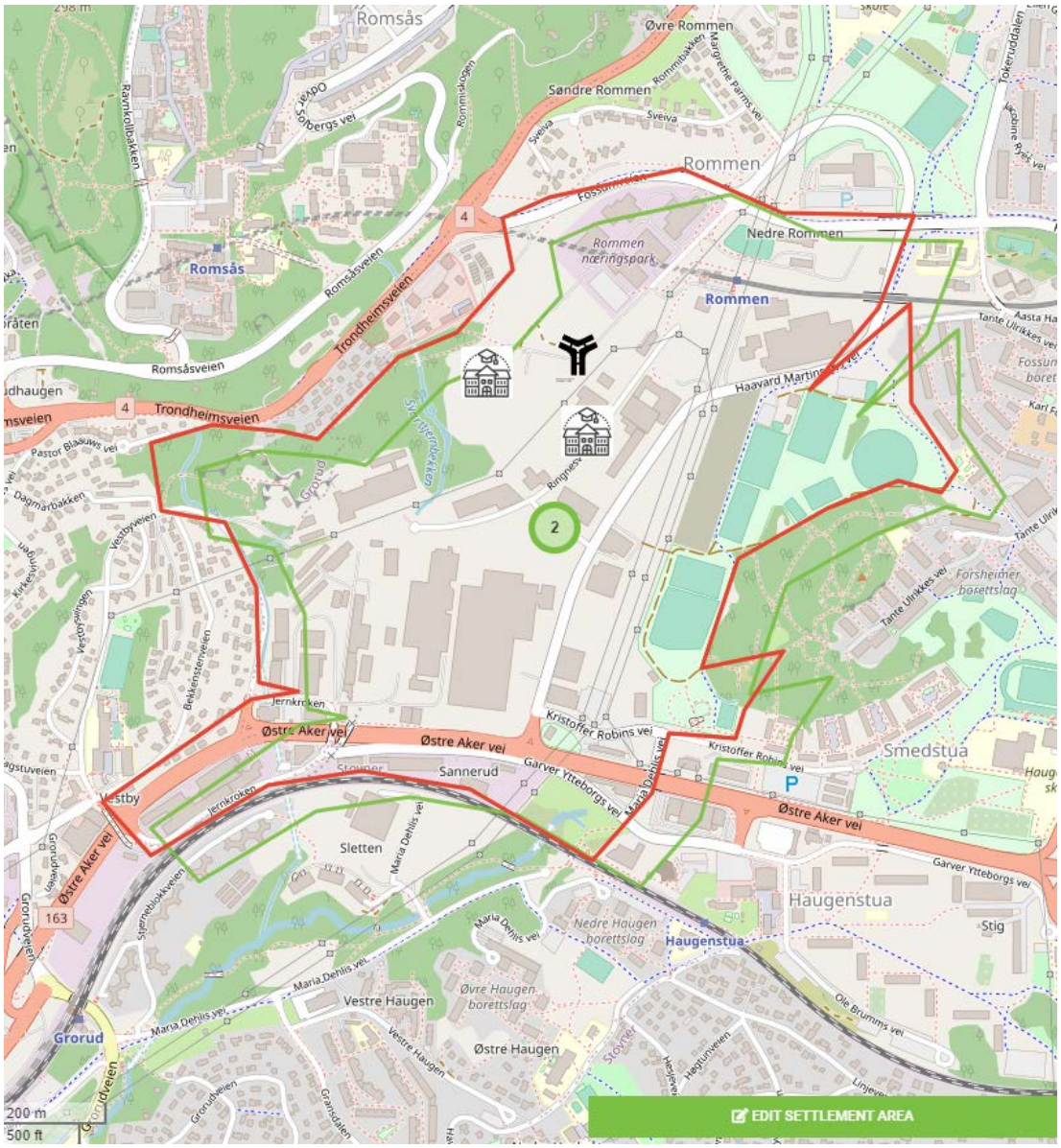


Figure 7-2. Screenshot of the settlement drawn in the tool in testing for case Nedre Rommen

Table 7-1 shows the input data for the case study Nedre Rommen with apartment buildings "Buildings scenario 1" and with office buildings "Buildings scenario 2". Changes were made to some of the buildings regarding building energy standard, technical systems, buildings elements and energy sources. Sidewalks was included on one side of the road as well as separate sidewalk/bicycle path.

Table 7-1. Input data for case study Nedre Rommen, Oslo municipality

Buildings scenario 1		
Name	**Type**	**Number of buildings**
☐ Brinken Bolig Felt F	AB Apartment building (Type 132) 4-5 floors	15
☐ boligen	AB Apartment building (Type 132) 4-5 floors	1

Buildings scenario 2

Name	Type	Number of buildings
☐ kontoret	N-OB Office building (Type 311) - 4 floors	15

Infrastructure

Name	Type	Length	Number of infrastructures
☐ Nedre Rommen	Urban center road	115 [m]	1

Demography

	Buildings		Suggestion based on buildings/dwellings added			User input for mobility calculations			
Building Type	Number of buildings	Number of dwellings	Adults	Children	Total number of people	Adults	Children	Total number of people	Difference suggestion vs. user inpu
AB Apartment building (Type 132) 4-5 floors	16	344	448	0	448	400	200	600	-152
Sum	16	344	448	0	448	400	200	600	-152

7.3 Results

In the scenario where the apartments were substituted with office buildings there were no inhabitants which make comparison of the results based on number of residents invalid. However, it is possible to compare the two alternatives using the settlement plot as reference (Figure 7-3). The results were used only to test the functionality of the comparison result part of the tool, not to get actual results, since the background data was not finalised and validated during the tool testing.

	Nedre Rommen	Nedre Rommen med næring
Quantities Residents	600	1
Quantities Settlement plot [m²]	1,070,000 [m²]	1,070,000 [m²]
Quantities Living area [m²]	26,900 [m²]	15 [m²]
Quantities Dwelling units	52.8	1
Quantities Degree of sealing	0.0024449689524228	0.0024028143153122
Energy Embodied energy [kWh] / residents	8,830 [kWh/residents]	7,750,000 [kWh/residents]
Energy Embodied energy [kWh] / Settlement plot [m²]	4.96 [kWh/m²]	7.26 [kWh/m²]
Energy Embodied energy [kWh] / unit	100,000 [kWh/unit]	7,750,000 [kWh/unit]
Emissions Greenhouse gases [kg CO2e] / residents	173,000 [kg CO2e/residents]	146,000,000 [kg CO2e/residents]
Emissions Greenhouse gases [kg CO2e] / Settlement plot [m²]	97.1 [kg CO2e/m²]	136 [kg CO2e/m²]
Emissions Greenhouse gases [kg CO2e] / unit	1,960,000 [kg CO2e/unit]	146,000,000 [kg CO2e/unit]

Figure 7-3. Screenshot from comparison view from the EE settlement tool

8 Case study Sluppen, Trondheim municipality

Sluppen development area in Trondheim municipality was chosen as a case study through their work in the research centre on Zero Emission Neighbourhoods in smart cities (FME ZEN, 2017-2024). The case was tested in 2021.

8.1 Case description

The municipal sub-plan for Sluppen is under development and the area is intended to connect the city of Trondheim together, from south to north and from east to west. The area plans promote facilitation for pedestrian, bicycle, and public transport into the city centre of Trondheim and the focus on mobility is high. The area should further increase the view of Trondheim city as an internationally acclaimed technology- and knowledge city and the area are part of both the FME ZEN, Smart city, and CityxChange projects and have a high focus on digital solutions, sustainability, and environmental issues (Trondheim kommune Byplankontoret, 2020). The area map is shown in Figure 8-1. There are different alternatives for rerouting the main roads in the area to make space for settlement development, depending on which solution is selected the area can have between 3500 dwellings up to 5000 dwellings.

Figure 8-1. Map over the case Sluppen, Trondheim municipality

8.2 Input data

The Figure 8-2 shows the map drawn out in the EE settlement tool with all corresponding housing and infrastructure elements. Since this was a test of the tool functionality not all buildings and infrastructure are added to the tool testing.

Figure 8-2. Screenshot of the settlement drawn in the tool in testing for case Sluppen

Table 8-1 shows the input data for the case of Sluppen. For the building parameters the main changes were to add a parking cellar, change building energy standard to passive house and to have district heating as energy source. The total number of people in the area was also increased by 1068 people.

Table 8-1. Input data for case study Sluppen, Trondheim municipality

Buildings

Name	Type	Number of buildings
KJELDSBERG boliger	TB Tall apartment block (Type 133) 6-8 floors	3
SMIDALEN bolig	AB Apartment building (Type 132) 4-5 floors	22
BRATSBERGBYEN	AB Apartment building (Type 132) 4-5 floors	16
NIDARVOLL boliger	TB Tall apartment block (Type 133) 6-8 floors	7
TEMPE boliger	AB Apartment building (Type 132) 4-5 floors	13
Kjeldsberg kontor	N-OB Office building (Type 311) - 4 floors	9

Infrastructure

Name	Type	Length	Number of infrastructures
NIDARVOLL infra	Sidewalk/bike path (without road)	720 [m]	1
Tempe	Sidewalk/bike path (without road)	0 [m]	1120

Demography

	Buildings		Suggestion based on buildings/dwellings added			User input for mobility calculations			
Building Type	Number of buildings	Number of dwellings	Adults	Children	Total number of people	Adults	Children	Total number of people	Difference suggestion vs. user inp
TB Tall apartment block (Type 133) 6-8 floors	10	700	700	0	**700**	1,000	100	**1,100**	-400
AB Apartment building (Type 132) 4-5 floors	51	1,632	1,632	0	**1,632**	2,000	300	**2,300**	-668
Sum	**70**	**2,332**	**2,332**	**0**	**2,332**	**3,000**	**400**	**3,400**	**-1,068**

8.3 Results

In the first test run of the quick results it became clear that some input data was faulty input as the plot area for infrastructure was larger than the total plot area (Figure 8-3). Adjusting the faulty input data gave a very different result (Figure 8-4) showing the importance of double checking the input values as well as the results and also showing how the tool can be used as a check for the input values.

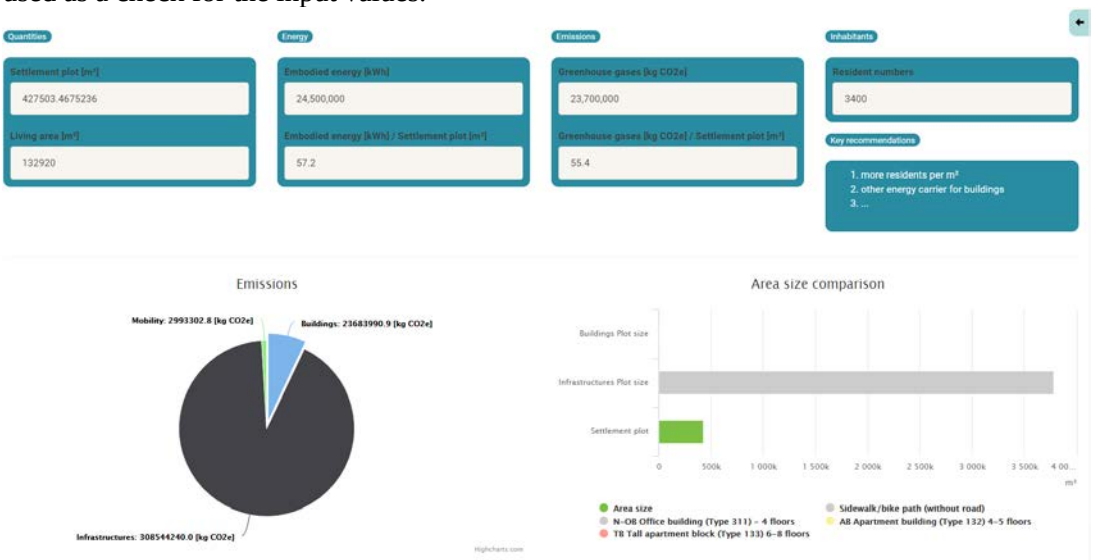


Figure 8-3. Screenshot from results for scenario with faulty infrastructure input

Figure 8-4. Screenshot from results for scenario with correct infrastructure input

9 Main findings and recommendations

Through the case study testing of the EE Settlement tool, the interviewees were also asked questions regarding their thought on the practical application of the tool and recommendations for further developments. They were asked questions regarding

- How is the availability of information requirements in the tool met?
- What type of decisions the EE Settlement tool could be used for?
- What criteria and aspects they see as important when planning a new area for development and how the EE Settlement tool contribute to answer out (social aspects, cost evaluations, etc.)?

This section summarizes the main findings from informal interview conducted during the tool testing. It summarizes the feedback from all case studies on the following topics related to the interview questions:

- Availability of input data – how easy or difficult is it for the users of the tool to get access to the data required for input into the tool to get relevant results.
- EE settlement tool as a decision support tool – discusses how the tool is useful in the planning process, in the work the urban planners do and the results they require to get.
- Important criteria and aspects in the planning process – identification of which aspects the urban planners need to focus on other than emission in the planning of new areas.
- Future recommendations – what do the interviewees see as useful extensions of the tool and further research areas.

9.1 Availability of data input

The availability of data input will vary depending on which stage of the planning the municipality is considering. For the case study that was in very early planning phase, some of the required data input was not decided upon and many assumptions would have to be made. A suggestion from one of the interviewees was that the tool could also show some uncertainty values in order to give a range of emissions instead of one single number.

The feedback in general was that the EE Settlement tool was easy to understand with regards to the input of data, and also easy to use as much of the data could also be kept as default values where specific values was lacking. They also see the usefulness of adding the data and having the input data represented as a whole, for example seeing the size of the area that is set of for infrastructure versus buildings.

9.2 EE settlement as decision support tool

For urban planners, the tool could potentially give important answers for evaluating and comparing different housing developments in the municipality. They thought that testing the completed version of the tool could help them to understand the difference between alternatives better, and the advantages and disadvantages of them.

The functionality of being able to duplicate a settlement in order to change certain parameters to make different scenarios was viewed as very useful for the urban planners as they can easily see the effect of changes in building stock, mobility parameters, and demography input. The potential for the tool to assess alternative configurations and measures for a specific settlement plot is described as important, by helping them to evaluate how different measures affect the environmental performance of the settlement. As an example, this could be used to evaluate whether to install ground source heat pump, build apartments in cross-laminated timber or to increase the frequency of the bus service from the settlement to reduce the environmental impact.

Several of the urban planners and developers saw the need for a "base case" or "reference scenario" for them to better understand how the settlement can be optimized compared to the standard. Many of the interviewees don't necessarily have in depth knowledge on environmental aspects and having a comparison can also make it easier to understand the numbers in the results part. As part of a larger municipal organization the urban planners see that more reporting on environmental aspects is being required for all planning phases and areas. The EE Settlement tool could provide the reporting needed to answer these questions.

9.3 Important criteria and aspects to evaluate in planning phases

Some urban planners think that including municipal cost for technical and social infrastructure would be very useful. However, there are also some of the interviewees that think the area with highest uncertainty and limited knowledge is on the environmental aspect and therefor this should be the focus rather than the social and technical cost aspects.

Other important criteria and aspects that should be evaluated during the planning phases in addition to the energy use and emissions, is information on densification, requirements to outdoor areas and other spatial qualities.

Several of the municipality had environmental and energy plan with high ambitions. Documenting the progress of the municipality in relation to achieving this ambitious plan, is something the tool could help them with.

9.4 Limitations and further recommendations

The EE Settlement tool was in general positively received by the participants in the case studies. They see many useful areas for the tool in their work.

It is important to mention that the tool testing for Norwegian case studies has focused on how the tool can be implemented as a decision support tool for municipalities, and not on the specific results for the case studies. The case studies have been used to have real life scenarios. However, with limited time available only partial information about the buildings, infrastructure and mobility have been inputted into the tool. In addition, the Norwegian case studies have not been tested with the final version of the tool since the final background data and both cost parameters and services are included in the very late stage of the project.

There are some suggestions that will further improve a tool to be able to use it even wider.

- The tool could show some uncertainty values in order to give a range of emissions instead of one single number.

- Many areas that the urban planners work with are areas with already existing infrastructure and buildings. Having a tool that could also evaluate transformation of areas would be of high interest.
- Several of the urban planners and developers saw the need for a "base case" or "reference scenario".
- In many of the early planning stages the development areas are quite large and very often divided into several sub-areas. It could be useful to have the possibility to input for each sub-area and add them together as needed as they usually follow different time schedule.

10 References

Breivika utivkling Bodø AS. (2018). *Planprogram - Utviklingsområde Vest.* Retrieved from https://bodo.kommune.no/omradereguleringsplaner/molobyen-article3062-2787.html

Elverum Vekst. (2017). *Ydalir masterplan Del 1 og Del 2.*

FME ZEN. (2017-2024). *Research centre on zero emission neighbourhoods*. Retrieved from https://fmezen.no/

Hamrevann. (n.d.). *Hamrevann home page*. Retrieved 06.03.2021, from https://www.hamrevann.no/

Kommunesektorens organisasjon (KS). (n.d.). *Noen fakta om nye kommuner fra 2020*. Retrieved 06.03.2021, from https://www.ks.no/fagomrader/demokrati-og-styring/kommunereform/noen-fakta-om-nye-kommuner-fra-2020/

Kristiansand Municipality. (2016). *Kommunedelplan for Hamrevann-området*. Retrieved 06.03.2021, from http://webhotel3.gisline.no/GisLinePlanarkiv/4204/1372/Dokumenter/KDPPB1372.pdf

Kristiansand Municipality. (2019). *Hamrevann - felt 1A og 1B*. Retrieved 06.03.2021, from https://www.kristiansand.kommune.no/navigasjon/bolig-kart-og-eiendom/plan-og-bygg/reguleringsplan/reguleringsplaner-under-arbeid/alfabetisk-liste/hamrevann---felt-1a-og-1b/

Marvika Utvikling AS. (2015). *Forslag til detaljregulering Marvikseltta senterområde*. Retrieved from http://webhotel3.gisline.no/GisLinePlanarkiv/4204/1363/Dokumenter/PB1363.pdf

Oslo kommune plan- og bygningsetaten. (2019). *Planprogram med veiledende plan for offentlig rom for Nedre Rommen.* Retrieved from https://innsyn.pbe.oslo.kommune.no/saksinnsyn/showfile.asp?jno=2019087987&fileid=8556666

SSB. (n.d.). *Population and land area in urban settlements*. Retrieved from https://www.ssb.no/en/befolkning/statistikker/beftett

SSB. (n.d.). *Registered vehicles*. Retrieved from https://www.ssb.no/en/statbank/table/11823

Trondheim kommune Byplankontoret. (2020). *Kommunedelplan for Sluppen - Planbeskrivelse.* Retrieved from https://drive.google.com/file/d/1M-x8LwEBz1psQwQ5Sn5lUeQZlmmG1EGA/view

Venås, C., Mellegård, S. (2018). Beregningsverktøy for bærekraftig by- og regionsutvikling. Identifisering av behov. SINTEF Notat 32. ISBN: 978-82-536-1602-5

11 Appendix 1 Interview guide

Part 1: Funksjonalitet

1. Har du noen generelle tilbakemeldinger på verktøyet? *(Er verktøyet brukervennlig?)*
    a. Er EE Settlement-verktøyet godt nok til å kunne brukes i din arbeidshverdag?
2. Hvilke deler av verktøyet bør det jobbes mer med?
    a. Har du noen spesifikke forslag som kan øke funksjonaliteten i verktøyet?
3. Hva av informasjonen som krevdes i verktøyet er det enkelt for dere å samle inn?
    a. Hva vil være vanskelig for dere å samle inn?
4. *Andre oppfølgingsspørsmål som kommer opp under test.*

Part II: Anvendelse og anbefalinger

- Hvilke verktøy som brukes (i planleggingssituasjonen) i dag er gode?
    a. Hvilke utfordringer knyttet til områdeutvikling er vanskelige å løse i dag, siden det mangler verktøy (evt. at verktøy er utilstrekkelige)?
- Ved hvilke typer beslutninger (i hvilke situasjoner/sammenheng) tror du verktøyet kan være nyttig?
    a. Hvilke typiske boformer og bosettingsmønstre ville være mest relevant for dere å evaluere i planprosessen?
- Hva er de viktigste kriteriene/aspektene i planleggingen av områdeutvikling i dag?
    a. Hvilke sosiale aspekter skulle du ønske et verktøy kunne bidra til å evaluere?
    b. Hvilke kostnader er viktigst å inkludere i et slikt evalueringsverktøy?

c. Hva er de viktigste manglene i verktøyet – hvilke viktige aspekter får man ikke evaluert?

12 Appendix 2: Meeting agenda

Agenda for møtet:

1. Kort presentasjon av prosjektet og verktøyet (10 min, presentasjonen er vedlagt). Ved interesse om prosjektet, se også nettsiden: https://www.sintef.no/projectweb/eesettlement/
2. Uttesting av verktøyet (60 min)
    a. Vi håper at du/dere kan registrere dere på forhånd, slik at dere har tilgang til verktøyet. Følgende er nettadressen til verktøyet: https://akaryon-development.com/ee-settlement/public/
    b. Det ville være flott om vi kunne bruke Ydalir som eksempel under gjennomgangen. I verktøyet må man fylle inn informasjon om boligområdet vi skal vurdere. Dersom det er tilgjengelig, er det flott om du kan ta med følgende informasjon:

Bygninger	Minimum	Antall bygninger av hver bygningskategori (eneboliger, rekkehus, leiligheter)
	Valgfri	Energistandard Energisystem Gjennomsnittlig BRA for ulike boligtyper Bygningsstandard (TEK17/Passivhus) Konstruksjonsmaterialer (Betong, tre eller massivtre) Ekstern garasje (Ja/nei)
Infrastruktur	Minimum	Lengde på veier av ulik standard (angitt av veibredde: 4,5 m, 5,5 m, 6 mm 7 m eller 7,5 m)
	Valgfri	Inkludere fortau/sykkelvei (ja/nei) Inkludere nedgravd infrastruktur som VA-rør, strømkabler eller fjernvarme (Ja/nei) Inkludere gatebelysning (ja/nei) Utbyggingsområdet i vanskelig terreng (ja/nei)
Mobilitet	Estimere	Avstand til regionalt senter og befolkningsantall for dette tettstedet Hvor ofte det går kollektivtransport i nærheten av området Omtrentlig antall innbyggere i det planlagte boligområdet, med fordeling barn/voksne Totalt antall innbyggere i nærområdet - innen en radius på en kilometer (ant. innbyggere/m2) Antall innbyggere og antall jobber i en radius på 5 km fra området.

Det har ikke noe å si om en del data ikke er tilgjengelig (siden det er default-verdier tilgjengelig i verktøyet). Det er et poeng at man skal få resultater uten at all data er kjent.

    c. Det trengs ingen annen forberedelse, og vi går igjennom og prøver å lage modellen for utbyggingsområdet vi har blitt enige om på forhånd. Flott om du da kan dele skjermen din under testingen.
3. Diskusjon om funksjonaliteten til verktøyet og implementering av verktøyet i planleggingen (se vedlegg) (30 min)
4. Kort diskusjon om evt. videreutvikling av verktøyet (20 min)

EE Settlement – Norwegian case studies

The vision of the project *EE Settlement – Embodied Energy, Costs and Traffic in Different Settlement Patterns* is to provide a decision support tool and a guideline which enable municipal planners and other stakeholders to assess the expected impacts of new developments in early planning stages. The main goal of performing case study tool testing is to get insight into how the EE Settlement tool performs when being used by the end-user.

This report gives an overview of the findings from testing the functionality of the tool as a decision support tool in Norwegian case studies. The report also summarizes the feedback from different municipalities involved in the tool testing on the tool functionality, user friendliness and how the tool can be practically applied as a decision support tool in the field of work.

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