Nicole Dolezal, NTNU Master’s Student

Social Effects of a Sustainable Positive Energy Neighborhood in Norway

Master's thesis in Sustainable Architecture

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Supervisor: Niki Gaitani

Norwegian University of Science and Technology
Department of Architecture

NTNU – Trondheim
Norwegian University of Science and Technology

Abstract

Climate change today has already begun to impact the way that humans interact with the environment around them. In Verksbyen, Fredrikstad, a sustainable positive energy neighborhood is underway. The design decisions that are made for the neighborhood should be prepared to accommodate in the event of negative climate change, while also fitting within the narrative of its location. The cultural and social aspect of the Fredrikstad area also needs to be considered in decisions. In order to find results, a quantitative survey will be administered. Given the social context, the most suitable design decisions may not be the best option for the area. Further insight into the background of the area will be conducted through data driven research of the city and its population. The results of this research should create a better understanding of the considerations to take into account in future neighborhoods and direct others to suitable design solutions.

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Abbreviations

AE	Affordability of Energy
AH	Affordability of Housing
AS	Access to Services
BIPV	Building Integrated Photovoltaic
DC	Demographic Composition
IPCC	Intergovernmental Panel on Climate Change
KPI	Key Performance Indicator
LC	Living Conditions
PED	Positive Energy District
PV	Photovoltaic
SPEN	Sustainable Positive Energy Neighborhood
SSB	Statistisk Sentralbyrå
WP	Peak Watt

1 Introduction

The world has become more aware of the changing climatic conditions that the earth is facing today. The most recent IPCC climate report has indicated that there must be action taken immediately to secure a livable future.[1] The transition to clean energy is happening now and the introduction of sustainable positive energy neighborhoods may be considered an end goal in many countries. In Norway, renewable energy already makes up 98% of all produced energy, with hydropower producing the majority of that.[2] The same cannot be said for the rest of the world. Only 29% of electricity production in the world is done so through renewable means.[3] The advancement of sustainable positive energy neighborhoods could be a means to help the transition to renewable energy.

A focus that will be taken in this thesis is the social effect of these neighborhoods on the people that will inhabit them. Various angles will be viewed in order to assert the social quality that the neighborhoods will provide. Introduction to the details of this research will follow, including the location of the study, methodology, and relevant background information. A question that will be prevalent throughout this thesis is if these neighborhoods will have a positive effect on those who reside in them. The introduction of SPEN's may be positive for the environment, but the social effect that they have on residents should also be considered.

1.1 Case Study

The case study used in this thesis will be Verksbyen, located in Fredrikstad, Norway. The buildings in this neighborhood are created by the development group, Arca Nova Gruppen. Their aim is to provide housing that is affordable, while still upholding a green building standard.[4] This is a project that is currently in development, and the portions of the study that are used in this thesis have yet to receive occupants, therefore much of the research that is conducted is done so based off of collected data from Fredrikstad.

Verksbyen incorporates technology such as PV's and a smart house operating system, the first of which will be reviewed in this thesis. The neighborhood itself will also be involved as it is expected to heavily influence the social aspect of life for the users. The neighborhood will be held to syn.ikia's social KPI's, which will be introduced in the background portion of this study.

1.2 Research Objectives

For Norway and other countries that are already more secure in energy, looking into the development of sustainable positive energy neighborhoods is a more obtainable possibility. While developing these neighborhoods though, it will be important to think about the possible social effects that such a project can have on the end users. While the neighborhood

[1] Pörtner et al., "IPCC, 2022: Summary for Policymakers."
[2] Energy, "Renewable Energy Production in Norway."
[3] REN21, "Renewables 2021 Global Status Report."
[4] Arca Nova Gruppen, "Verket Panorama."

will have an effect on the users, design options in the buildings that they will inhabit will also influence them socially.

The main objectives of this thesis are to find out what the social effects of a sustainable positive energy neighborhood have on the people that inhabit it. Transitioning to these types of neighborhoods may have a positive effect on the environment, but it should be done in a way that can benefit the end users rather than hinder them. The objective is for the results of this study to help determine if these neighborhoods may be sustainable for those who inhabit them, and if not, what can be done to change that.

1.3 Research Questions

From the research objective, the primary question of this thesis can be known as the following:

1. **What are the social effects of a sustainable positive energy neighborhood on its residents?**

In order to answer this primary question, secondary questions are posed. These questions are refined to fit the different categories that fall within the main question and are as follows:

S1. What are the effects of the technical system on residents?

S2. What are the effects of the materials on residents?

These two questions are posed are they directly influence the pricing for the homes, which in turn will reflect on the monthly expenses for residents through their mortgage or rent. While the pricing for the housing used in this study has already been determined, this information is still relevant due to the savings that it can achieve for the building, and therefore the residents.

S3. How do social KPI's do in this neighborhood?

S4. What are the long-term effects of this neighborhood on its residents, socially?

While the first two sub questions focus on pricing, questions 3-4 focus on the social aspect. This includes a focus on social KPI's, which will be introduced in the background portion of the thesis. They present an emphasis on not just the present, but also the future of the neighborhood.

1.4 Thesis Structure

The remainder of this thesis will be structured as follows:

- 2 Background: Relevant background information introduced.
- 3 Methodology: Explanation of the process that this thesis will take, including methods of research.
- 4 Results: Overview of the results on the family groups from the pricing and social effect chapters.
- 5 Discussion: A discussion of the results takes place, with thoughts regarding the limitations and long-term outcome of the study included.

- 6 Conclusion: Final thoughts regarding the study are conveyed, along with ideas for future additions to the study.

2 Background

This section will look into the background that is necessary to understand the thesis. The first information that will be highlighted is more material regarding the case study, in this instance the neighborhood that it is situated in. This is relevant as each SPEN is likely to have different surroundings, so knowing what the area is like for Verksbyen should be noted.

The social KPI's are also introduced and reviewed in this chapter. They will introduce the categories that will be followed throughout the rest of the study. The KPI's also directly influence the methodology of this thesis.

The literature review will be summarized in this portion as well. Literature is collected here and referenced in the methodology portion of the thesis. This includes collecting data that has already been established by other sources.

2.1 Verksbyen, Fredrikstad

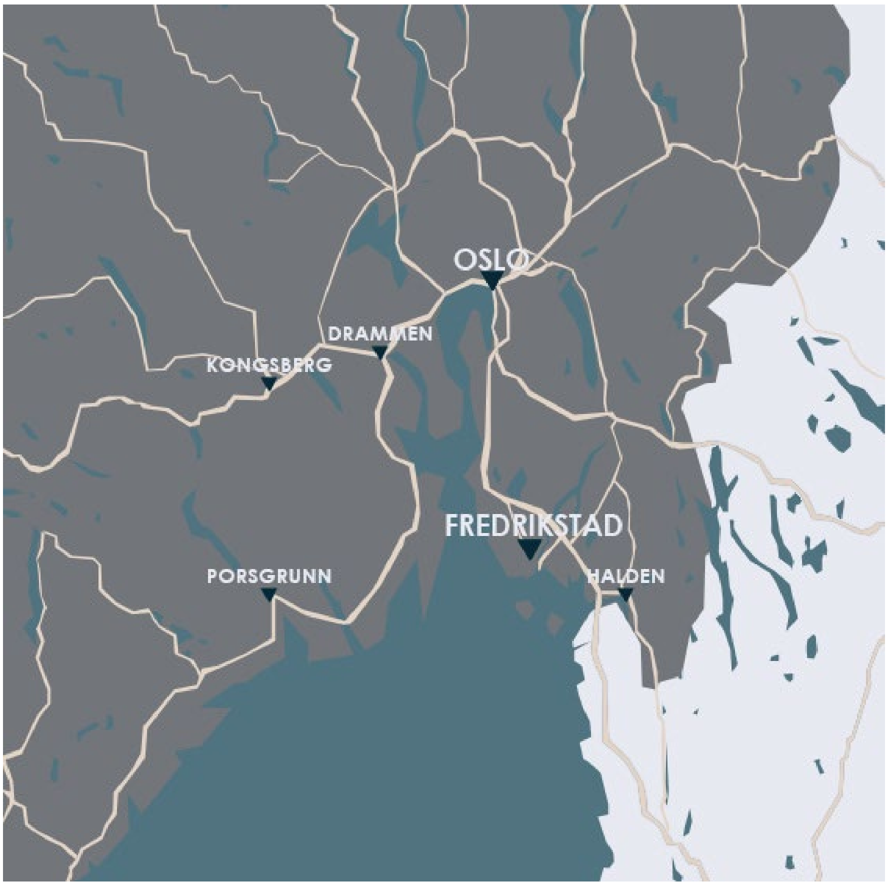

Figure 1: Overview map of surrounding area near Fredrikstad.

Fredrikstad is a city of 69,568 people that is located in the southeastern area of Norway, or roughly 100 kilometers south of Oslo.[5] Verksbyen is a neighborhood within the city. A closer

[5] "Statistics Norway."

look into Verksbyen allows a view of what the environment there will be like, such as where grocery stores, schools, and health clinics are. A main circle with a 1-kilometer diameter is drawn to indicate which services are immediately nearby, and which are further away. As seen in Figure 2, the three main facilities are all within a 1-kilometer range, with more options being available beyond it. The reason for the 1-kilometer range is that once one gets beyond that, not only is a walking range of over 10 minutes occurring for some areas, but they would also be leaving the Verksbyen neighborhood at that point. Main roads have been illustrated that connect the city, while local roads have been emphasized in or near Verksbyen.

Figures A.1-3 illustrate the coverage of these buildings independent from each other.

Figure 2: Nearby services, data collected from Google Maps[6].

[6] "Google Maps."

2.2 Social KPI's

In order to gauge the social aspect of this, social KPI's from syn.ikia are used in this research. The KPI's that will be observed in this study have been highlighted are as follows:[7]

1. Affordability of Energy (AE)
2. Affordability of Housing (AH)
3. Access to Services (AS)
4. Demographic Composition (DC)
5. Living Conditions (LC)

While the remaining KPI's are also relevant, they will not be focused on in this research.

[7] Andresen et al., "WP3 Technology Integration in Smart Managed Plus Energy Buildings and Neighborhoods - D.3.1 Methodology Framework for Plus Energy Buildings and Neighborhoods," 3.

Social KPI's from syn.ikia

Category	Sub Category	KPI Type Sub/Core	KPI	Used
Social Performance	Equity	Sub	Access to Amenities	
		Core	Access to Services	■
		Core	Affordability of Energy	■
		Core	Affordability of Housing	■
		Core	Democratic Legitimacy	
		Core	Living Conditions	■
		Sub	Sustainable Mobility	
		Sub	Accesible or Universal Design	
	Community	Sub	Demographic Composition	■
		Sub	Diverse Community	
		Core	Social Cohesion	
	People	Core	Personal Safety	
		Core	Energy Consciouness	
		Sub	Healthy Community	

Table 1: syn.ikia KPI's[8]

[8] Andresen et al., "WP3 Technology Integration in Smart Managed Plus Energy Buildings and Neighborhoods - D.3.1 Methodology Framework for Plus Energy Buildings and Neighborhoods."

2.3 Inclusion of Energy Pricing

The need for the inclusion of energy pricing is due to it being relevant in calculating the expected electricity bills that the residents will be paying every month. While this is included in the background portion of the thesis, a portion of it can also be considered to fit in to the methodology portion. It has been placed here, however, as there is information gathered that is relevant for other portions of the background section.

2.3.1 Energy Pricing

In Norway, the total consumption of electricity for the year 2020 was 211 TWh. A total of 22% of that is consumed by households, and the average household in Norway uses roughly 16,000 kWh of electricity per year.[9] Statnett predicts that energy usage will rise in the next 20 years throughout Norway, however, as their study does not include an exact number for predicted household energy usage, the current average will be used in this study.[10] The Norwegian Water Resources and Energy Directorate have also made a prediction that energy consumption will increase by 2030, and has noted the importance of energy efficiency.[11]

It is acknowledged that energy pricing varies throughout Norway, with prices in the south often being more expensive than in the north. Recently, there has been a sharp increase in the price of electricity in Norway. This can be seen in Figure 10. Various spikes have occurred in the past, normally due to extended dry seasons, however, they have never reached recent levels.[12]

The future of energy prices is constantly fluctuating. As seen in Statnett's "Long-term Market Analysis 2020-2050", an update made to the report in early 2021 has already revised their estimates, indicating that energy will increase more than what they had originally predicted. Their current estimate is that in Southern Norway, electricity will increase to roughly 50 euros per MWh, or 51 øre/kWh, which is actually cheaper than what is currently being recorded.[13]

This makes it apparent that the report must once again be updated, as current affairs and conditions have likely influenced prices, and will likely continue to do so. This matter alone makes it clear that the future of electricity is difficult to predict, as there are many different unexpected factors that can throw off predictions. If the current prediction is used that energy will increase throughout the next decade, it can be assumed that energy bills will become more difficult to pay in the future. Statnett has, however, reported that they predict energy prices to lower by 2040.[14]

Using the most recent data for energy pricing, the energy bills for the families will be calculated using the 16,000-kWh average. Bills will also be calculated for the lowest recorded point in the past five years, and the 51 øre/kWh estimate from Statnett. Statnett published their report in spring of 2021, and the previous year, 2020, had an average

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[9] "Energy Use by Sector."
[10] Gunnerød et al., "Long-Term Market Analysis 2020-2050."
[11] "Energieffektivisering - NVE."
[12] "Statistics Norway."
[13] Gunnerød et al., "Long-Term Market Analysis 2020-2050."
[14] Gunnerød et al.

electricity rate of 19,57 øre/kWh. As they had predicted an increase in price of 168%, a new price using the same change of percentage will also be used.

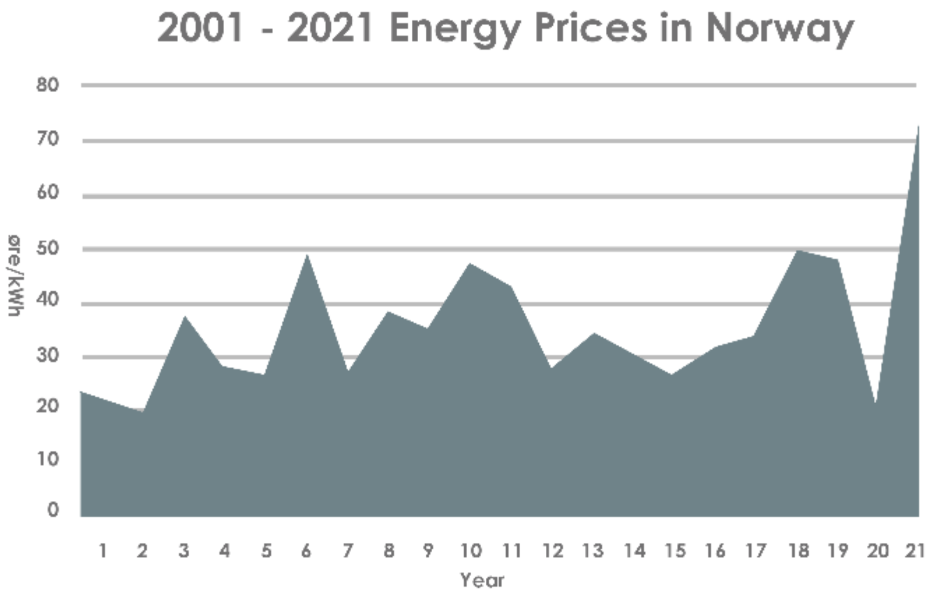

Figure 3: 2001-2021 Energy Prices in Norway, data from SSB.[15]

Energy Price	Energy Bill
5-yr low 14 øre/kWh	2240 NOK/year 186 NOK/month
2021 Quarter 4 108 øre/kWh	16,640 NOK/year 1386 NOK/month
Statnett 2030 Prediction 51 øre/kWh	8160 NOK/year 680 NOK/month
New 2030 Prediction 279 øre/kWh	44,640 NOK/year 3720 NOK/month

Table 2: Energy Bills

2.3.2 Energy Poverty

Energy poverty has been increasing in recent years, and the reason behind it can be apparent in the previous section. Energy prices have increased over 600% from the 5 year low in comparison to the final quarter of 2021. If this rate continues, energy poverty will become more apparent in Norway.

A report by T.L. Bredvold mentions that, "…in the context of research on energy poverty in Europe, Norway is generally unexplored territory." He does continue to mention that there are very few statistics on Norway as many reports of energy poverty in Europe normally

[15] "Statistics Norway."

come from the EU, which Norway is not a part of. He also notes that in 2016, only 2.4% of Norwegians "…were behind on paying the electricity bills."[16]

Since 2016, though, the prices of electricity have surged. Bredvold's report itself was published in December of 2020, before the spike in costs. He notes that one of the ways to cope with energy poverty is to invest in energy efficiency measures.[17] This is, in fact, a measure that Arca Nova Gruppen is taking with Verksbyen. The homes will have a smart house feature that aims to reduce electricity consumption by automating features such as lighting, heating, and cooling, along with other measures.[18]

An article that addressed the EU notes that a solution to energy poverty is to require countries to mandate measures protecting those at risk of it. An example of which includes ensuring that it will not be possible to cut off power to residents who are unable to afford their electricity bills.[19]

As seen in Table 2, it is difficult to tell what the price of electricity will be tomorrow, but it is beneficial for Verksbyen to already have energy efficiency methods installed. This will be beneficial for the residents, and hopefully help reduce their total energy consumption.

[16] Bredvold, "Where No One Is Poor, and Eneregy Is Abundant: A Study of Energy Poverty in Norwegian Households."
[17] Bredvold.
[18] Arca Nova Gruppen, "Verket Panorama."
[19] Dobbins et al., "Strengthening the EU Response to Energy Poverty."

2.4 Technical Systems

Multiple technical systems can be looked at when considering Verkbyen, however, only the photovoltaic system will be considered in this study. The cost of the system will be looked into, along with the benefits of it. The current prices at Verksbyen have already been set for the housing that is used in this study, however, as the energy prices are also being looked at later on, it is important to see how they will be able to affect the buildings in reducing the cost of energy on the residents.

In addition, glazing options for the building will also be considered, particularly the prospect of picking either double or triple pane glazing.

2.4.1 PV System

Verksbyen will be incorporating a BIPV system in their building design. The building that is used for reference is House L from Verksbyen's Panorama, the plan for which can be seen in Figure A.4. It is estimated that the annual solar radiation for the south of Norway is 1100 kWh/m^2 and that the cost for them is 1000 NOK per m^2, however, 20% of solar radiation being lost from reflection will also be accounted for in upcoming calculations.[20]

Roof Area	388 m^2
Total Cost	388,000 NOK
Annual Energy	341,440 kWh/m^2
Annual Savings	14 øre/kWh: 47,801 NOK 108 øre/kWh: 368,755 NOK 51 øre/kWh: 170,720 NOK 279 øre/kWh: 921,888 NOK

Table 3: PV Information

Now that the total cost has been determined, calculation of the payback period will also be calculated. The interest rate used is 5.5%, as various figures have been found for it. An offer from Otovo, though, mentions that they would offer this rate through loans made with SpareBank 1.[21] The monthly payment requirements using this rate would be roughly 4200 NOK.

Total Payback Period	14 øre/kWh: 8.5 years 108 øre/kWh: 1.3 years 51 øre/kWh: 2.5 years 279 øre/kWh: 7 months

Table 4: Payback Period for BIPV's

The payback period for the BIPV results in some very generous calculations. This is due to the fact that the information has been calculated using the maximum possible kWh possibly from the PV's, with no accounting for errors or faults. It is to be expected though that if energy prices increase, the payback period will become shorter. It could also be speculated that this would drive the demand for PV's in the market up, and in return sharpen their price. Solar Together also notes that the standard payback period is generally 12-26 years.[22]

[20] Sweco AS et al., "Kostnader ved produksjon av kraft og varme."
[21] "Otovo debuts Nordic solar loan offer | Otovo."
[22] "How Long until Solar Panels Pay for Themselves?"

Perhaps the results are skewed due to such a heightened electricity price, the fact that there are no errors accounted for in the calculations, or both.

2.5 Materials

To provide more depth to this study, a look in materials will also be done. Specifically, the glazing. Both double paned, and triple paned glazing are looked at in this instance. A determination of whether or not Verksbyen should consider using one or the other types of glazing will be concluded.

2.5.1 Glazing

As Norway is located in a cold climate, it is important to prevent the loss of heat through windows, so a low U-value is crucial in these climates. In a study done on double pane versus triple pane glazing, it has been found that in the United States, the majority of Energy Star rated buildings have switched to using triple pane windows.[23]

Another discovery is that price is not the first factor that the builders in a survey conducted by this study prioritize. A total of 69% of builders first prioritize performance, followed by 59% then considering price. It is noted that triple pane glazing is the preferred option due to the fact that it outperforms double pane glazing in many instances including:[24]

- Noise Reduction
- Reduction of Condensation
- Durability

The most often reason that triple pane windows are not selected is due to the cost. Depending on the order size, the difference in price between double and triple pane windows can up to a 3x difference.[25]

As the building's are already saving a significant amount due to the BIPV's, it may not be a bad idea invest in the triple pane windows. They have been noted to create a better living condition, as they reduce the amount of outdoor noise pollution that makes it inside. They also have a lower U-value and can prevent heat loss, which is all the more important in cold climates such as Norway.

[23] Gilbride et al., "Double or Triple? Factors Influencing the Window Purchasing Decisions of High-Performance Home Builders."
[24] Gilbride et al.
[25] Gilbride et al.

3 Methodology

Now that the literature review has been conducted, an introduction to the methodology of this thesis may begin. A survey methodology is used to understand the social context of the neighborhood that the case study takes place in. The survey focuses on quantitative responses so that it can be fully answered in the case that there are no users available, which is the current case. From the survey, research methods driven by data collection are conducted.

The relevance of the case study is important when considering aspects of the questions such as housing and energy pricing. The tables from the energy pricing section of the thesis will be heavily referenced in the upcoming research.

3.1 Social Indicator Survey

The social indicator survey consists of ten questions that can all be categorized within the syn.ikia social KPI's. Several of the questions are derived from a survey created by syn.ikia, and are indicated as such. The process of selecting the questions was heavily influenced by the literature review. The rankings of the social KPI's done by syn.ikia was referenced, followed by the practicality to quantitatively answer questions. The questions are meant to help answer S3 and S4, by focusing on the social impact on future residents. The questions are listed in table 2 below. [26]

Immediately, several questions can be answered by referencing information that has already been discovered. The answer to question 6 is that there are services available to the inhabitants, with more options available beyond 1 kilometer distance if desired.

[26] Andresen et al., "WP3 Technology Integration in Smart Managed Plus Energy Buildings and Neighborhoods - D.3.1 Methodology Framework for Plus Energy Buildings and Neighborhoods."

Social Indicator Survey

Q #	Question	Type	syn.ikia
Q 1	Based on predicted energy prices, what will be the expected income spent on energy for families?	AH/AE	
Q 2	Is there any possibility for the families to be unable to pay their utility bills on time due to financial difficulties based off their predicted income?	AH/AE	X
Q 3	What is the estimated cost that will be spent by the families on rent, mortgage, maintenance, and dwelling related services?	AH	X
Q 4	What is the likelihood of the dweller to spend a higher share than 40% of their equivalized disposable income on housing?	AH	X
Q 5	What are the predicted household sizes and distributions in this area?	LC	
Q 6	Will the inhabitant(s) have adequate access to services (education, health, etc.)?	AS	
Q 7	What are expected energy prices throughout the next 20 years?	AE	
Q 8	What are the recorded energy prices of the previous 20 years?	AE	
Q 9	The whole dwelling unit is not overcrowded, meaning more than 30m2 for 1 bedspace unit, and 45 m2 for 2 bedspace units.	LC	X
Q 10	Is the household annual equivalized income less than 6478 EUR?*	DC	X

Table 5: Social Indicator Survey – questions from syn.ikia are marked.

3.2 Family Scenarios

To get a gauge for what families may experience with the introduction of sustainable positive energy neighborhoods, several test families were created. These groups were made using publicly available data from SSB, with the majority of the information being directly related to Fredrikstad. The data collected here helps to answer Q5 from the survey, as it helps to determine that family types that need to be created. Four different family types were created, each having different circumstances that future users in Verksbyen could have.

The housing within Verksbyen has also been considered and narrowed down to two possible options for the families. Mortgage and rent rates are calculated for the housing types so that they may be helped to answer Q3 and Q4.

3.2.1 Housing Options

The housing that is used for families are units from Verksbyen's Panorama's Hus L. Two separate units have been chosen and will be considered for the family groups. There will be a possibility that a family could comfortably live in either housing type, or that only one type will be suitable for them.

A mortgage is calculated using the mortgage rate for green homes from DNB, which is currently 2.09%.[27] In this instance, it is assumed that a principal loan will be taken out for the home save for the down payment. The mortgage payment equation will be used in which:

$$M = P \frac{r\,(1 + r)^{n}}{(1 + r^{n}) - 1}$$

M = Mortgage Rate
P = Principal Loan
r = interest rate
n = lifetime payments of mortgage

Figure 4: Mortgage Payment Equation[28]

A repayment time of both 20 and 30 years will be used in this calculation. The results from these calculations will be used in satisfying Q3 and Q4.

[27] "Price List Loans - DNB."
[28] "Mortgage Calculator."

Figure 5: Housing B, image from Arcanova[29]

Figure 6: Housing A, image from Arcanova[30]

Housing Type	Total unit space (m^2)	Price	Expected Down Payment*	Expected Mortgage – 20 yrs	Expected Mortgage – 30 yrs
Housing A	$64m^2$	4,445,000 NOK	666,750 NOK	19,267 NOK/month	14,133 NOK/month
Housing B	$74m^2$	5,095,000 NOK	764,250 NOK	22,085 NOK/month	16,196 NOK/month

*15% mortgage rate used.

Table 6: Housing Types

Housing A Yearly Payments	20-Year Repayment: 231,204 NOK 30-Year Repayment: 169,569 NOK
Housing A Yearly Payments w/ Electricity – 20 Year	14 øre/kWh: 233,444 NOK 108 øre/kWh: 247,844 NOK 51 øre/kWh: 239,364 NOK 279 øre/kWh: 275,844
Housing A Yearly Payments w/ Electricity – 30 Year	14 øre/kWh: 171,809 NOK 108 øre/kWh: 186,209 NOK 51 øre/kWh: 177,729 NOK 279 øre/kWh: 214,209 NOK
Housing B Yearly Payments	20-Year Repayment: 265,020 NOK 30-Year Repayment: 194,352 NOK

[29] Arca Nova Gruppen, "Verket Panorama."
[30] Arca Nova Gruppen.

Housing B Yearly Payments w/ Electricity – 20 Year	14 øre/kWh: 267,260 NOK 108 øre/kWh: 281,660 NOK 51 øre/kWh: 273,180 NOK 279 øre/kWh: 309,660 NOK
Housing B Yearly Payments w/ Electricity – 20 Year	14 øre/kWh: 196,592 NOK 108 øre/kWh: 210,992 NOK 51 øre/kWh: 202,512 NOK 279 øre/kWh: 238,992 NOK

Table 7: Annual Mortgage and Electricity Payments

The housing types both satisfy question 9 from the survey, as they both cover the total meterage that is needed to avoid overcrowding, therefore in that respect they are both suitable for the family groups to inhabit.

Another important statistic to note is that according to SSB, a survey from 2012 records that the average housing expenses at that averaged to be 31% of a household's income. It should also be noted that the average household size in Norway is 2.15.[31]

[31] "Statistics Norway."

3.2.2 Family A

Figure 7: Family A

The first family consists of a family of four, with two adults under the age of 45, and two children under the age of 6.

Despite their income being the highest of the four family types, they may have issues due to also having the largest household.

Composition	Two adults under 45 and two children under 6.
Yearly Income After Tax	846,400 NOK
Equivalized Income After Tax	211,600 NOK
Q2 – Inability to pay electricity bills.	The family will always be able to make their full bills, however, it may be more difficult for them than the other family types. It is apparent that if the cost of electricity goes up to 279 øre/kWh, they will likely have difficulties as that would put them far above their equivalized income.
Q3 – estimated cost for families spent on bills.	Reference Table 7
Q4 – more than 40% of equivalized income on housing (84,640 NOK)	Housing A 20-Year Repayment: Yes – 109% Housing A 30-Year Repayment: Yes – 80% Housing B 20-Year Repayment: Yes – 125% Housing B 30-Year Repayment: Yes – 91%

Table 8: Family A Information

3.2.3 Family B

Figure 8: Family B

Family B consists of two adults over the age of 65. Their average income is seen as being reduced than those under 65, likely due to the retirement age in Norway being 61, meaning that they could possibly be living off of pensions.

Composition	Two adults over 65
Yearly Income After Tax	615,700 NOK
Equivalized Income After Tax	307,850 NOK
Q2 – Inability to pay electricity bills.	This family will not have the inability to pay their electricity bill. Reference Table 2.
Q3 – estimated cost for families spent on bills.	Reference Table 7
Q4 – more than 40% of equivalized income on housing (84,640 NOK)	Housing A 20-Year Repayment: Yes – 75% Housing A 30-Year Repayment: Yes – 55% Housing B 20-Year Repayment: Yes – 86% Housing B 30-Year Repayment: Yes – 63%

Table 9: Family B Information

3.2.4 Family C

Figure 9: Family C

Family C is a couple under the age of 45 with no children in the household.

Composition	Two adults under 45, no children in household.
Yearly Income After Tax	684,200 NOK
Equivalized Income After Tax	342,100 NOK
Q2 – Inability to pay electricity bills.	So far, this family type is the one that will have the most ease in making their payments. Reference Table 2.
Q3 – estimated cost for families spent on bills.	Reference Table 7
Q4 – more than 40% of equivalized income on housing (84,640 NOK)	Housing A 20-Year Repayment: Yes – 67% Housing A 30-Year Repayment: Yes – 49% Housing B 20-Year Repayment: Yes – 77% Housing B 30-Year Repayment: Yes – 56%

Table 10: Family C Information

3.2.5 Family D

Family D consists of a single adult that is under the age of 45. It is important to include this family type, as nearly 1 in 5 Norwegian citizens live alone.[32]

Figure 10: Family D

Composition	Two adults under 45, no children in household.
Yearly Income After Tax	332,500 NOK
Equivalized Income After Tax	332,500 NOK
Q2 – Inability to pay electricity bills.	This family will be able to pay their electricity bills. Reference Table 2.
Q3 – estimated cost for families spent on bills.	Reference Table 7
Q4 – more than 40% of equivalized income on housing (84,640 NOK)	Housing A 20-Year Repayment: Yes – 69% Housing A 30-Year Repayment: Yes – 50% Housing B 20-Year Repayment: Yes – 79% Housing B 30-Year Repayment: Yes – 58%

Table 11: Family D Information

[32] "Statistics Norway."

4 Discussion

Now that the studies have been concluded, a discussion of the results may occur. All ten questions have been answered and assembled here. Reasoning and thoughts regarding the answers will be discussed. The mention of long-term effects will also be pondered while referencing the results. Limitations that may have hindered the study, along with solutions as to what could be done differently is also deliberated.

4.1 Results

#	Social Indicator Survey	Type	syn.ikia
Q1	Based on predicted energy prices, what will be the expected income spent on energy for families?	AH/AE	
A1	Reference Table 2.		
Q2	Is there any possibility for the families to be unable to pay their utility bills on time due to financial difficulties based off their predicted income?	AH/AE	X
	Reference 3.2 Family Scenarios		
Q3	What is the estimated cost that will be spent by the families on rent, mortgage, maintenance, and dwelling related services?	AH	X
	Reference 3.2 Family Scenarios		
Q4	What is the likelihood of the dweller to spend a higher share than 40% of their equivalized disposable income on housing?	AH	X
	Reference 3.2 Family Scenarios		
Q5	What are the predicted household sizes and distributions in this area?	LC	
	Answered through SSB in 3.2 Family Scenarios.		
Q6	Will the inhabitant(s) have adequate access to services (education, health, etc.)?	AS	
A6	Yes – the inhabitant will have immediate access to services as seen in Figure 2.		
Q7	What are expected energy prices throughout the next 20 years?	AE	
A7	Difficult to assume. Reference 2.3.1 Energy Pricing.		

Q8	What are the recorded energy prices of the previous 20 years?	AE	
A8	Reference Figure 3.		
Q9	The whole dwelling unit is not overcrowded, meaning more than 30m^2 for 1 bedspace unit, and 45 m^2 for 2 bedspace units.	LC	X
A9	The dwelling has been found to not be overcrowded, as seen in Table 6.		
Q10	Is the household annual equivalized income less than 6478 EUR?* 6478 EUR = 66,146 NOK as of 18/05/2021	DC	X
A10	No. Family A = 211,600 NOK Family B = 307,850 NOK Family C = 342,100 NOK Family D = 332,500 NOK		

Table 12: Social Indicator Survey and Answers

As seen in the results, it is apparent that Family A would have the most difficulty in keeping up in this new neighborhood. Even with the lower mortgage rate from Hus L being a green building, they are constantly nearing, or exceeding their rate of equivalized income to costs. The reduction, or elimination of energy bills would benefit them significantly, and as noted in Table 3, there should be a significant burden lifted from the energy bills due to the building's BIPV system.

4.3 Social Effects

In question 4 from the survey, it is found that every family will spend at least 40% or more of their annual equivalized income on housing. Most family types are still able to operate within their means. The only family that runs a risk is Family A, as they expend over 100% of their equivalized income in certain scenarios. A solution for them would be to live in the cheaper housing option, housing A, or to get a different mortgage, such as one with a longer payback period. At it's most expensive, however, Family A is still spending less than 40% of their total income on housing and bills, which is closer to the range that SSB found in their survey.

4.4 Possible Long-term Effects

The most pressing long-term effect is that of energy prices. If the users are to live in a sustainable positive energy neighborhood, they will not experience the brunt of the energy hike like how those outside of SPEN's would. With the reduction of energy costs and the incorporation of energy efficiency measures in Verksbyen, residents will likely be able to have an easier time until the energy prices decrease in 2040 as predicted by Statnett.[33]

If this neighborhood creates happy end-users, it can be expected that more SPEN's will be able to be developed, whether it be by Arca Nova Gruppen, or another developer. The

[33] Gunnerød et al., "Long-Term Market Analysis 2020-2050."

expansion of SPEN's will help ease energy costs for many residents, and as noted in the previous survey, while these neighborhoods may be considered slightly expensive for the residents, the cost is not significant enough that it should deter buyers.

4.5 Limitations

Several limitations have been noted already but will be reviewed now. These limitations impede the ability to have a more reliable answer to the research question, however, not to the point that the question is unanswerable.

4.5.1 Lack of Interviewees

A significant limitation is that the case study is still in development, therefore there are no end users ready to be interviewed, or concrete data that has already been recorded. This limits the data to only what has been measured in the past, causing the creation of predictions such as the family type scenarios. It would be interesting to be able to assess the energy consciousness KPI by talking to end users, as this could provide more information on energy usage in the residence.

4.5.2 Energy Prices Shifting

The ever-changing energy market is also a limitation in this research. As seen with the Statnett report, there is not a completely reliable way to predict the future of energy prices, as there are always factors occurring that will change the predictions. The workaround is to keep adjusting the predictions until the time eventually passes and the concrete data is available.

Despite the limitations, the survey was able to be answered, which in turn helps us to answer the research questions.

6 Conclusion

By following the methodology introduced earlier in this thesis, the results were eventually able to be revealed.

6.1 Research Questions

Returning to the original research questions, after reviewing the results and discussion, a more final conclusion may be made. First, the sub questions will be reviewed:

S1. What are the effects of the technical system on residents?

S2. What are the effects of the materials on residents?

The BIPV system will have a positive effect on the residents, as a reduction in energy costs will be beneficial if the current energy price hike continues. Even if the price reduces, low energy bills can only serve to further secure the families abilities to live well in this neighborhood.

After looking at the glazing options, while triple pane glazing will increase the price of the units, it is beneficial due to the increased energy savings. An added bonus is the reduction in noise pollution from outside as well.

S3. How do social KPI's do in this neighborhood?

S4. What are the long-term effects of this neighborhood on its residents, socially?

As noted in the discussion, the majority of the family types will be able to sustain themselves in this neighborhood. Better results could be achieved, as there are currently no families that successfully pass Q4, but the remaining results are sufficient as they provide evidence that the family should be able to live in Verksbyen on their current funds.

1. **What are the social effects of a sustainable positive energy neighborhood on its residents?**

In a situation where the price of energy is constantly rising and the need to transition to renewable energy more pressing, SPEN's will certainly be helpful for the residents. It has been determined that the four family types are able to live sustainably within this neighborhood, albeit some with a bit of difficulty, however, that means they can only benefit from reduced energy cost. The area that Arca Nova Gruppen is developing this SPEN in has also been determined to adequately cater to a resident's needed services, as seen in Figure 2. Further research including the end users can create more data that will be helpful in the development of more sustainable positive energy neighborhoods in the future.

6.2 Future Work

While the social indicator survey created for this research has proven useful, further development could be made to create a survey that reaches the end users as well, or even those who are just living in the current neighborhood, as they will also likely be impacted by the implementation of SPEN's. The addition of such data would be beneficial for enhancing the scope of this research.

A collaboration could also be intriguing, such as combining the social research with technical research directly tied to the buildings going up in Verksbyen. This includes simulating how the buildings will operate with families in them, and how different climatic conditions could impact the energy usage of the buildings. These studies could consider more technical systems as well, rather than just PV's.

Overall, the prospect of expanding this research is exciting, and help to further the understanding of what social effects that SPEN's will have on those who will live in them. More research on this topic will help the development of new neighborhoods like it and create an easier transition to living sustainably.

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Appendices

Figure A.1, data from Google Maps[34]

[34] "Google Maps."

Figure A.2, data from Google Maps[35]

[35] "Google Maps."

Figure A.3. data from Google Maps[36]

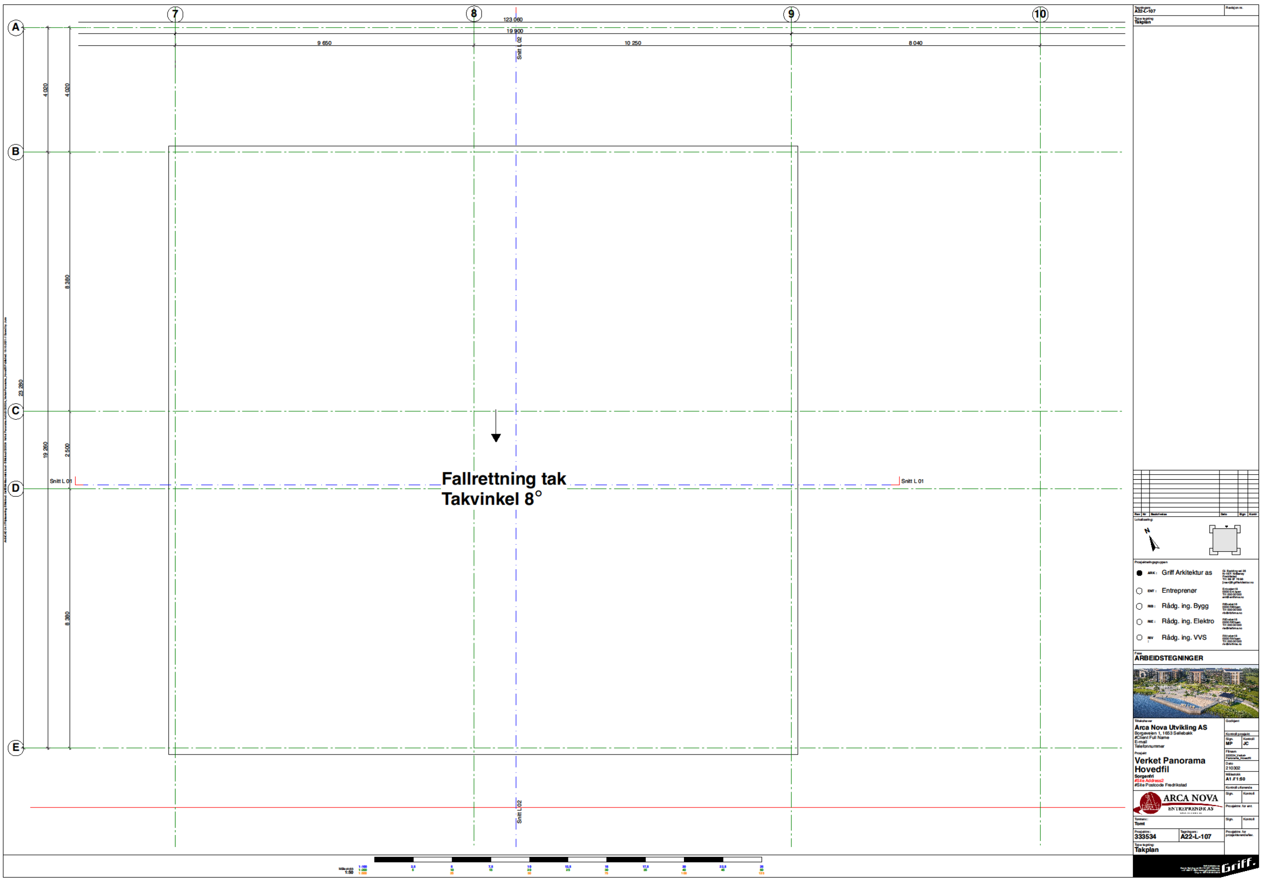

Figure A.4[37]

#	Social Indicator Survey	Type	syn.ikia
Q1	Based on predicted energy prices, what will be the expected income spent on energy for families?	AH/AE	
Q2	Is there any possibility for the families to be unable to pay their utility bills on time due to financial difficulties based off their predicted income?	AH/AE	X
Q3	What is the estimated cost that will be spent by the families on rent, mortgage, maintenance, and dwelling related services?	AH	X
Q4	What is the likelihood of the dweller to spend a higher share than 40% of their equivalized disposable income on housing?	AH	X
Q5	What are the predicted household sizes and distributions in this area?	LC	
Q6	Will the inhabitant(s) have adequate access to services (education, health, etc.)?	AS	

[36] “Google Maps.”
[37] Arca Nova Gruppen, “Verket Panorama.”

Q7	What are expected energy prices throughout the next 20 years?	AE	
Q8	What are the recorded energy prices of the previous 20 years?	AE	
Q9	The whole dwelling unit is not overcrowded, meaning more than $30m^2$ for 1 bedspace unit, and 45 m^2 for 2 bedspace units.	LC	X
Q10	Is the household annual equivalized income less than 6478 EUR?* 6478 EUR = 66,146 NOK as of 18/05/2021	DC	X

Table A.1: Created Social Indicator Survey