Toward an energy-sensitive society!

An Investigation on Alleviating Energy Poverty in Swedish Neighborhoods

Through Co-designing an Energy-sensitive Society

(Case study: Hammarkullen, Gothenburg)

60-credit Master's thesis

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Automn 2022- Spring 2023

Department of Architecture and Civil Engineering

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Chalmers University of Technology
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Abstract

Energy poverty (EP), the difficulty in finding a balance between energy expenditures and income in developed countries (Spirkova et al., 2016), became more severe after the Ukraine war and the resulting fuel crisis in Sweden (Platten, 2022). Although most of the alleviation methods discuss the impact of energy retrofitting projects and building performance improvement on tackling EP, the role of inhabitants is not negligible. This thesis focuses on the role of architectural design in reducing energy poverty on a neighborhood scale with a focus on social sustainability and giving active roles to people.

Various methods exist to alleviate EP, from technical interventions to social considerations. However, the next step of the thesis, interviewing housing companies and experts in the field of EP, identified that only focusing on technological interventions might have paradoxical results compared to the action taken in Sweden due to the gaps in energy policies. Therefore, this thesis considered social interventions such as raising public awareness of energy poverty (EP) and promoting energy-efficient behaviors more practical for alleviating EP in Sweden at the current time.

For the case study, firstly, Jättesten, located in Gothenburg, was selected as it is supposed to be a part of a pilot PED (Positive Energy Districts) project. However, the interviews demonstrated that in this neighborhood, the rate of public interest in getting involved with the co-design workshops of this thesis is low. Therefore, Hammarkullen was selected to be studied. This neighborhood struggles with social challenges like segregation, and emerging EP might worsen the problem (Sareen et al., 2022). Therefore, it is necessary to investigate EP in this area. Furthermore, as Hammarkullen's inhabitants are willing to get involved in the research projects, engaging with them during this thesis was much more uncomplicated than with Jättesten.

During this thesis's workshops, the neighborhood was transformed into an energy-sensitive society through a co-design process with the 7th-grade students, probably most affected by EP due to being young (Churchill & Smyth, 2022), of one of the schools in Hammarkullen. An energy-sensitive society in this thesis refers to a community where people are aware of energy-efficient lifestyles, and the neighborhood itself can raise its inhabitants' awareness of energy-related issues such as EP and its reduction methods through appropriately designed public spaces such as energy cafes and interactive artistic monuments.

To meet such a co-design goal, communicating and visualizing a complicated issue such as EP was essential in making it understandable for the students. Therefore, research on visualization methods, the key to effective communication about environmental issues (Chalal et al., 2022), was done. Then, collage techniques, storyboards, and a game simulated in an augmented reality tool were selected as tools to communicate with the 7th-grade students. These adapted methods led to spontaneous conversations about energy-saving behaviors among the students in an amusing way which is an essential part of the process of teaching sustainable lifestyles.

The final design results of the thesis are visualized collages of Hammarkullen as an energy-sensitive society. With the help of the students, this co-designed face of the square could be a key element in transforming Hammarkullen into a place where inhabitants can learn about energy-efficient behaviors and EP through various activities in public spaces such as energy cafes. Moreover, the design interventions in the square have adopted multiple tools and interactive artworks to combine energy-efficient behaviors with the inhabitants' daily life and make them unconsciously aware of such behaviors. These actions could be one step forward in alleviating EP by raising awareness and giving active roles to the inhabitants.

Keywords: Energy poverty, Young people involvment, participatory approach, Citizen engagement, Energy-saving behaviors, Raise public awareness

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A short story of my life

Entering Architecture school changed my life entirely. The long nights sitting late and trying to create a non-existed building or neighborhood became like a hate-to-love relationship for me. Sometimes I felt that I had a superpower to change society and design behaviors through my designs. On the other hand, sometimes I could feel powerless as I could see all those fancy plans and strategies were not practical for people from all walks of life. In these situations, I used to come up with a question: Is Architectural design a luxury tool that could be used only by wealthy individuals and companies, or is it really meant to make a difference in the communities?

Adding to these concerns, paying attention to the environmental impacts of my designs and trying to design net-zero energy constructions were always prominent to me.

To find the answers to these questions and learn how to develop a holistic perspective for designing constructions that are advantageous for both societies and the environment while also taking into account economic benefits, I became motivated to begin a second Master's program at Chalmers University in Sweden.

At Chalmers, I always attempted to get involved in the studios which consider both the social and environmental aspects of sustainability. During these courses, I learned more about participatory approaches to engage different groups of stakeholders and people with projects. The outcome of these studios, my academic skills, and my passions motivated me to work on a relatively new issue in Sweden: energy poverty.

This newly arisen problem captured my attention as it could challenge me with all factors that have been important to me as soon as I became an Architecture student. First, rethinking the methods to provide affordable access to energy for everyone is close to my desire to plan for a beneficial strategy for diverse groups of people. Secondly, designing and managing low-carbon and net-zero energy buildings and neighborhoods are related to the skills I gained in my first Master's degree. Finally, analyzing the current issues and trying to find solutions to build a sustainable society is another essential factor to me.

As a result, I am grateful that I have begun a journey to combine all of my skills and passions while learning new ones to take my first step toward becoming a designer who not only knows how to communicate with people and create a dialogue between them and companies but also knows how to play an influential role in energy transition projects.

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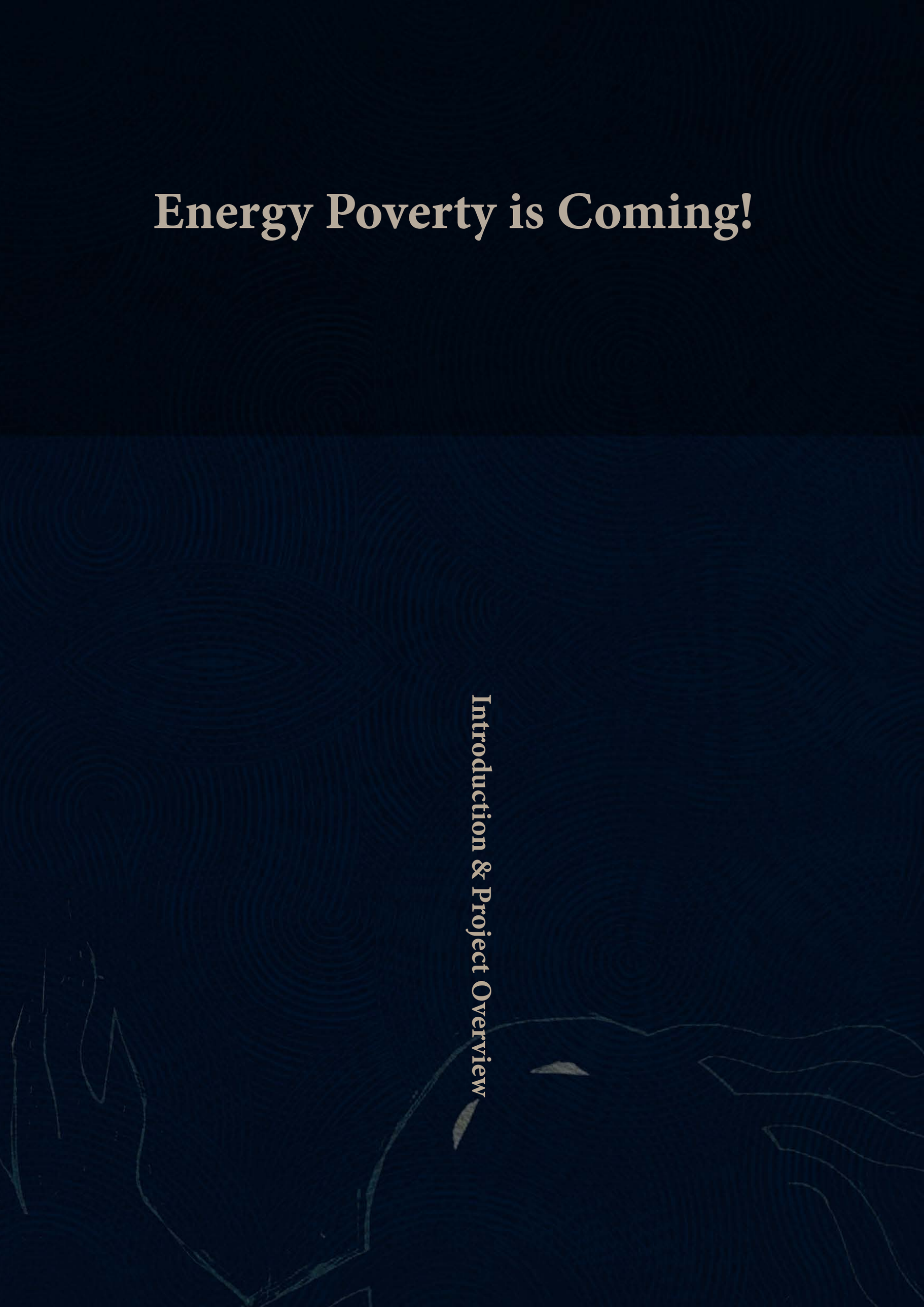
Energy Poverty is Coming!

Introduction & Project Overview



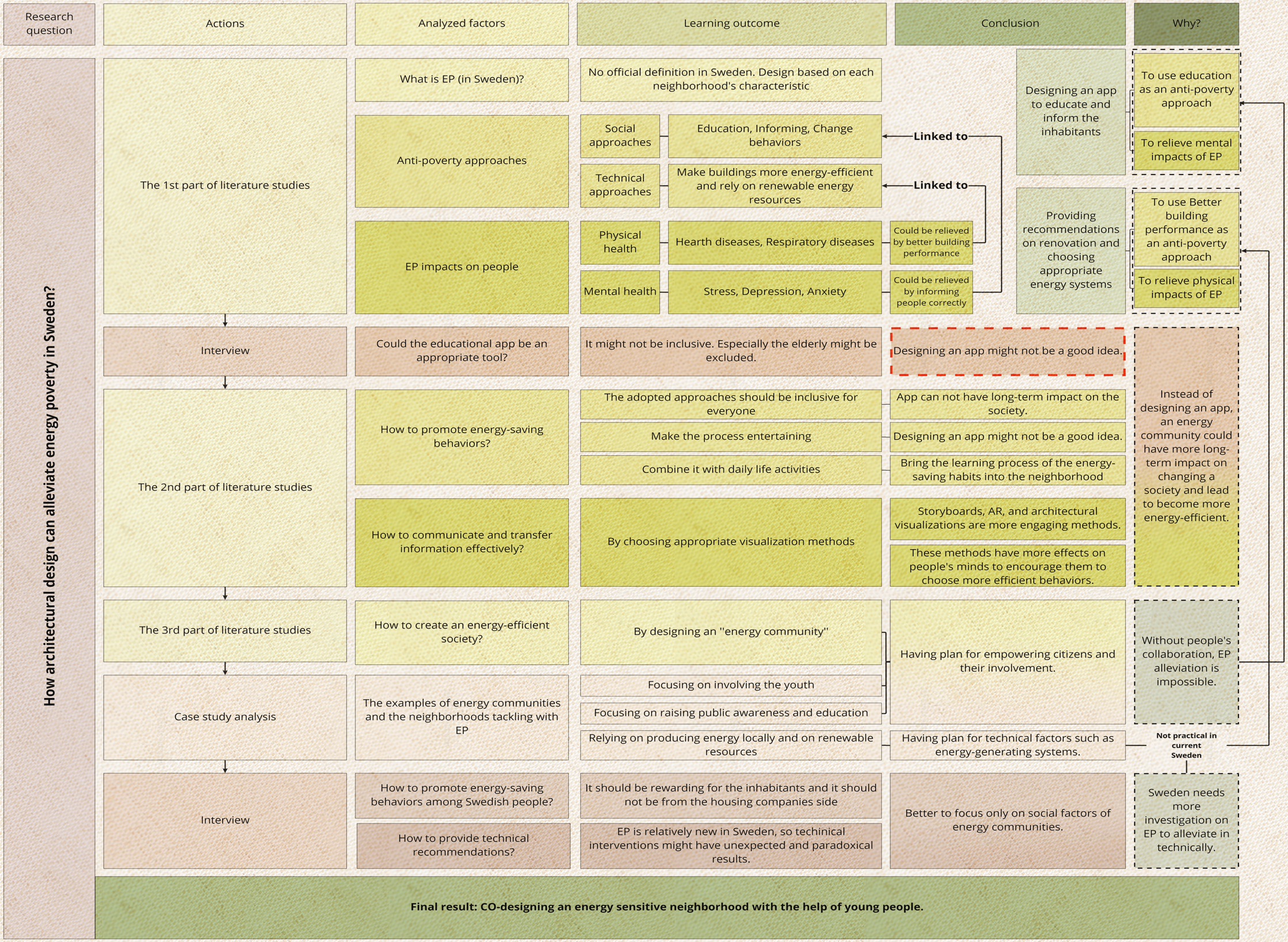


Fig. 1.1. The journey of this thesis

She is Sweden's social support system.

For a long time, she protected Swedish households and brought satisfaction for them.

But, the situation changed due to Ukraine war.

Fuel shortage resulted in an increase in energy costs.

So, energy poverty showed up itself in Sweden.

And some households were affected by energy poverty.

Fig. 1.2. Problem description

1.1. Background and Problem Description

Energy poverty (EP) is a global issue that can have different meanings based on the characteristic of a country. Its definition in developing and underdeveloped countries refers to providing people with access to energy resources, while in developed countries, it is about ensuring that all the inhabitants do not have any difficulties paying their energy bills. As this thesis focuses on Swedish neighborhoods, the meaning of EP in this study is mainly about affordability to make sure there is a balance between households' energy expenditures and their income (Spirkova et al., 2016).

Concentrating on this thesis's context, EP was a relatively minor issue in Sweden compared to its other European counterparts until the end of 2021. The reason could be found in this country's strong social support system and high energy performance of building stock. Moreover, there was another protection for the tenants called "warm rent," meaning that the heating cost is included in the paid monthly rent (Platten, 2022). But, the Ukraine war and the resulting fuel shortage in Europe changed the situation in Sweden. The energy price increased, and many Swedish sectors, including housing one, were affected by that. As a result, energy poverty showed up in Sweden and brought challenges for some households to heat their houses. During this year, mainly rural areas and the residents living in detached houses have been affected by this problem, and the ones living in rental homes have had more protection due to the capital of housing companies (Platten, 2022). However, if energy poverty could not be alleviated, even the tenants would be faced with an increase in rents to compensate for the rise in energy costs. Even now, it can be seen that some of the policies are going to be changed. For instance, since July 2022, individual metering and billing, called IMD, has been discussed to be applied for apartment buildings with the worst energy performance. In these buildings, the heating and domestic hot water would be measured separately, and the cost would be separated from the warm rent, and already the IMD has been used in some districts (Boverket website, 2022).

This increase in fuel cost would have more negative impacts on vulnerable families. Vulnerability in the context of EP refers to families with lower income than average, households who are not familiar with the methods to save energy and control their energy consumption, or a combination of both (Dubios & Meier, 2016). As vulnerable inhabitants usually become marginalized in society, some challenges, such as EP and the lack of proper information among the inhabitants, could accelerate segregation in a community. The importance of this subject becomes even more highlightable in already segregated neighborhoods such as Hammarkullen to control the emerging EP challenge's negative side effects on its inhabitants. These negative effects of EP are even more significant on the younger generations due to a few reasons (Spirkova et al., 2016): First of all, energy poverty can result in poor living conditions, which can threaten both physical and mental health (Thomson et al., 2017), although everyone, regardless of their age groups deserve to live in a situation in which their health-related condition is acceptable, the importance of taking care of the youth's health is even more prominent as they are in their growing age.

Second, energy poverty can impact young people's education and opportunities for the future. For instance, they need consistent access to electricity at home, which would limit their ability to study or complete schoolwork at night. This may affect their academic progress and reduce their opportunities to pursue further education or find employment in the future (Banerjee et al., 2021).

Thirdly, energy poverty can worsen social injustices and keep people in poverty for a long time. As mentioned, energy poverty is more common among young people from low-income families, which might restrict their possibilities and repeat disadvantageous tendencies. This may result in a vicious cycle of poverty that is challenging to escape (Churchill & Smyth, 2022).

Therefore, there is an urgent need to find solutions to alleviate EP to not only provide affordable access to energy resources for everyone but also prevent the acceleration of inequality in the community and guarantee a brighter and socially sustainable society for all the inhabitants specially for the future generations.

1.2. Aim and Research Question

Aim: Provide an example of how energy poverty could be tackled on a neighborhood level in Sweden by involving the youth and promoting energy-saving behaviors to co-design an energy-sensitive society.

This thesis focuses on the role of architectural design in alleviating energy poverty (EP) in Swedish neighborhoods, with a specific case study on Hammarkullen, Gothenburg. The aim is to find quick reactions and long-term responses to the rising EP crisis in Sweden, especially among the younger generation, which are essential for securing a sustainable future. The thesis will collaborate with young people living in Hammarkullen to test techniques that increase awareness of EP and teach energy-saving habits.

Additionally, the thesis aims to co-design the Hammarkullen Center with the youth to transform the square into an energy-sensitive center, providing a sense of belonging to their neighborhood. Overall, this thesis investigates artistic and architectural methods to alleviate EP and promote energy-saving behaviors, focusing on engaging the youth in the project.

Therefore, the main research question is:

How can architectural design alleviate energy poverty in Swedish neighborhood?

To find the answer, three operational questions have been defined:

1- What are the tested anti-poverty approaches in other countries?

2- How could a behavior be changed and replaced with an energy-efficient one

3-Which visualization methods are more practical for communicating with inhabitants, especially the younger ones?

The first question investigates the anti-poverty approaches tested in other European countries to learn from similar projects. These anti-poverty approaches explore two different aspects: Technical and social. The technical approaches would help learn more about the methods that optimize energy consumption. The social ones refer to the strategies that would raise public awareness of EP and promote energy-efficient behaviors.

The second question aims to find out how more energy-efficient ones could replace the current habits among people.

The third question would lead to a broader knowledge of how to encourage the inhabitants to follow energy-efficient habits. Moreover, these methods would be practical to act as a bridge between theories and design and bring all the learning outcomes from the literature studies into the design to accomplish the objective of this thesis.

1.3. Methods and Tools

Literature studies, interviews with housing companies and experts familiar with EP and the case study area, workshops, game design, co-designing of energy cafe and hammarkullen center.

Visualizing the results with the help of collage.

The main research question includes a few parts that should be investigated separately in this thesis. The first part is the scope and dimension of energy poverty in Sweden. As this problem used to be relatively small in this country, there is no official definition for that (Platten, 2022). In this case, the first step is acquiring a deep understanding of EP in the Swedish context with the help of literature studies and interviews with housing companies. The first interviews in this part were conducted with people working in Poseidon, the landlord of the first case study, Jättesten, to estimate the dimension of EP and the energy crisis in this neighborhood and determine whether it is possible to have a co-design process in this area.

The second interview was held with Bror Johansson & Co AB, a private housing company. The reason for having this interview was that beyond the borders of a particular neighborhood, all the areas of Gothenburg struggle with the same social challenges and legal barriers when encountering the current energy crisis. Moreover, as this company was trying to promote energy-saving behaviors through installing flyers in their buildings, which is similar to this thesis's goals, it seemed to be a good candidate to learn from their experiences.

Furthermore, some short discussions were done with Mikael Mangold. Mikael Mangold and his research team mainly work on energy efficiency and segregation issues with a focus on national and European target groups (Adapted from his profile on the RISE website). These discussions helped understand the definition of EP in Sweden deeper.

Another interviewee was Claes Johansson, the deputy chairman of the Gothenburg waste and water management department, to learn about the Swedish rules and restrictions in designing energy communities and producing energy locally.

Backing to the research question, the second part investigates various anti-poverty approaches tested in other counties, which could be met with the help of literature studies and analyzing similar European projects to figure out which methods or tools might be practical in Sweden to tackle EP.

Another part of the research question is to alleviate EP through design by hearing people's voices and considering their needs to engage them with energy projects by the means of participatory approaches. To meet this goal, published articles can open a horizon of tested strategies that could be practical for communicating with people. Then, interviews with

How can architectural design alleviate energy poverty (EP)?

The pre-start cluster of the operational questions and the methods to address them:

What is the definition of EP?

Acquiring a deep understanding of the Energy poverty in Sweden and learning more about the laws and rules to estimate which anti-poverty approaches could be practical in this country**. Literature studies, articles on Sweden's policies, interviews with researchers in this field, and housing companies** were used to meet this goal.

What are the impacts of EP on people?

First, with the help of **interviews** with the housing companies and **literature studies** the dimension of EP's impacts on people's lives were estimated to offer design methods based on the inhabitants' needs.

The first cluster of the operational questions and the methods to address them:

What are the tested anti-poverty approaches?

Learning about anti-poverty approaches to alleviate EP. In this part, **literature studies and analyzing case studies** were helpful.

How to change a behavior?

Acquiring a deep understanding of one of the critical factors in alleviating EP which is promoting energy-saving behaviors, also known as an anti-poverty approach by the **literature studies**.

How to communicate with people effectively?

To learn more about how to encourage the inhabitants to follow energy-efficient habits and also learn how to make complicated issues such as EP understandable for everyone. In this part, **literature studies**, **interviews**, and holding **workshops** to test the tools were helpful.

The second cluster of the operational questions and the methods to address them:
(Bridging from theory to design)

What is the role of energy communities in alleviating EP?

Learning about energy communities as a way to alleviate EP through. In this part, **literature studies and analyzing case studies** were helpful.

What are the energy cafés?

To learn about diverse activities which can result in raising public awareness of EP. **Literature studies** were practical to answer this question.

The final approach: Co-designing an energy café and transforming the Hammarkullen square into an energy-sensitive center by the help of the youth living in the area.

with Ola Terlegård, an active member of the Vårt Hammarkullen association, and Joachim Svärd, Nytorpsskolan's teachers, made it possible to hold a collage workshop with the teenagers living in Hammarkullen. These workshops are part of this thesis's co-design process.

To complete the first workshop and test a digital tool to have a co-design workshop with the teenagers, augmented reality would be used as a gaming tool to co-design the Hammarkullen center in to combine energy-saving behavior with the inhabitants' daily lives with the help of students.

Finally, the results of these interviews and workshops were gathered and pictured with the help of a collage to visualize an energy-sensitive society and its required public spaces such as energy cafe with the aim of suggesting various activities and methods which can result in raising public awareness of energy-efficient behaviors an involve the inhabitants in the process of EP alleviation.

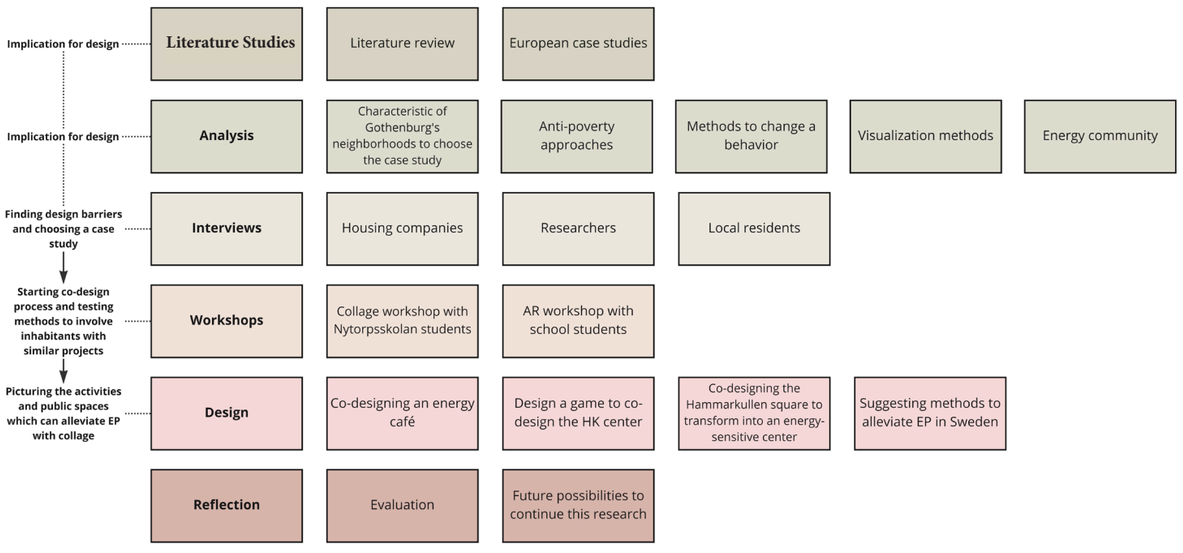


Fig. 1.3. Methodology of the thesis

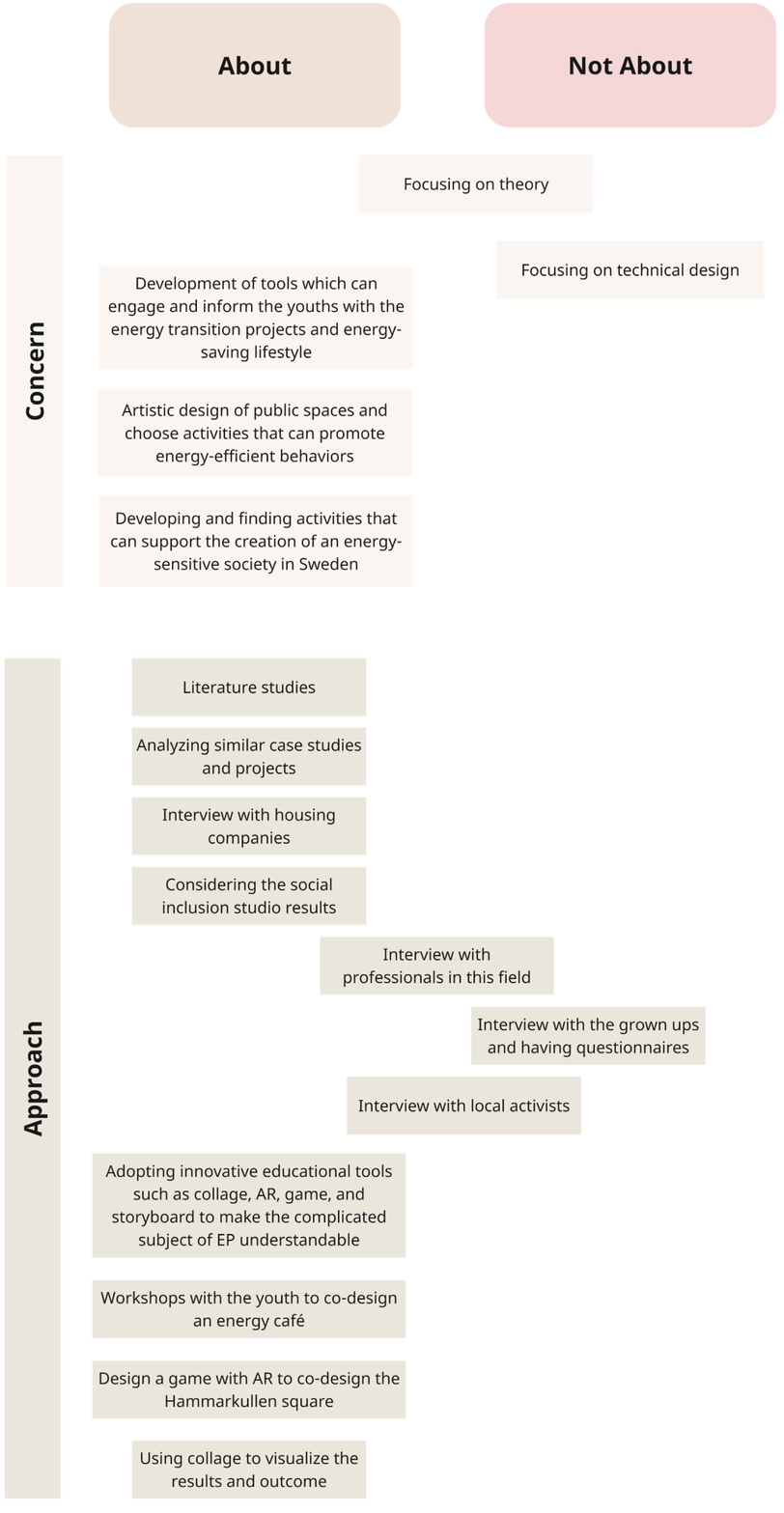


Fig. 1.4. Delimitation diagram

Fig. 1.4. The darkness of energy poverty could be overcome when people, decision-makers, and researchers work hand in hand to create an energy-sensitive society.

Images used in this collage have been inspired from: Rob Hodgson, the Shutterstock website. Art studio life website, Pngtree and Freepik websites

Hi Hammarkullen!

About the Case Study

2.1. Case Study

Hammarkullen, Gothenburg, Sweden
The square of the neighborhood that would be developed in a few years

2.1.1. Why Hammarkullen?

Hammarkullen is a neighborhood located in the norther-eastern part of Gothenburg city. This district was built between 1968 and 1970 as a part of the million program project (Source: Gothenburg city website). Although Hammarkullen is known as a vulnerable area and struggles with challenges such as social and economic ones, its unique character distinguishes it from other neighborhoods in Gothenburg with similar issues. The fantastic and exceptional character of Hammarkullen is the extraordinary motivation of its residents to play an active role in their living area. This desire makes Hammarkullen a dynamic community with various associations run by the tenants and inhabitants. Thus, unlike Jättesten, holding workshops and meetings in Hammarkullen would be much more straightforward. It means having co-design and co-discussing processes that could be tested and followed in this area which is vital for meeting the goals of this thesis.

Moreover, the author has been involved in a project related to Hammarkullen in the social inclusion studio; hence, there is sufficient knowledge of the area beside the network to hold events in the district.

2.1.2. Why Hammarkullen square?

Hammarkullen Square, or hammarkulletorget, is situated near this neighborhood's only tram station. In 2021, three architectural proposals were presented to the residents as future development plans for the center. As these proposals needed to be clearer to Hammarkullen's inhabitants, they asked Chalmers to help them to establish a common dialogue with Bostadsbolaet, the housing company of the area, to encourage them to involve the tenants in the development process. Therefore, this request became a project plan for the social inclusion studio, one of the Master's courses in architecture and planning beyond sustainability program. The thesis's author was involved in the project with Viktor Nording and Tahrene de Vos, which made her familiar with the neighborhood.

As this thesis looks for ways to create an energy-sensitive community through participatory approaches, this neighborhood could be a good candidate due to its mentioned characteristic. Moreover, the square is part of an active development project, and this thesis wants to investigate how it could be designed and developed to meet the development requirements and also promote energy-saving behaviors.

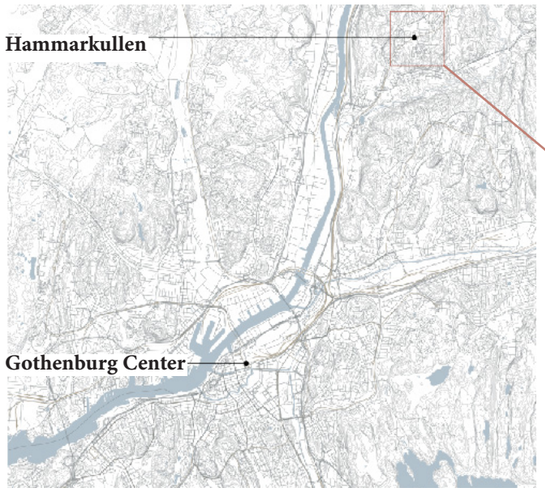


Fig. 2.1. Hammarkullen on the Gothenburg map

Fig. 2.2. The Hammarkullen square on the neighborhood

Fig. 2.3. Taken by the author

2.2. A flashback to the social inclusion project

Participatory Approaches in Development Process – Rebuilding Hammarkullen Center

Team memebers: Tahrene de Vos, Katayoun Mohammadi, and Viktor Nording

This project involved the Hammarkullen's inhabitants in the development process of the square by holding various workshops such as the audiovisual workshop and the collage one. The final meeting of this social inclusion project was holding a ''Big meeting" with 200 invitees. These invited individuals included staff from Bostadsbolaget, local associations, and the inhabitants who had registered for the event.

The ''Big meeting" and an exhibition were the first step in establishing a dialogue between the housing company and the residents to make the final proposal understandable for people and consider their needs and viewpoints in the next phase of evaluating the proposal. This project was a learning process filled with many experiences and emotions that opened up a new horizon for everyone who contributed.

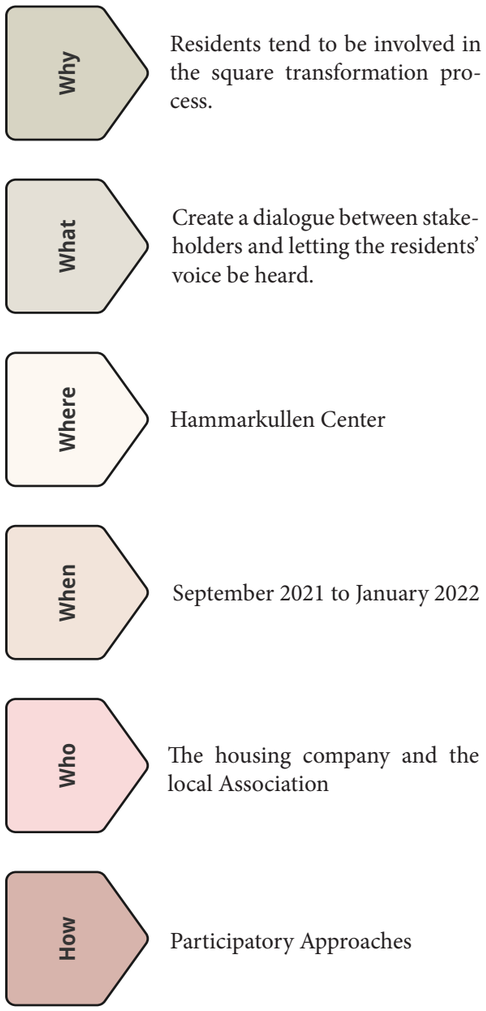


Fig. 2.4. Summary of the Social inclusion studio

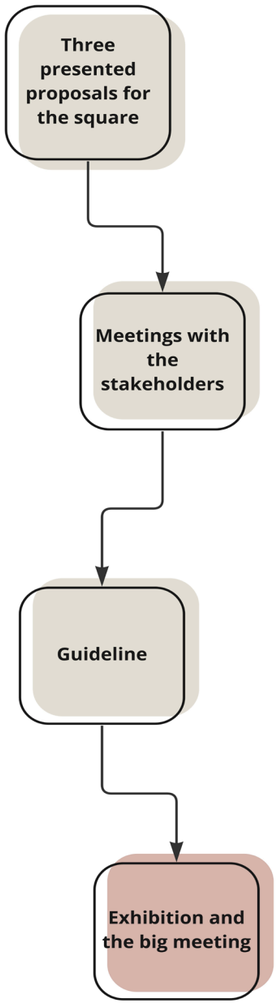


Fig. 2.5. The journey of the social inclusion project

Fig. 2.6. Taken by the author

2.2.1. How can the social inclusion project contribute to this thesis' goals?

First, the social inclusion project allowed this thesis author to create a network in Hammarkullen. Based on that, holding events and workshops would be much more straightforward in the neighborhood.

Secondly, spending approximately five months in the area during the mentioned course has familiarized the author with the district, which means there is less need to walk around the case study area and try to know it better.

Finally, the outcome of the "Big meeting" could be used in this thesis design part to adapt the co-design workshops to the needs of the inhabitants. To clarify, a glance at the future of Hammarkullen might be helpful:

Hammarkulletorget will be transformed in a few years based on the proposal designed by the Link architecture company. But, the inhabitants have some concerns and ideas and wish that the decision-makers consider them in the plans. The Chalmers students, including this thesis author, have gathered these needs and thoughts in the "Big meeting."

This thesis aims to create an energy-sensitive society in Hammarkullen to meet not only people's needs but also raise their awareness of energy-saving behaviors. Hammarkullen residents' needs have already been collected. They could be considered when the author is going to design workshops and the energy-sensitive society in parallel with the ongoing development plan of the square.

Fig. 2.7. The Big Meeting (Taken by the author)

2.2.2. Description of collected data from the ''Big meeting"

At each table during the Big meeting, the attendees were divided into eight groups. A site plan of the concept chosen for further development was sent to each group.

Fig. 2.8. The participants talk about their concerns (Taken by the author)

Participants were encouraged to make notes on the drawing about the discussion that had taken place throughout the event. The collected data was divided on the site plans into three key categories to acquire an overview of what had been written and discussed. The location of the notes on the compiled map is the same as on the original sketch. The topic of the notes was linked to a specific location on the map. The three data categories are:

- Services and physical objects
- Questions
- Statements and concerns

Fig. 2.9. The example of collected data (Taken by the author)

The question category can not be used in this thesis as Bostadbolaget, and Link architects should answer them. Moreover, these questions are mainly about the development plan and the future of apartments in the area, and their answers are not that much related to this thesis's subjects and goals.

But the rest categories, concerns and needed services, could be considered in designing an energy-sensitive community as there are overlaps between these concerns, the future transformation plan, and this thesis's final goal. For instance, installing solar panels, having gathering spots, and paying much more attention to green areas are factors that could be seen in an energy-sensitive society as well.

The collected information from the residents during the ''Big meeting" event was so varied, and in some cases, it was irrelated to both this thesis and the designed development plan of the square. Thus, as mentioned, only the related ones were selected for this thesis.

These concerns and demands can be seen in the image shown below. The picture is the site plan designed by Link for transforming the Hammarkullen center and is similar to the one that each group of participants had on the day of the ''Big meeting". The participants used sticky notes to brainstorm with their teammates and express their thoughts and ideas. The ones close to the thesis's purposes could be seen in both thesis workshops, and final designs have been collected and added to the site plan. These needs can be seen below:

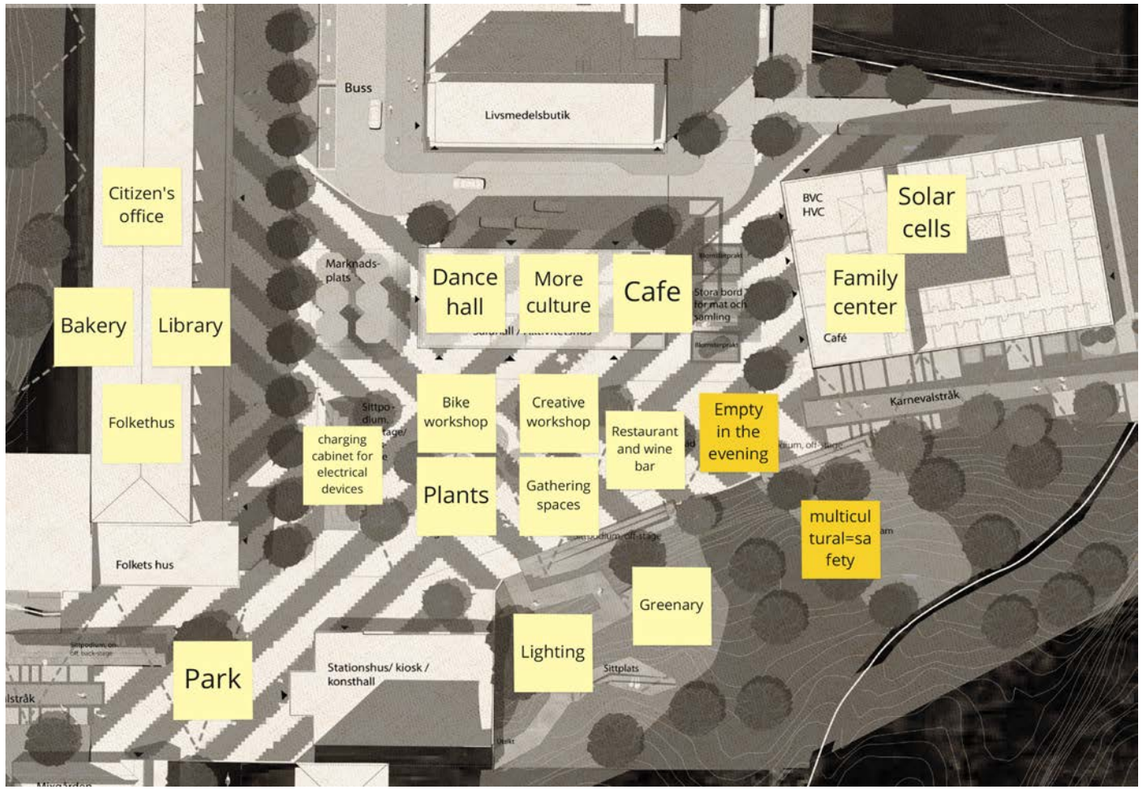


Fig. 2.10. The collected inhabitants' needs and concerns which have overlap with the characteristic of an energy-sensitive society

What is going to be done in this thesis?

This pictured timeline shows Hammarkullen from the past to the future. Alongside the illustrated 3D model designed by Link Arkitektur for developing the square, a sketch could be seen which describes the aim of this thesis for transforming the Hammarkullen into an energy-sensitive community by co-designing an energy park and energy café. This sketch and thesis's process visualize a future for Hammarkullen square parallel to its development plan; in other words, it is looking for an answer to this question: How could this presented transformation proposal promote energy-saving behaviors?

The past of Hammarkullen from 1970-1980
(Photographer of the pictures used in collage: Jens S. Jensen)

The present of Hammarkullen
(Pictures taken by Viktor Nordling)

The social inclusion project to create a link between the present situation of the area to its future

The future development of Hammarkullen designed by Link Arkitektur
(Source of the pictures used in collage: Link website)

The future of Hammarkullen as an energy-sensitive community
(Images inspired from: Freepic, plural design websites, and Swaifudin, Z. Shirodkar, S.)

Time to broadening knowledge!

Literature studies

In this section, you are going to read about the following:

Energy Poverty Definition
To learn more about the scope of EP and acquire a deeper understanding of that in the chosen context.

The impacts of Energy Poverty on People
A better understanding of the possible effects of an issue on the users would lead to better solutions based on people's needs.

Anti-poverty Approaches
To learn more about the tested alleviation methods in other European countries.

3.1. Energy Poverty Definition

When a low-income household living in a poorly efficient building must pay for high energy bills, it could be said that they suffer from energy poverty (Spirkova et al., 2016) which is a complex challenge worldwide. The definition of EP differs from one country to another; briefly, energy poverty in developing or underdeveloped countries refers to the availability of energy resources for everyone. But, in developed countries, EP is more related to affordability (Sy & Mokaddem, 2022; González-Eguino, 2015). As this thesis focuses on a Swedish neighborhood in Gothenburg city, the ultimate goal is to investigate the latter concern.

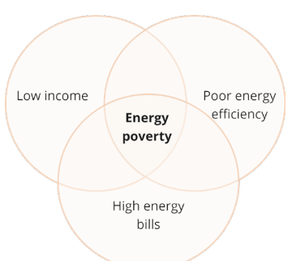


Fig. 3.1. Energy poverty indicators (Adapted form: Spirkova et al., 2016)

There are also more precise definitions in the European context (Fig.3.2.): for instance, according to Boardman (1991) definition, which is also the most common explanation of this problem, if the energy bills of a family are above 10 percent of their earned money, then they have been faced with energy poverty (Madlener, 2020). Generally, when a family earns less money than the average and needs to spend on its energy demands more than expected, they suffer from EP (Middlemiss, 2017). Moreover, it has been said that having difficulties meeting basic energy needs is another sign of energy poverty (Middlemiss, 2017; González-Eguino, 2015).

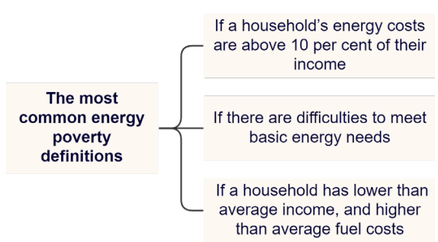


Fig. 3.2. Some of the energy poverty definitions (Inspired from: Middlemiss., 2017)

Beyond all of these words and sentences which try to make EP more understandable, it should be considered that there is no universal and single definition of energy poverty. The reason is that each country, city, and even neighborhood has its own characteristics. This means the roots and the results of energy poverty would differ from one context to another (Doukas & Marinakis, 2020; Noka et al., 2019). Therefore, each country needs to define EP based on the circumstances, policies, and indicators of their land (Herrero, 2017).

3.2. Energy Poverty in Sweden

The EP was not a significant issue in Sweden before the Ukraine war. But after that, some Swedes began to experience difficulty managing their everyday expenses and energy bills at the same time. Thus, action needs to be taken to become familiar with EP in this country (Platten, 2022).

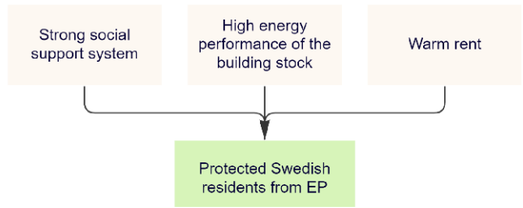


Fig. 3.3. The reasons why Sweden's energy poverty rate used to be low (Inspired from: Platten, 2022)

As it has been discussed by Platten on her published article in 2022, the term "energy poverty" had not been used in Swedish policy because there had previously been no cause for concern. Due to this, there has not been enough research done on the issue. It is crucial to identify energy poverty in Sweden at this time. Two factors, namely affordability and flexibility of capital, might be employed to gain a deeper knowledge of EP in this nation and possibly lead to a Swedish definition. The first is more concise and related to how the problem is understood in developed countries. The second, flexibility capital, estimates whether all the opportunities of having fair access to energy resources have been distributed equally among residents. This term will become even more critical in the future when existing systems of generating and distributing energy are going to be replaced by smart systems. Flexibility capital also shows the potential of households to control unexpected increases in fuel costs from now on (Platten, 2022).

Moreover, it is essential to know that the results of energy poverty are not only limited to financial issues but also impact the quality of life (Neacsa et al., 2020). In general and with regard to the suggested factors and mentioned consequences, it could be said that The economic impact of energy poverty is intensified by the combination of low affordability and limited flexibility capital. On the other hand, in a situation in which affordability is low, but flexibility capital is high, there would be a risk for comfort and well-being (Platten, 2022). These factors could be helpful to come up with a Swedish EP definition.

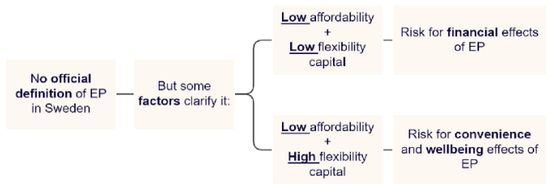


Fig. 3.4. How to understand energy poverty in Sweden (Inspired from: Platten, 2022)

Consequently, it could be said that there is no need to have a strict definition of energy poverty (Doukas & Marinakis, 2020). Instead, based on each case study's characteristics and conditions, a dominant understanding of this issue could be discussed (Noka et al., 2019). For instance, as mentioned, two factors can help researchers, planners, and other professionals to understand EP in Sweden. By that, they could introduce suitable solutions and identify target groups better (Platten, 2022).

3.3. The Impacts of Energy Poverty

Although the primary concern related to energy poverty is providing affordable energy access, the impact of this issue is much broader than economic matters. In other words, energy poverty is a multifaceted challenge affecting many aspects of people's lives (Zhang et al., 2021).

To provide a comprehensive understanding, many articles have mentioned the term ''Hidden energy poverty," which refers to the negative impacts of EP on people's living standards (Urquiza et al., 2019).

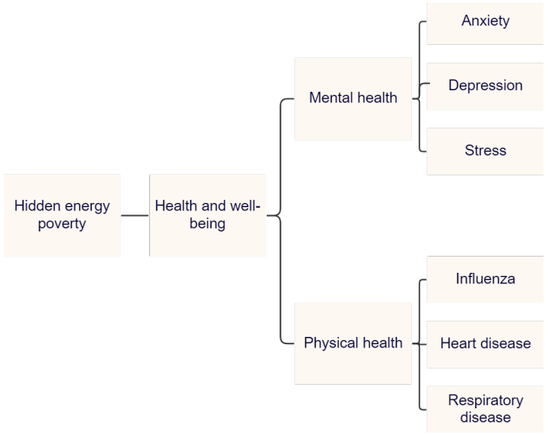


Fig. 3.5. The impacts of EP on mental and physical health (Inspired from: Thomson et al., 2017)

These side effects of EP impact individuals' living conditions from diverse aspects ranging from their physical health to their mental one (Thomson et al., 2017). To provide examples, living in buildings that do not have ideal and standard situations might have negative effects on people's physics. For instance, various diseases, such as respiratory illnesses or flu, might result from living in poor houses or without appropriate insulation, where thermal comfort can not be achieved (Ballesteros-Arjona, 2022).

Regarding mental issues caused by facing EP, it could be said that encountering high energy bills, which do not have a reasonable balance compared to a family's income, might impose pressure and stress on them and threaten their mental health (Thomson et al., 2017).

These negative impacts affect children more severely than adults, who are much more vulnerable to unstable and unhealthy living conditions (Gabriel et al., 2023).

3.4. Anti-poverty Approaches

As was mentioned in the previous parts, the definition of energy poverty is unique in each context due to the case study's characteristics (Doukas & Marinakis, 2020). If the meaning is different, then the approaches must also be unique to respond to the issue more practically. Hence, various methods have been tested in diverse countries to address energy poverty. Analyzing these examined methods would help the decision-makers, designers, planners, and other experts learn from their counterparts in different countries and enable them to devise a solution for their own projects. There are several methods available to transfer knowledge, which include applying the same policy in a foreign country (copying), adjusting and merging features of existing policies, using design and implementation features from other countries as a source of inspiration and impetus for new policy development, or making policy adjustments (Noka et al., 2019):

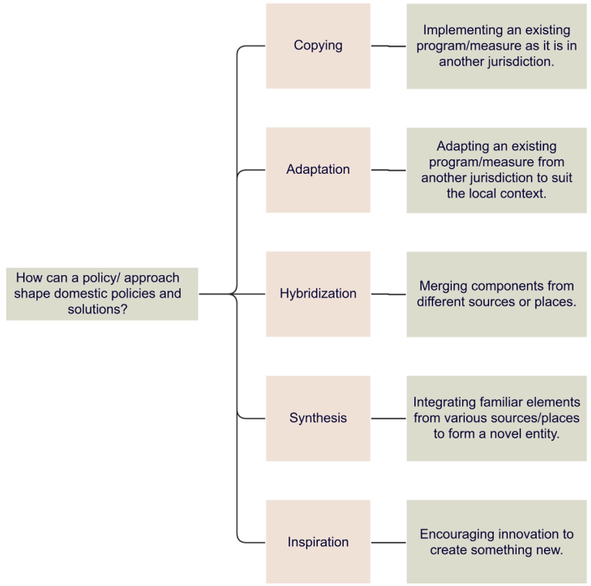


Fig. 3.6. The ways by which a policy or an approach can be used to shape domestic ones (Adapted from: Noka et al., 2019)

As seen in the above diagram and based on the analyzed case studies, which will be presented in the following chapters, it seems that adaptation and hybridization could be practical for this thesis. Also, some tested tools could be considered an inspiration to use in the Swedish context and pursue this study's subject. For instance, a few case studies such as the work done by Thoams et al, (2021), highlight the role of involving young people with environmental- related projects. In some other studies such as the study of English & Carlesn (2019), it could be concluded that having public spaces that inhabitants can visit regularly is prominent to becoming familiar with energy-saving behaviors (Martiskainen, et al., 2020). These approaches could be combined into an adaptable concept of energy cafes to create a better result. This combination of ideas is called hybridization (Noka et al., 2019). Moreover, the offered activities in these public spaces must be adapted to the needs of Hammarkullen and its residents. Therefore, the outcome of investigated anti-poverty approaches would be used by this thesis by using them as an inspiration which should be adapted and hybridized based on the selected case study for this thesis. Thus, there are plenty of ways to apply the learning outcomes of other countries to a Swedish context. After examining the adjusting methods, it is time to learn more about the worldwide anti-poverty approaches.

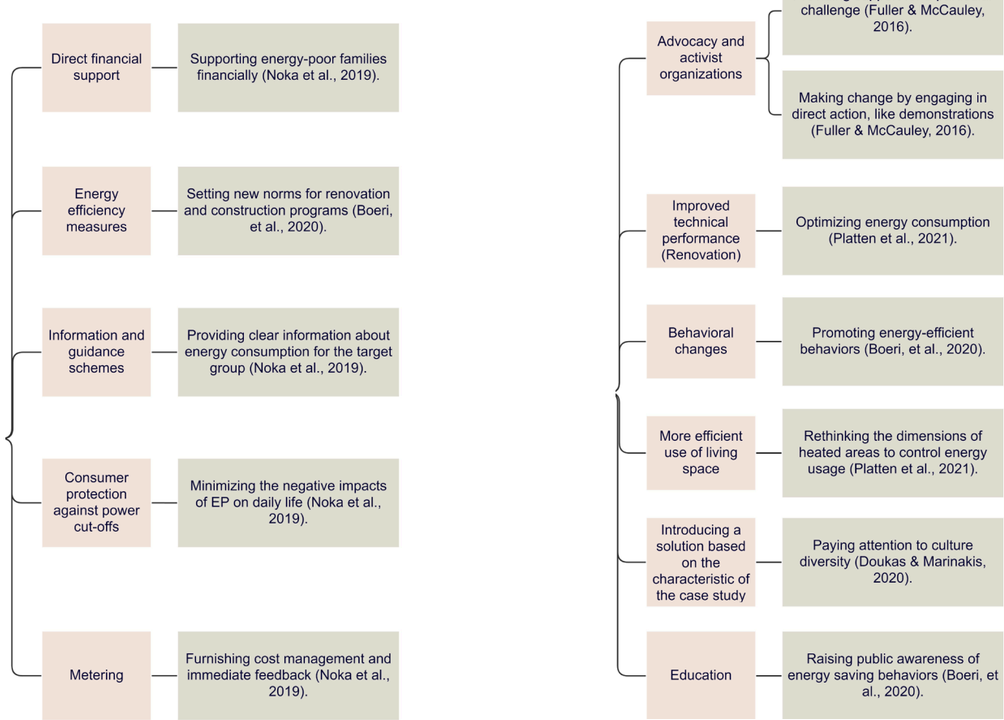


Fig. 3.7. Anti-poverty approaches tested in the European countries

While specific approaches tested to address energy poverty, like offering direct economic help to at-risk families and defending them from power disconnections, produce temporary relief (Noka et al., 2019), a permanent resolution is required to tackle EP effectively. Consequently, approaches that impart knowledge to individuals and educate them on adopting more efficient energy practices are crucial for transforming behavior and taking one step forward to reducing EP (Boeri, et al., 2020). Thus, based on the literature studies done in this thesis, it seems the following methods have the potential for long-lasting impacts on society in mitigating energy poverty:

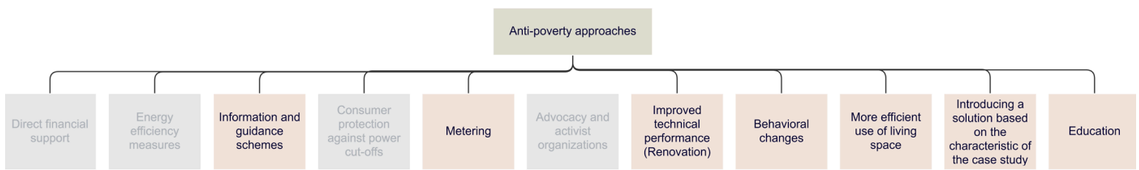


Fig. 3.8. Anti-poverty approaches Suitable for this thesis goal and EP alleviation in Swedish context

As energy poverty is a multifaceted challenge, various solutions or alleviation methods ranging from political and economic to artistic ones have been tested. Thanks to a few resources mentioned below, some of the approaches leading to the alleviation of energy poverty have been organized in this thesis. The following figure summarizes these approaches and provides a short description of them:

In this section, you are going to read about the following:

Behavioral Models
To learn how to change a behavior and promote energy-efficient one.

Visualization Methods
To become familiar with various tools for communicating with people, engaging them with the project, and raising their awareness.

Briding from theory to design: Could designing an app be a solution to alleviate EP?

Energy Community: Design solution?
To design an "energy-sensitive community'

3.5. Behavioral Models

3.5.1. Why and How to Promote energy-efficient behaviors?

How people consume energy, and their awareness of optimizing it significantly impact the load imposed on power grids on a city scale (Xu et al., 2020). Also, the success of energy retrofitting and energy transition projects depends on ensuring the users are aware of their roles in meeting the goals of such projects to create a green and efficient community in terms of energy consumption (Xue et al., 2022).

Success in this context has two meanings:

1. Ensuring users know how to optimize their energy consumption and consume energy effectively. This would benefit both people and energy providers as better energy usage would result in more reasonable monthly energy costs for inhabitants and a more straightforward decision-making process for policymakers (Santangelo et al., 2021).

2. Facing public acceptance. By paying attention to people and providing accurate and sufficient information, energy retrofitting projects would face higher societal acceptance (Xue et al., 2022).

These facts clarify why it is vital to raise public awareness of energy-efficient behaviors and attempt to replace ineffective manners with more functional ones in society. Promoting these behaviors would engage users interactively (Kouroupetroglou et al., 2015) in dealing with EP. Moreover, it would increase public approval for energy-related projects approved by decision-makers (Xue et al., 2022). To meet this goal, some behavioral models, such as Fogg and Hooked models, could be used:

3.5.1.1. Fogg Behavioral Model [1]

As can be seen in the figure 3.9. , encouraging people to pursue a desirable energy-efficient behavior highly depends on how much the provided information and the necessity of these behaviors are clear and understandable for everyone. Another influential factor is how the willingness to follow such behaviors could be activated in people's minds.

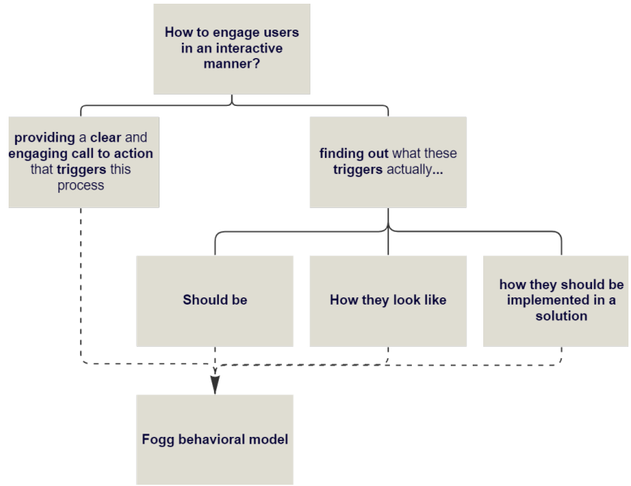


Fig. 3.9. How to promote a new behavior (Inspired from: Kouroupetroglou et al., 2015)

A spark, facilitator, or signal could create this willingness. As this thesis focuses on EP reduction, which is a complicated concept to be understood, facilitating could be considered a trigger. This refers to simplifying the meaning of the challenge; in this study EP, the importance of pursuing energy-saving habits and their impacts on individuals' lives.

Looking at the figure demonstrates, in addition to triggers, two more factors impact the process of promoting a new habit: Motivation and Ability.

The first refers to pleasant and unpleasant items that inspire people to follow instructions. For instance, they could do certain behaviors because they know that they would be punished by refusing to do them. On the other hand, individuals can behave in a way that would bring social acceptance to them, and by that, they can feel good about themselves. This thesis tries to design an energy-sensitive society that makes accepting an energy-efficient lifestyle a social and pleasant norm instead of forcing people by, for.

1- Source of the paragraph: Kouroupetroglou et al., 2015

example, scaring them of their monthly energy bills.

The last factor, ability, discusses that the process of pursuing a habit should be available for everyone. This means the promotion process should not take that much time or money for people to learn new behaviors and be manageable to apply to their daily routines. In this case, this thesis suggests that combining energy-efficient behaviors with inhabitants' daily activities and bringing them into the most visited public spaces could be a good idea.

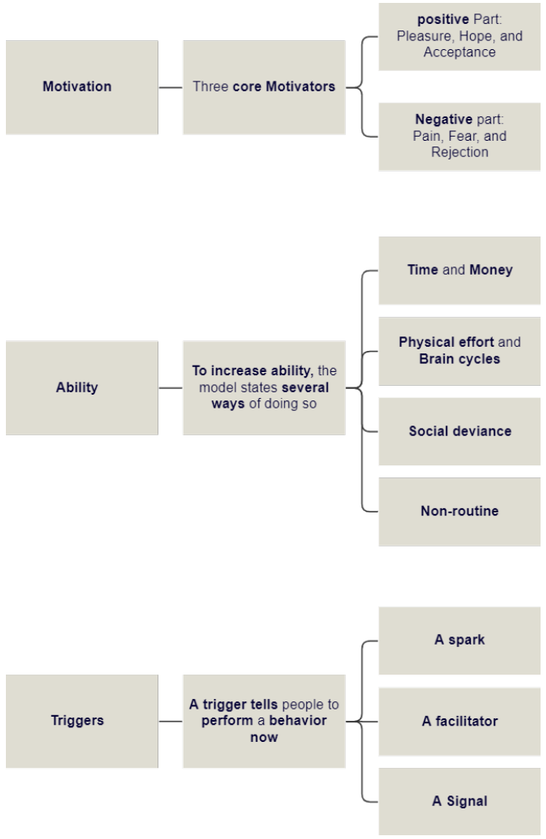


Fig. 3.10. Important factors that impact process of promoting a behavior (Inspired from: Kouroupetroglou et al., 2015)

3.5.1.2. Hooked Behavioral Model

Based on the previous model, another one suggested by Eyal (2014) could be used for designing applications to promote behavior.

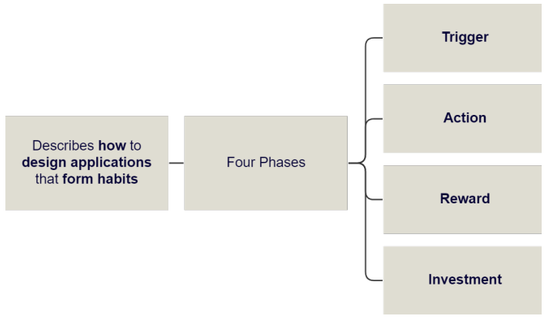


Fig. 3.12. The factors of Hooked behavioral model (Inspired from: Kouroupetroglou et al., 2015 & Eyal, 2014)

This model is similar to the previous one. However, it discusses the importance of taking action after facing a trigger. This model believes this action could be happened by giving rewards to people following certain behaviors (Kouroupetroglou et al., 2015).

3.6. The role of visualization methods in forming a habit

The mentioned behavior models describe the factors which can play essential roles in promoting a particular behavior in a society.

It was clarified that users need to be motivated to do an action, and to reach that, promising a reward and using suitable triggers could be practical (Kouroupetroglou et al., 2015). There are numerous factors that can influence people's inclination to conserve energy and inspire them to follow energy-efficient instructions, yet certain variables are considered more dominant than others, as seen in figure x (Rist & Massodian, 2019).

Among the factors listed in the mentioned chart, raising public awareness and considering the economic benefits sound more practical in Sweden based on interviews and investigations of published articles.

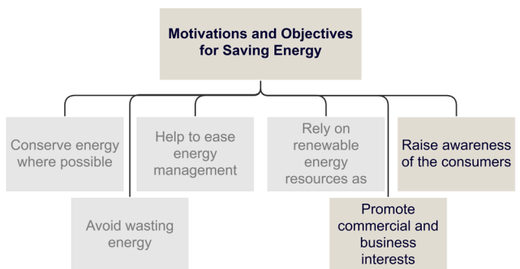


Fig. 3.13. Motivation to promote energy-efficient behaviors (Adapted and inspired form: Rist & Massodian, 2019)

The reason is that Swedish societies still need to familiarize themselves with the energy crisis, as it is a relatively new issue in this country (Platten, 2022). Therefore, informing the citizens is prominent, which is also an anti-poverty approach.

Moreover, thinking about the financial benefits is important as many neighborhoods around Gothenburg, including Hammarkullen, will be developed in a near future (Göteborgs Stad, 2014). In this case, creating energy-sensitive communities should be close to the framework of these development plans to capture the attention of funders and decision-makers.

Nevertheless, triggering motivation in people with the mentioned goals, economic benefits and raising public awareness, and inspiring them to adapt themselves and their lifestyles to more energy-efficient ones highly depends on how the information is communicated and visualized (Xu et al., 2020). The effectiveness of the visualization methods impacts public participation (Chalal et al., 2022). In the shown diagram, different categories of visualization methods could be found:

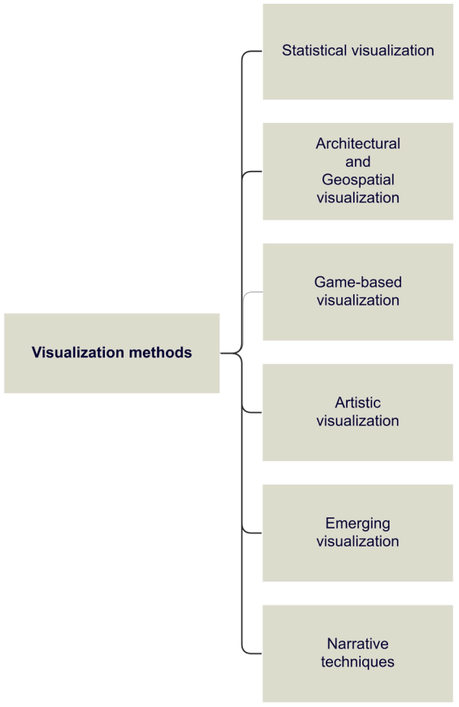


Fig. 3.14. Various visualization methods (Adapted and inspired form: Chalal et al., 2022)

As this thesis aims to design an energy-sensitive society through co-design workshops, a high engagement rate in the workshops is necessary. In addition to these events, the thesis will present various methods and activities that can promote energy-efficient behaviors on a neighborhood scale and how to transfer information to the inhabitants functionally, especially the younger ones. Hence, once again, the importance of adopting the best methods becomes highlightable.

Diverse categories of the visualization methods' have been summarized in the tables on the following two pages (Fig.3.14.). Some of them, such as statistical visualization, will not be used in this thesis. The reason is that such methods have been tested before, and they are not clear to everyone; thus, they are not known as engaging tools (Chalal et al., 2022).

Moreover, the participants of this thesis's workshops are students in the 7th grade, and understanding the meaning of different charts and diagrams would be even more challenging for them. On the other hand, other methods like storyboards, architectural visualizations, and augmented reality could be more entertaining tools to be used in the workshops and even in the future Hammarkullen as an energy-sensitive neighborhood. The advantage of these art-based methods over statistical ones is that art can talk about invisible issues, such as the energy crisis, in a way that would be clear for all age groups and would have a profound impact on people's emotions which might result in encouraging them to care more about the environment and lead to conserving energy (Thomas et al., 2021).

In this case, art is the center of attention in this thesis. It has been used in the form of collage works to discuss the results of each literature study part and also for brainstorming. Also, some other visualization methods such as storyboards, AR, and narrative techniques would be combined to create a game, resulting in engaging the students and co-designing the neighborhood center and energy café with them.

In the following pages, the presented tables demonstrate the investigated visualization methods, when each of them could be used, some recommendations, and the fact about whether they would be used in this thesis or not:

Literature Studies

Visualization categories	Technique	When to use	Recommendations/Considerations	Is this method/tool going to be used?
Statistical visualization [1]	**Line and area graphs**	Comparing at least two variables	1.Avoid using graphs with multiple lines. 2. When it comes to monitoring appliances, disaggregated area line graphs outperform aggregate ones.	**No!** This thesis uses collage and other visualization methods to picture an energy-sensitive society.
	Bar column graphs	1. Comparing amounts in various groups or categories. 2.Setting objectives and making normative comparisons.	1. Not usable for changes over time. 2. Soft colors could be used	
	Pie charts	Giving totals and breakdowns of subcategories.	1.It is better to use diverse colors. 2.Long labels are not understandable.	
	Gauge/Dial charts	1. displaying just one linear. 2. Progression of data value. 3. Establishing objectives and benchmark comparisons.	1.User-friendly and clear to be understood. 2. Taking up a lot of space is a drawback. 3. They can't be used to represent a variety of variables.	
	Radar charts	1. Examine changes over time in one or more datasets. 2. Comparing various categories. 3.Comparing variables on various scales.	1. Hard to understand 2. Not appropriate for visually measured variables.	
	Time-Pie charts	1. Examine changes over time in one or more datasets. 2. Comparing various categories. 3.Comparing variables on various scales.	It is possible to roughly estimate the contribution of each group or category. However, length-based visualizations, such as time-stack graphs, should be employed in their place for the precise measurement.	
	Time-Stack graphs	1. Examine changes over time in one or more datasets. 2. Comparing various categories. 3.Comparing variables on various scales.	Compared to time-pie visualization, time-stack visualization is simpler and quicker to understand.	
	Time-tone visualization	1. Examine changes over time in one or more datasets. 2. Comparing various categories. 3.Comparing variables on various scales.	1. Some units such as KWh are unclear. 2. Different users can interpret numerical text representations the quickest. 3.A variety of units should be employed.	
Architectural and Geospatial visualization [1]	**2D/3D geographic representation**	1. Perfect for neighborhood eco-feedback systems. 2. Encourage peer-to-peer education. 3. Specifying objectives and benchmarks. 4.Aid in the end-users' decision-making on retrofitting procedures.	1. Assist in the selection of well-informed retrofitting measures. A 2.3D one is expensive and complicated. 3.End users should have the option of 2D or 3D.	**Yes!** They can be used in preparing the **workshop materials.** Also, make the project more **understandable** and address the ***Information and guidance schemes*** for anti-poverty approaches.
	2D/3D Architectural visualization	1. Comparing the amounts in various groupings or categories. 2. Specifying objectives and benchmarks.	1. Cost-effective close-range photogrammetry. 2. Thematic mapping in color improves comprehension. 3. Mapping comprehensive and varied information reduces their efficacy. 4. More interesting than graphs.	
Game-based visualization [1]	**2D stylized visualization**	1. Provide a sense of belonging. 2. Adopted by a variety of users. 3. Encourage student collaboration. Establishing objectives and making normative comparisons. 5. Informing residents. 6. Spreading knowledge about how usage affects the environment.	1. Encourages the sharing of ecological values, which contributes to engagement. 2. Affordable and appropriate for people of all ages.	**Yes!** The second workshop was designed as a game. Adaptable to **education** anti-poverty approach and having **fun in behavioral changes**.
	2.5D stylized visualization	1. Provide a sense of belonging. 2. Adopted by a variety of users. 3. Encourage student collaboration. Establishing objectives and making normative comparisons. 5. Informing residents. 6. Spreading knowledge about how usage affects the environment.	1. Encourages a sense of belonging. 2. Adopted by a variety of groups. 3. It is a useful method for depicting huge urban regions.	
	3D stylized visualization	1. Establishing objectives and benchmark comparisons. 2.Education 3. NOT increasing public knowledge of how usage affects the environment.	1. storyboards can make this method cost-effective. 2.Informing the users specially the kids. 3.If the audience is composed of children and teenagers, including scenes/themes they are passionate about them in the storyboard can offer an engaging and fun experience.	

Visualization categories	Technique	When to use	Recommendations/Considerations	Is this method/tool going to be used?
Artistic visualization [1]	**Digital-based artistic visualization**	1.Spreading knowledge on how usage affects the environment. 2. Evoke curiosity and emotions	1. Providing emotional attachment to the users. 2. Alcoholic persons would not accept this method due to feeling guilty. 3. Statistical visualization can complete this method.	**Yes!** digital visualizations such as collage are used as a method to visualize the results, thoughts, and ideas. Both physical and digital ones are used in preparing workshops' materials. Adaptable to **education** and **informing** anti-poverty approach.
	Physical-based artistic visualization	1.Spreading knowledge on how usage affects the environment. 2. Evoke curiosity and emotions 3.Promote a sense of community.	The input provided by physically based creative visualization may not be sufficient for some users. Therefore, it is recommended to use additional visualization approaches, such as statistical ones.	
Emerging visualization [1]	**AR visualization**	1.Aid end users in comprehending the geographical component of their energy data 2. Encourage peer-to-peer education. 3. Promote a sense of belonging.	1. Color coding and textual information increase its effectiveness. 2. Users and stakeholders may be involved. 3. Co-creation with participants is advised.	**Yes!** They address a **few anti-poverty** approaches **at the same time:** *Education, Behavior change, information and guidance.* and provide fun which can engage the workshops' participants
	VR visualization	1. To encourage ethical community behavior. 2. To clearly express and depict the information. 3. To offer a 3D world that is participatory and immersive. 4. Relieving mental fatigue.	1.Using diverse energy unites is recommended. 2.Possibilty to be combined with BIM models. 3.Much more amusing than 2D models.	
	Thermal imaging visualizations	1. Examine and contrast the results of various retrofitting strategies. 2. DO NOT encourage peer-to-peer learning. 3. Promote a sense of belonging.	1. Comparing thermal imaging to 2D geographic encourages more pro-environmental behavior. 2. To make them understandable, a thorough manual with examples of thermal images and algorithms is required.	AR was used in the 1st workshop to make the section more clear and in the second workshop to design a game.
Narrative techniques	**Comic** [2]	1.Educating and spreading knowledge among the youths. 2.to encourage social interaction and behavior change.	1. It is preferable to combine this technique with others, including poetry and narration. 2. Demands interdisciplinary cooperation. 3. Collaboration is advised.	**The storyboards** could be **helpful** as they address these anti-poverty approaches: Education, Behavior change, information and guidance. **The participatory co-creation narrative design** would be used in the second workshop in combination to storyboard **Animation** is **impractical** as it needs related **computer skills.**
	Storyboard [3]	1. To make the learning process easier 2. To change behaviors 3. To interactively involve consumers	1. Could be created through a co-creation approach. 2. May be applied to serious games. 3.Hard to have multi characters in a story	
	Participatory co-Creative narrative design [4]	1. Becoming aware of the issues and demands of users. 2. To advance interactive architecture. 3. Establish communication between users and stakeholders.	1. Recommended to be combined with AR. 2.Giving freedom to the users to interpret. 3.If AR is going to be used, computer skills are required.	
	Animation [5]	1. To convert research results into understandable information. 2. To exchange experiences and discover more about diverse points of view.	1. Collaboration is advised.	

1- Source: Chalal et al., 2022 *with a few changes in style and sentences*

2. Inspired from Tomas et al., 2021

3. Inspired from Kouroupetroglou et al., 2015

4. Inspired from Han et al., 2022

5. Inspired from Ewald et al., 2023

3.7. Bridging from theory to design: Could designing an app be a solution to alleviate EP?

The first part of the literature studies highlighted that the key to alleviating energy poverty is creating a long-lasting impact on society by informing people about the energy crisis and educating them about how to overcome the situation by controlling their energy consumption and pursuing energy-efficient behaviors. This information and knowledge would create peace of mind for the inhabitants instead of keeping them in the darkness of ignorance, which could be a source of pressure and stress known as hidden energy poverty. Based on the learning outcome of this section of studies, it seemed that designing an application or platform which could provide guidelines on understanding the energy bills and the techniques for reducing the usage of energy might be an excellent solution to raise public awareness and giving active roles to the residents in alleviation process of the current energy crisis. Or, maybe developing and improving the existing apps could be also practical.

However, based on the interviews in the next chapter, it was demonstrated that such apps do not have a long-lasting impact on changing behavior. Moreover, less informed inhabitants, such as older people, might find it challenging to work with an app. Therefore, designing an app can not be inclusive in terms of engaging and informing diverse groups of people and raising their awareness. Thus, as this thesis looks for an inclusive solution, the idea of designing an app shifted into designing an energy-sensitive society adapted from energy communities.

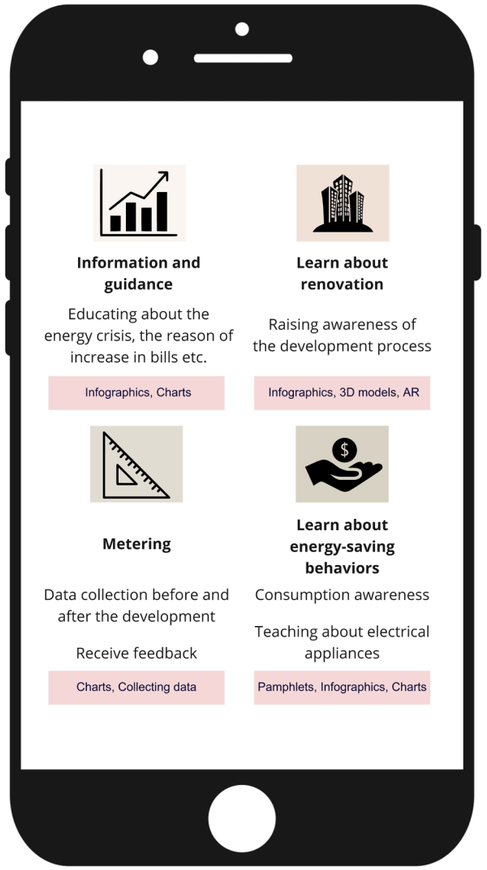
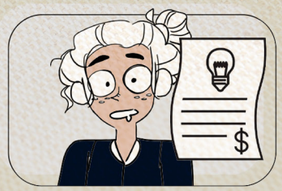


Fig. 3.15. Diverse parts of the application

How can app play a role in EP alleviation on the building scale:

Waking up in a room with low temperature as she has turned off the heaters to save money



Although living in coldness, the energy bills are still so high.

She turns off the lamps to save money.

Now, she lives in coldness and darkness. So, Anxiety and depression attacked her.

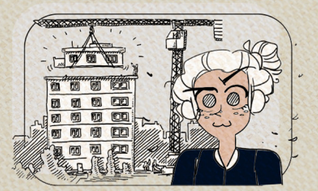
Energy bills are so high.

She opens the application to learn about effective ways of energy-saving methods.

Instead of turning off the heaters, she knows how to set a temperature and wear warm cloths.

Instead of turning off the lights, she changes them with more efficient ones.

How can app play a role in EP alleviation on the neighborhood scale:



The neighborhood is changing, but she doesn't know what's going on

People she knows are leaving as they can't afford the increase in rent after the renovation.

She doesn't know her neighborhood anymore and doesn't feel a sense of belonging. So, she doesn't care about it.

She has read about the renovation process in the app.

She can play an active role in her neighborhood and leave a comment on renovation processes.

There are various events and activities around the neighborhood to inform her about the renovation processes and energy-saving behaviors.

She feels a sense of belonging to the neighborhood and learns from it a lot.

3.8. Energy Community

Energy communities (ECs) are known for their voluntary and inclusive nature, combining environmental and social community objectives with non-commercial aims. There are two main definitions of ECs: Citizen energy communities and renewable ones. These two groups have similarities regarding governance, ownership, purpose, and activities. When it comes to government, participation should be voluntary and accessible to everyone. Ownership emphasizes the role of citizens and local businesses in the energy sector, and both of the mentioned ECs aim to prioritize social and environmental benefits over economic ones. Furthermore, both activities, such as producing energy, storage, and distribution, are similar (European Commission, 2019).

However, they have some differences, which are shown below:

Differences	Citizen energy communities	Renewable energy communities
Closeness to the energy resources	Local communities do not not need to be near to the energy resources.	Local communities should be close to the energy resources.
Activities	Operations are only related to electricity grid.	several operations using all types of renewable energy
Participants	**Anyone can take part**, but decision-making by stakeholders in large-scale commercial activity where energy is the main economic activity is prohibited.	The **participation** in the **restricted** group is limited to natural persons, local authorities, and MSMEs who do not consider it their primary economic activity.
Autonomy	Only shareholders who are not involved in significant commercial activities in the energy sector should possess decision-making authority.	Must remain independent from individual members or traditional market actors who are part of the community as members or shareholders.
Effective control	Large and medium-sized businesses are prevented from exercising any significant influence or control.	MSMEs located in close proximity to the renewable energy project may have the ability to exercise control over it.

Table 3.2. The differences between the two groups of ECs (Adapted from: The European Commission website, 2019).

Beyond the similarities and differences, Energy communities can be related to this thesis's goals by involving various sectors of society, decision-makers, and citizens in the process of generating energy, distributing it, and even selling power to take care of everyone's profit (Ceglia et al., 2020).

This holistic view is not restricted to private people's or companies' benefits; the other advantages of EC could be observed in finding solutions for environmental issues. For instance, by relying on renewable energy resources, EC tries to reduce CO2 emissions and provide better air quality. By involving the residents and paying attention to their ideas, needs, and thoughts on a societal scale, attempt to integrate a community (Moghadam et al., 2020). The comprehensive strategies of the ECs have the potential to decrease energy poverty by 12 to 16%. This would happen by ensuring that everyone has affordable access to energy resources. In some countries like Italy, this concern is combined with implementing renovation plans for poor energy-performance buildings (Ceglia et al., 2020), which would achieve better results.

Therefore, the objectives of this thesis can be met by the following contributions of energy communities:

*Empowering citizens by providing them with information and involving them in energy transition projects (related to the investigated anti-poverty approaches).

*Serving as catalysts for local communities and providing social leadership (as an anti-poverty approach).

*Facilitating a fair, efficient, and collaborative energy usage through cooperation and partnership models that promote a just and democratic transition (Close the aim of the thesis which is EP alleviation).

3.9. Best practices of energy communities

Co-designing low carbon public services *(Source: European Commission, 2021)*

Country: Finland

Powered by: Solar

*Learning outcome: * Citizen involvement could happen from a project's early stages.* Energy-saving habits should be combined with people's daily life and local businesses.*

Fig.3.16. li on the map. Source: Google map

The primary goal of this project is to lead Finnish societies to produce less CO2 faster. Even from the early stages of this project, citizens were involved by sending them the neighborhood map and asking the inhabitants to highlight their favorite spots. People from different age groups were part of the project to discuss what needed to become better as well as to develop a shared plan with local policymakers. As a result, the people of Ii had a deep sense of ownership, were proud of their city, and there was no public opposition to the project.

In addition to the collected maps, a few interviews were held with the youth and older citizens. The focus of interviews and collected data from the inhabitants was to make the area more efficient regarding energy consumption. Based on this aim and people's viewpoints, the first action was to solve the traffic issue. The other goals were set to be done each year.

Noteworthy parts of the project:

* Decision-makers used participatory approaches to involve people.
* Awesome energy-efficient habits plan with a focus on flourishing local industries.
* Well done combination of the yearly city funding and co-design actions.

Energy Safari: having fun with energy *(Source: European Commission, 2021)*

Country: Netherlands

*Learning outcome: * Raising awareness of energy consumption would be better to become a fun process. * By creating a sense of belonging in the inhabitants, they would act as team members and try their best to improve their neighborhood. * The importance of visualization methods*

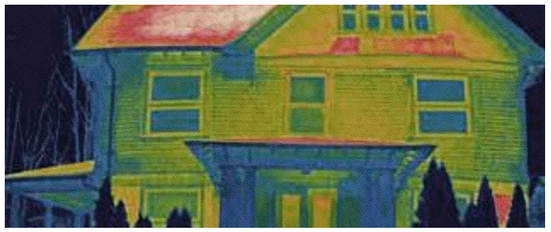


Fig.3.17. The example of the thermal images. Source: European Commission, 2021

Entertainment plays a vital role in making energy-efficient habit promotion more victorious. If raising public awareness is combined with fun activities, the inhabitants would be more likely to be engaged with the project and pursue particular behaviors.

In the Safari project, a group of people could walk around the neighborhood with each other and, with the help of a leader. On these trips, they could take thermal pictures of the buildings. They also could have this chance to order a similar image of their property. This process raised awareness of energy loss and the importance of renovation.

Moreover, after a while, the residents started to inform their neighbors about each other's building situation and encouraged them to improve their performance.

Noteworthy parts of the project:

* Energy is invisible, and people have a hard time understanding it and how to consume it better. Thus, some visualization methods, such as thermal images, can make hard-to-understand elementals clearer.
* Collective power is a reliable tool to make society more energy-efficient.

Let’s talk to each other!

Interviews

BOSTADS AB POSEIDON

Who was interviewed?

Housing developer of Hisingen area

When was this meeting held?

January 13, 2023

Why was this meeting held?

To estimate the dimension of EP impacts on people living in Jättesten and the possibility of holding workshops.

What was the outcome of this workshop?

Holding workshops and similar events in Jättesten is challenging and likely impossible; thus, the thesis's case study should be changed.

4.1. Is Jättesten a welcoming neighborhood for this thesis?

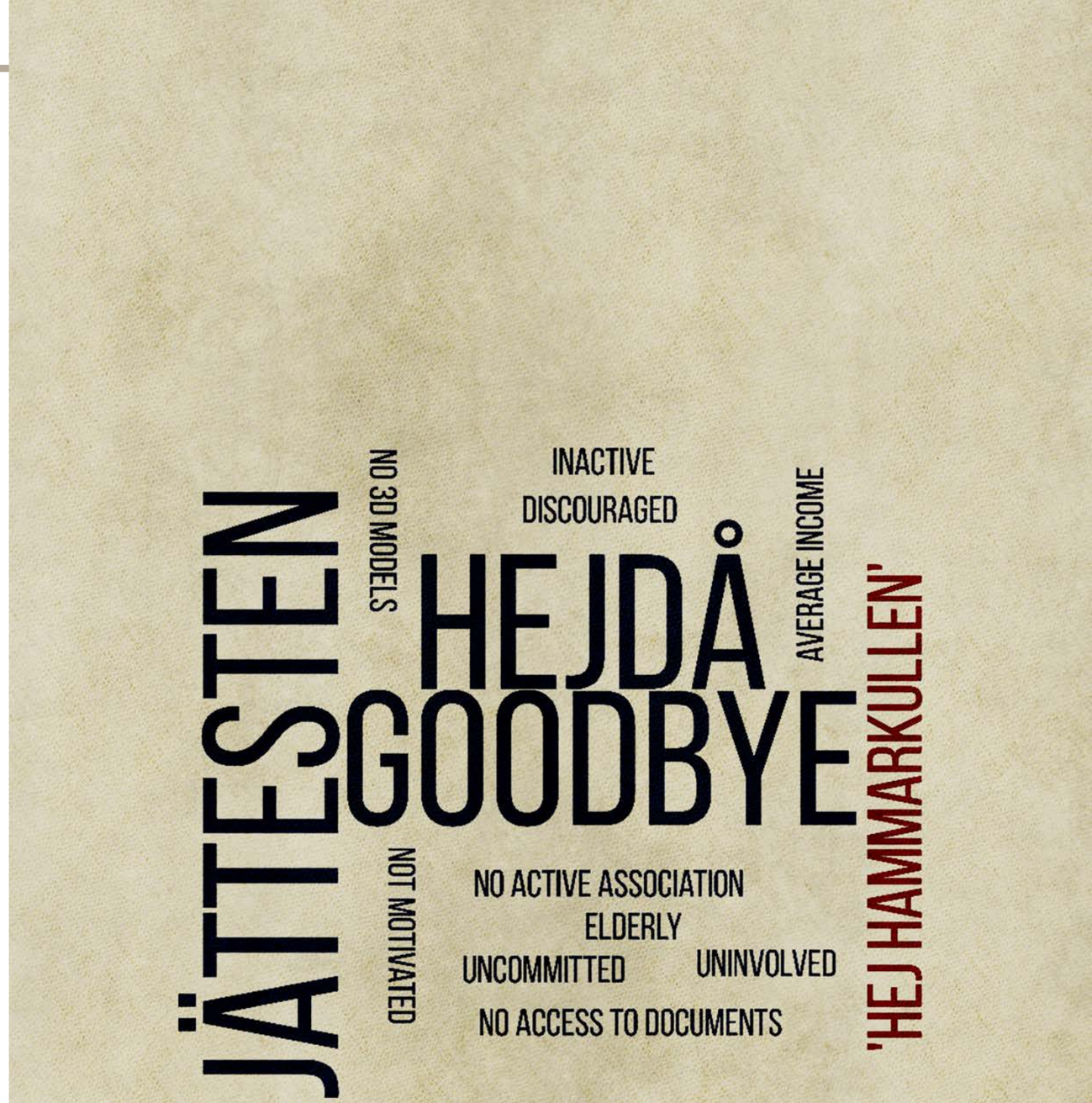
This interview discussed several essential aspects of an energy crisis in a neighborhood. One of the critical questions asked was regarding the social and economic status of the inhabitants living in Jättesten. It was explained that most of the tenants in the area are single people and elderly. As for their financial situation, the inhabitants had an average income, allowing them to pay their rent and energy bills with no problem. Therefore, the current energy crisis has not impacted the area yet.

The interviewer also inquired about possible ways to engage the inhabitants in energy-saving practices. The staff of Poseidon explained that the younger generations were less interested in participating in such activities due to their busy schedules. However, the older generation was more passionate about it.

The interview also discussed potential solutions to alleviate the energy crisis, such as adding solar panels and separating domestic hot water from the warm rent. However, these options were costly and time-consuming.

In this discussion, it became clear that the key to encouraging the tenants to save more energy is to make this process rewarding. However, they needed clear examples of making the process rewarding and pleasant for inhabitants.

Overall, the interview sheds light on the fact that Jättesten has a low possibility of being engaged in the co-design processes, which was one of this thesis's main steps. In this case, the author decided to change the case study and shift it to Hammarkullen, which is a welcoming neighborhood.



4.2. Designing an app to raise awareness and create inhabitants involvement?

Who was interviewed?

One of the app developers in Poseidon

When was this meeting held?

January 17, 2023

Why was this meeting held?

To estimate the practicality of designing a mobile application in alleviating EP

What was the outcome of this workshop?

Designing an app might not be adaptable to this thesis's goals as it does not necessarily involve and engage people.

In this interview, the interviewee discussed an app that provides various functions for tenants. The app includes a notice board for news and tenant information, a booking function for resources like laundry and bicycle pools, tenant information about the apartment and area, a form for reporting faults and errors, services for seeking parking spaces or another apartment, and a community-based function that enables tenants to participate in discussions outside of the environment.

When asked about the research process to determine which information must be provided to the users, the interviewee explained that they purchased the app through procurement and decided on a standardized version from their contractor. They based the functions on their website's existing versions and added appropriate other features.

The interviewer also asked whether the users were involved in the design process through participatory approaches or interviews. They responded that they had not involved the users in the start-up process; however, they discussed involvement and user input in upcoming functions and features.

Regarding the involvement process, the interviewee suggested using one of the features in the app that still needed to be fully implemented, such as polls and surveys. This feature could be used initially for feedback about the app and its functions. They can also include questions about the app in tenant surveys that they send out.

The interview provides valuable insights into creating an app for tenants. It highlights the importance of considering the users' needs when creating an app, even if it is a standardized version. The interviewee's response suggests that they are open to involving the users in future updates, which is crucial for ensuring that the app remains relevant and valuable.

In conclusion, as this thesis aimed to involve people and follow a co-design process, designing an app could not be compatible with the objectives of this thesis.

4.3. How do the housing companies deal with EP?

Who was interviewed?

Vice director of Bror Johansson & Co

When was this meeting held?

Why was this meeting held?

1. This housing company tries to promote energy-saving behaviors which is close to this thesis's concerns and their experiences could be helpful for the author.

2. To become familiar with housing companies' challenges after emerging energy crisis in Sweden

What was the outcome of this workshop?

1. Giving information about the energy crisis might affect the wrong target groups.

2. Promoting energy-saving behaviors should be rewarding for the inhabitants.

3. Technical interventions such as optimizing the piping system might result in paying more money which sounds paradoxical.

This meeting was held to understand how the housing companies tackle the emerging energy crisis. This company was selected as their approach to dealing with the fuel cost increase was similar to the goals of this thesis which is raising public awareness and promoting energy-saving behaviors among people.

This interview revealed the actions taken by this housing company to address the crisis and how they were impacted by it. One of the primary steps taken by the landlord was to change the pipes of their heating systems to make them more efficient and save energy. This step resulted in a significant reduction of energy consumption by 50%. However, the landlord was surprised to see a higher energy bill from their energy provider, Göteborg Energi. The reason behind the higher bill was the policies of the energy provider, which required customers to pay more if they consumed less energy than a calculated amount. This brought new challenges for the landlord as they had expected to use the saved energy to compensate for the budget spent on improving the heating system's pipes.

The housing company also tried to motivate tenants to save energy by raising awareness through flyers, letters, and emails. However, this effort faced some challenges, including the tenants' beliefs that saving energy only benefited the company. The landlord realized it was crucial to target the right people and provide them with precise information possibly through better flyer design.

Furthermore, the landlord identified the need to overcome tenants' beliefs that saving energy only benefited the company. They need to understand that keeping energy helps both the landlord and themselves, the environment, and the whole of Sweden. Additionally, they sought the help of energy consultants provided by Gothenburg municipality to give more advice to tenants free of charge.

In conclusion, the unexpected energy crisis required immediate action from landlords and tenants to address the issue. The landlord in this interview took several steps, including optimizing the heating system and raising awareness among tenants to reduce energy consumption. However, they also faced challenges motivating tenants to follow instructions and overcoming their beliefs that saving energy only benefited the company. Targeting the right group of people, providing clear information, and overcoming tenants' beliefs were identified as crucial factors for success.

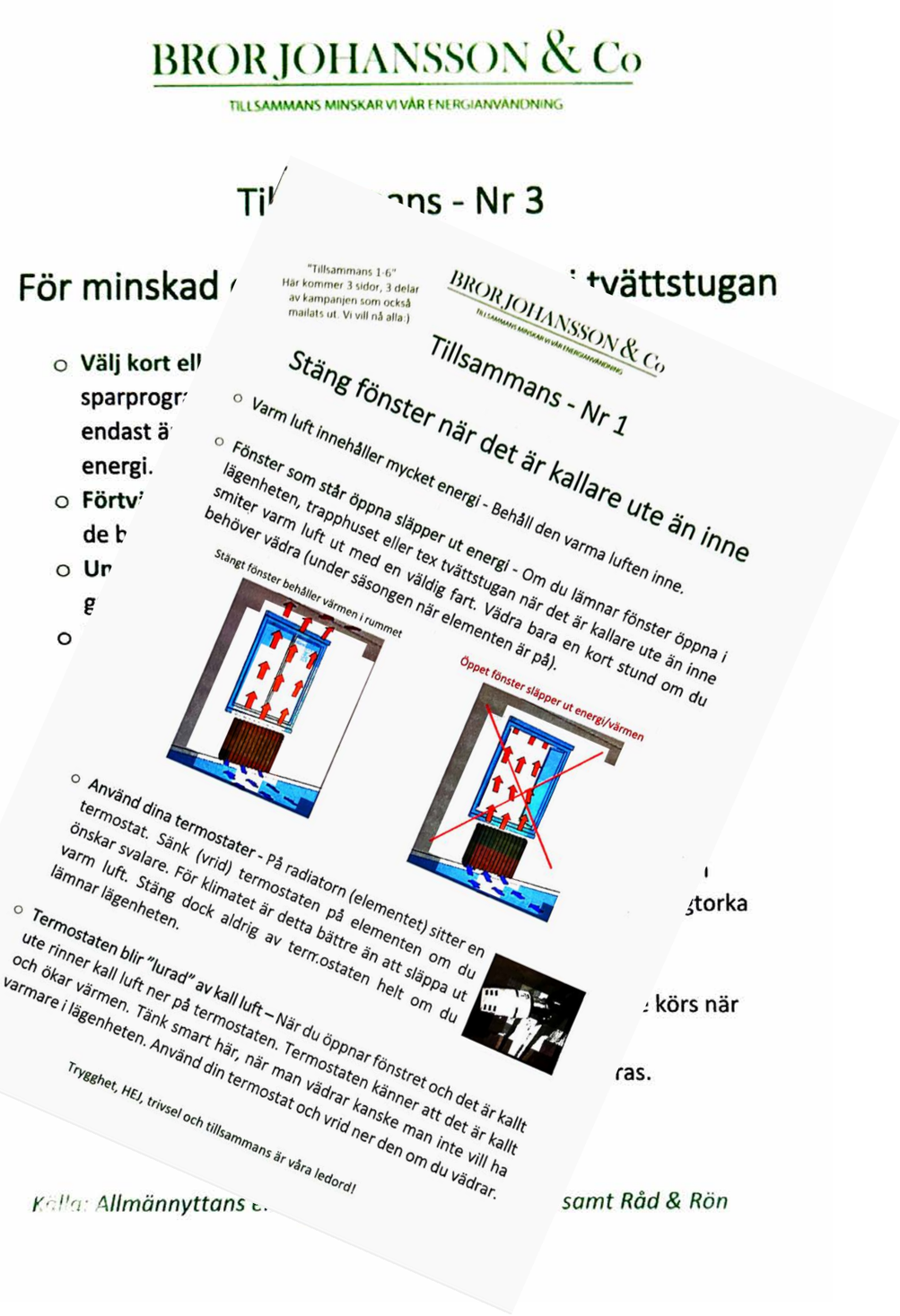


Fig. 4.1. Examples of the installed flayers in the buildings
Source: The Bror Johansson & Co website

Fig. 4.2. The "*Big Meeting*" between inhabitants and Bostadsbolaget. *Picture taken by the author*

4.4. Hi again, Hammarkullen!

This interview aimed to provide updates on the Hammarkullen Center transformation process, analyzing the possible impacts of the energy crisis on the inhabitants and finding a possibility to engage the residents with this thesis's workshops.

This conversion clarified that the square transformation process had remained the same since last year. This means the chosen architectural proposal by Link Arkitektur, alongside the participants' opinions and viewpoints, has been sent to the city planning office for evaluation, adaptation, and cost estimation. This office is expected to announce the results in May, after which another meeting will be held to present the newly made changes to the architectural design to the inhabitants.

During the interview, the subject of the current fuel crisis was brought up, and Ola mentioned that they had been faced with a 50% increase in the cost of hot domestic water. This raise was unexpected to them, and they encountered financial issues. He also mentioned that he and his neighbors at least expected to hear about the reason for this rise; however, they still need to give them clear information, and they are worried now. This fact highlighted the importance of this thesis subject for involving people and raising their awareness.

At the end of the meeting, Ola suggested holding the thesis workshops with the students of Nytorpsskolan as they have been involved in an architectural project with Bostadsbolaget related to renovating the existing buildings with the help of students and Minecraft.

Therefore, he provided contact information about the teachers working in the school to ask them whether there is a possibility of holding workshops with their students.

Who was interviewed?

Ola Terlegård, social activist in Hammarkullen

When was this meeting held?

February 8, 2023

Why was this meeting held?

In the social inclusion studio, Ola actively worked with Chalmers students to establish a common dialogue between the tenants and Bostadsbolaget. Also, he has sufficient knowledge of the neighborhood and the upcoming square development plan. Thus the primary goal of holding this meeting was to become updated about the area's current situation and estimate the possible opportunities to engage the inhabitants with this thesis.

What was the outcome of this workshop?

1. Being updated on the square development plan.

2. Learning how Hammarkullen's inhabitants have been effected by current energy crisis.

3. Finding new networks for holding

Fig. 4.3. Nytorpsskolan. *Picture taken by the author*

Who was interviewed?
Joachim Svärd

One of the school teachers at Nytorpsskolan, Hammarkullen, Gothenburg

When was this meeting held?

February 21, 2023

Why was this meeting held?

1. To estimate the possibilty of holding workshop in the school.

3. Discussing whether Minecraft could be a good tool

What was the outcome of this workshop?

1. The workshop time was set.

2. Minecraft can not be a practical tool in this school. Therefore, another tool should be found.

Hello Nytorpsskolan!

This meeting aimed to talk to one of Nytorpsskolan's teachers to estimate the possibility of holding a workshop with the students. Moreover, as this teacher and his students were participating in one of the renovation projects of Bostadbolaget and they are familiar with architectural tools such as SketcUp, they could be a great target group for this thesis's workshops. Furthermore, the teacher is testing Minecraft as a tool to make complicated renovation projects more straightforward for his students; therefore, this thesis could also use it as an engaging tool.

This meeting clarified that a group of students is working on an architectural project funded by Bostadsbolaget to redesign the interior spaces of existing apartments in Hammarkullen. The project is a learning process for the students and the housing company. The students have been taught to make 3D models of their apartments in SketchUp, and they have become familiar with some concepts related to designing buildings and the construction process. Furthermore, they have basic knowledge of energy-saving methods and their necessities in today's world.

Therefore, these students, being in the 7th grade, were the excellent target group for this workshop to test visualization and educational methods resulting in raising information on EP and sustainable lifestyle understandably. However, the project related to using Minecraft as a tool is separate from this project with the housing company and is supposed to be launched in September 2023. In this case, this thesis needed to find tools other than Minecraft to engage the students with the workshops.

Furthermore, during this meeting, the time of the workshops was set, and the duration time of each workshop was decided to be 45 minutes up to one hour to ensure that students would remain focused.

Time to Wrap up!

Literature studies & interviews learning outcome

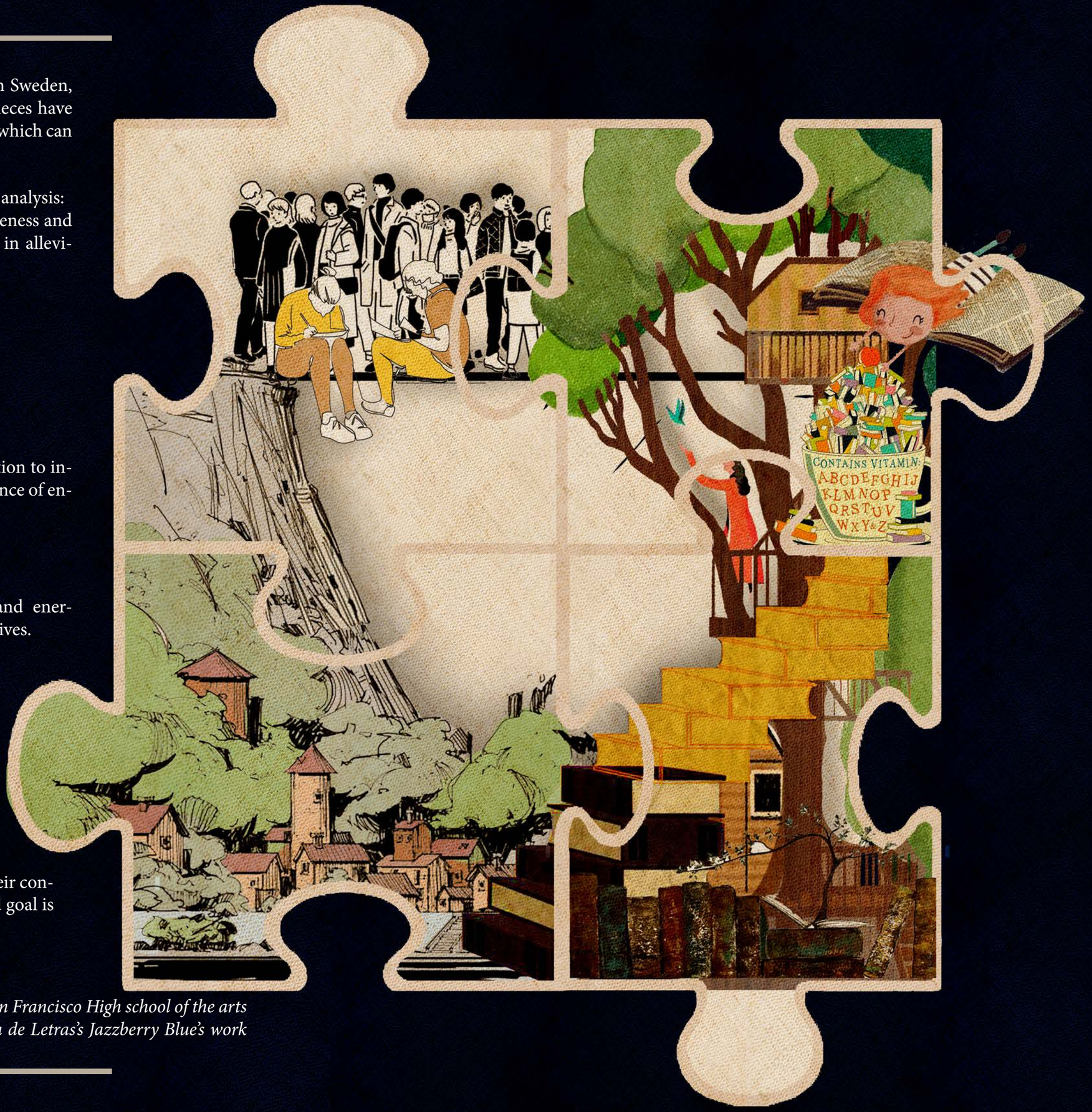
This thesis goal, EP alleviation in Sweden, is like a puzzle. Some missing pieces have been found through the process, which can be seen below:

Literature studies and case study analysis: They showed raising public awareness and changing behaviors could result in alleviating EP.

The mentioned methods in addition to interviews highlighted the importance of entertaining activities

and brining this information and energy-efficient behaviors into daily lives.

Moreover, the role of people and their contribution to meet such a mentioned goal is not negligible.



Images used in this collage have been inspired from: Freepik, San Francisco High school of the arts website, Art, and Sutterstock websites. George Brad's and Sepa de Letras's Jazzberry Blue's work also has been inspired.

5.1.The learning outcome of literature studies and interviews

Holding interviews with Poseidon's staff and one of the persons working on a project of designing an app at RISE for raising awareness of energy consumption revealed that such platforms might not be a practical engaging tool for the inhabitants as not all the persons have sufficient skills for working with these platforms, especially the elderly. Moreover, making people familiar with these applications and giving them information about the existence of such tools would be a challenging process.

Also, the second part of the literature studies highlighted that a systematic behavior change which is the key to EP alleviation, could happen through ''fun" and ''continuous" activities. The first factor emphasizes considering the role of entertainment when the decision-makers or architects would like to promote a specific behavior in a society. According to more investigations on the published articles, such tools as storyboards and games could provide an amusing infrastructure to teach energy-efficient behaviors to the residents.

Fig. 5.1. Promoting energy-saving habits need to be enjoyable. (Image inspired from: Sepa de Letras' s work and Art website)

The second factor is ''being continuous," which refers to the constant exposure to the elements or activities that remind people of energy-saving behaviors and their importance. This concept led the author of this thesis to learn more about ''energy communities", which provide the mentioned concern for the inhabitants and give them active roles.

Energy communities focus on both technical and social aspects of society. They plan collaborative, citizen-driven energy initiatives that advance converting to renewable energy while elevating citizens. They help to broaden public support for renewable energy initiatives and make it simpler to entice private capital for the clean energy transition. By boosting energy efficiency, reducing consumers' electricity costs, and generating local jobs, they also have the potential to benefit citizens directly (The European Commission website). Therefore, creating an energy community could be much more effective in alleviating EP than designing an application. In this case, transforming Hammarkullen into an energy community sounded like a good solution.

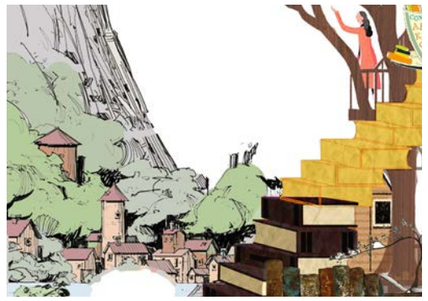


Fig. 5.2. Energy community might alleviate EP (Image inspired from: San Francisco High school of the arts website)

To do so, more research was conducted to learn about the energy communities, and also some case study analysis was done. At the same time, it was necessary to choose approaches adaptable to Sweden's needs and potential. Thus, a few interviews with a private housing company and an expert in designing energy systems were held to estimate the possible technical considerations in this thesis's design part. These interviews indicated that the technological interventions or suggestions might not necessarily result in the desired result. For instance, one of the problems that the Bror Johansson housing company has is that they have spent a relatively significant budget to change the pipes of their owned building to reduce their energy consumption to half. They succeeded in meeting this goal, but surprisingly they were forced to pay more money to Göteborg Energi as they started purchasing less electricity! This paradox could be observed in different parts of Sweden's energy policy because the current energy crisis is relatively new in this country, and there is a need to revise the rules in the future.

Based on the results of the interviews and learning more about Sweden's policies, this thesis direction was narrowed down into considering the social benefits and investigating the methods that could raise public awareness of the current situation and possibly similar ones and capture people's attention to the necessity of saving energy. As mentioned, the reason for centralizing only on the social factors of energy communities is that focusing on the technical ones would need to analyze numerous paradoxical rules and considerations. Thus, concentrating on empowering citizens and giving them knowledge would be much more functional. In this case and as studied in the literature, some public spaces, such as energy cafes and reshaping the whole neighborhood, could be beneficial.

Fig. 5.3. Raising public awareness and empowering citizens could be the key for EP alleviation (Image inspired from: Shutterstock and Freepik websites)

As this thesis's learning process is adaptation, hybridization, and inspiration, the idea of an energy cafe was broader than just a gathering place to discuss energy consumption. In this project, an energy cafe is a place with plenty of entertaining activities in which people can learn more about EP and better understand why they must pay more for their energy bills and how they can control them. Besides, even the type of food served in its restaurant would be considered to be low-used energy.

Furthermore, as literature studies demonstrated, empowering the inhabitants is also prominent in EP alleviation. This could happen by showing people how important their viewpoints are for the designers and decision-makers and how much they could change their living areas. Based on this factor, this energy cafe was co-designed with the youths living in Hammarkullen.

The question here is, why the younger people? The reason could be found in the articles and similar case studies. When it comes to education, young people become an important target group as they will shape their society in the future, and they can impact their parents. Also, they have fresh ideas to be involved in a co-design process, especially in this thesis.

However, more than having one energy cafe in a neighborhood is needed to promote energy-saving behaviors, and it was mentioned that continuous exposure to these behaviors is needed. Accordingly, the whole district must be reshaped to make its residents more conscious of energy consumption. Hence, another co-design process is required to create the components of such an area to combine the mentioned concerns with the inhabitants' daily life.

These actions would result in creating an energy-sensitive society where people are aware of energy-efficient lifestyles, and the neighborhood itself can raise its inhabitants' awareness of energy-related issues such as EP and its reduction methods through appropriately designed public spaces such as energy cafes and interactive artistic monuments.

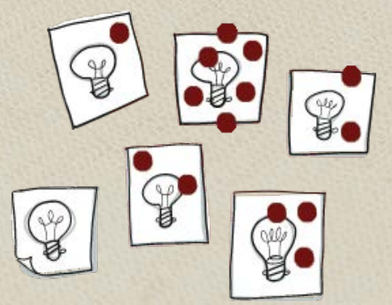
Fig. 5.4. Transforming Hammarkullen into an energy-sensitive community

EP alleviation needs analysis, design, and citizen involvement. Some public spaces, such as energy cafés, and bringing energy-efficient behaviors into daily lives are prominent. This thesis aims to co-design the mentioned spaces with the help of students living in HK.

Images used in this collage have been inspired from: Dream time and Shutterstock websites, Marybethleonard's brand, Leif Peng's (2013 & 2008) Christopher DeLorenzo's, Peter Vidani's, Rafel Mayani's, Chris Dove's, and Austin Briggs's work

We need each other's help!

Workshops



The first workshop
February 28, 2023 for 2 hours

Where?

- Nytorpsskolan

Who?

- 20 of the 7th-grade students

Why?

- Co-designing the energy café
- Testing a tool which can encourage students to think about energy-saving methods

Outcome

- The cafe was co-designed with them.
- A discussion was formed about the importance of saving energy.
- They devised some ideas and solutions to motivate adults to care more about energy consumption.
- The collage was an excellent, engaging tool. Even the students who did not used to participate in the class , took active roles. and which surprised the teachers.

6.1. A glance at the first work-

Using the collage technique to complete the prepared section of the energy cafe. This co-design process was about the activities held in the cafe; the food served, and even the lighting types and the color of the walls. Another aim was to encourage the students to think about the factors affecting energy consumption and make it easier to understand.

Before holding the meeting with the teacher the workshop's materials were prepared and checked with this thesis's supervisors. These materials are accessible on the following pages. In brief, they include a section of the energy cafe, a huge number of pictures to be used in students' collages and provide them the flexibility to choose, a 3D model of the café simulated in augmented reality, and markers.

Both 2D and 3D models were accessible as based on the investigations on the visualization methods, both models should be available to make them more understandable for the participants.

On the day of the workshop, even the tables and chairs were arranged to create a group work environment.

Before asking the students to make the collage of energy cafe, a simple presentation was given to the students in Swedish to provide them with an idea about why they were going to make a collage and also the importance of saving energy.

They were asked to design their café in a way to promote energy-saving behaviors and also try to reduce their cafe's energy consumption. To do so, they were told that the type of lamps, the color of the walls, and even the food served at the café could have impacts. They were allowed to choose any pictures they wished, but with only two conditions: when they were going to select an image, they had to make sure that all of their teammates agreed, and also, they had to write why they had chosen that.

The workshop was supposed to last only one hour to ensure the students would have their full attention; however, surprisingly, they showed a lot of enthusiasm; thus, the teachers suggested extending the workshop duration to almost two hours.

The last fifteen minutes of the workshop were allocated to the students to discuss their work and present it to their classmates.

Fig. 6.1. Taken by the author

6.1.1. Workshop materials

The section of the energy café was designed to create various spaces to make the interior spaces more capable of having diverse activities. As seen below, three floors were drawn in addition to a balcony and two semi-floors. Two personages were added to make the section more understandable, and before holding the workshop, the section was shown to the random children in the 7th grade to make sure it was clear for this age group.

As there was a possibility that a few students found the section confusing, based on the experience of working with kids, a 3D model of the energy café building was simulated on SketchUp to show it in the classroom with the help of a projector. Furthermore, the Augment app was used to bring the modeled café into real life via smartphones and AR.

The Augment platform can transform the SketchUp models into AR ones with a fourteen-day free license. This platform's logo can be seen below:

AUGMENT

To fill this empty section, a considerable number of pictures with various categories were prepared and printed. The types of photos were selected based on the literature studies and case study analysis results. These previous investigations showed which kinds of activities or design components might be functional in an energy café. The next page shows these pictures:

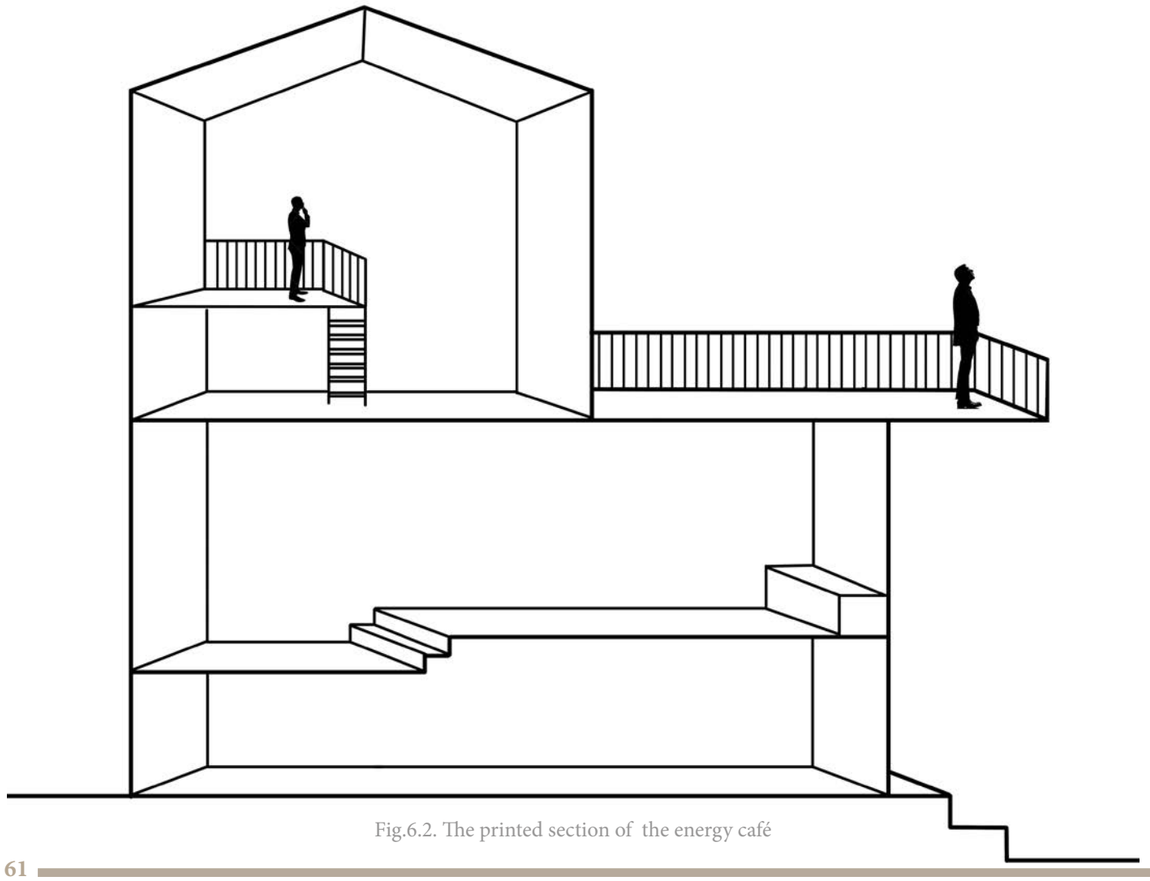


Fig.6.2. The printed section of the energy café

Fig. 6.3. The printed images for the workshop

6.1.1.1. Pictures' categories

Based on the read articles and the analyzed case studies, the following categories were selected as the images which possibly can be used by the students in their collages:

Fun and informative activities to raise public awareness amusingly in the café, including **cinema** and **theater**, **book club**, **music** and singing song, **cafeteria**, painting and **art workshop**.

Fig.6.4. The examples of the café's activities

The type of **windows**, **lamps**, and even the **curtains** could affect the energy consumption of the café. Thus, the mentioned elements were the other category of the chosen images.

Fig.6.5. The examples of the windows, lamps, and curtains

Based on the studies, in energy cafés, even the **food** type and the **cooking process** need to be considered to consume less energy and produce less waste. Therefore, the other category was allocated to diverse types of **vegetables**, images of **greenhouses** to capture the attention to produce food locally, and various food from different cultures as it is needed to give a sense of belonging to all the participants of the workshops and even to the possible visitors to the café.

Fig.6.6. The examples of the food

The **color** and **material of the walls** would have similar impacts; hence, the markers were given to the students to think about the color and the materials of the walls and floors. Diverse **personages** doing various activities, **plants**, **recycle bins**, and **solar panels** were the other provided images.

Fig.6.7. The examples of personage and renewable energy resources

6.1.2. How did the workshop hold?

The workshop was supposed to be started at 8 in the morning at Nytorpsskolan. At 7:30, this thesis's authors started preparing the students' classroom. It began by organizing the chairs and tables with a U-shape arrangement to create a group work environment.

Fig.6.8. U-shape arrangement to create a teamwork atmosphere

A big table with images on it, was located in front of the class window and behind the students' working table. The reason for not putting the pictures on each group's table was to give the students the freedom to choose their favorite photos and also provide them with this opportunity to walk around the class to keep them energetic during the workshop time.

Fig.6.9. The various categories of printed images

The workshop started at 8 in the morning with twenty students divided into three-person groups. In the beginning, a short and simple presentation with this title was given to them in Swedish: **''Låt oss designa ett energicafé tillsammans!"** or *Let's design an energy café together!*

First, they were told that the workshop host is an architecture student at Chalmers, and she is working on her thesis concerning saving energy and promoting energy-efficient behaviors. Then, they were reminded why they must save energy by saying simple sentences such as why it is essential for the planet, our family, and ourselves. They also learned how to save energy, which could be helpful for them in the next stage of the workshop, which was collage-making.

After that, they were told that their role in saving energy could be much more significant by helping the workshop host to design an energy café. They were given information on the meaning of energy café, collage, the type of activities, and components they could have for their café.

They were allowed to choose as many images as they wished but under two conditions: first, they had to have the agreement of all team members to select a picture. Secondly, they must write a short sentence or a keyword about the reason for choosing a photo. The reasons for these rules were to encourage them to work as a team rather than as individuals. This sense of teamwork, alongside the second demand about writing their reasons, would be a practical way to motivate them to think and discuss the methods and activities that could impact energy saving. Furthermore, these processes would prevent them from selecting and assembling random pictures meaninglessly.

Fig.6.10. The workshop host gives presentation to the students

The students started by choosing their favorite images from the table, and the host helped them by introducing different categories. Some students were so excited from the beginning, as picking pictures was so amusing for them. A few of them were not enthusiastic at first, but fortunately, their classmates made them excited by showing a few images from their cultures, such as Chinese food. This spontaneous action was so interesting and showed how necessary it was to think about diverse cultures and traditions when providing the materials.

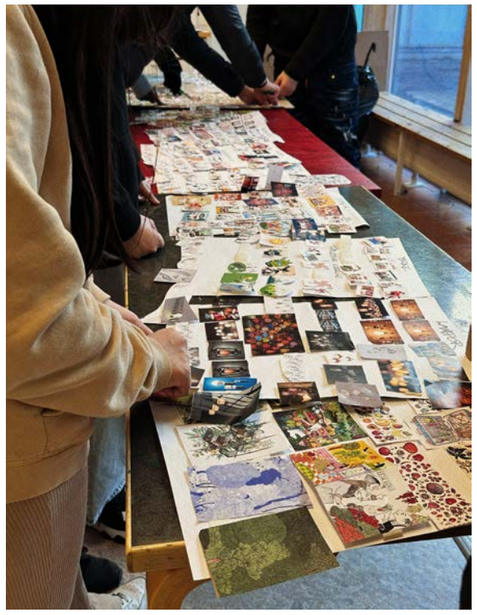


Fig.6.11. Students choose their favorite printed images for making a collage.

During the image selection period, a conversation was formed by the students around the table about how energy could be saved and how this process could become enjoyable and engaging for all age groups. Luckily, this conversation and finding the difference between the impacts of different activities and components on consumption were so funny for the students and became a reason for them to come up with questions. As they were not sure about the effects of all the provided pictures, they started asking questions of each other, the host, and their teacher, which was a good sign since it could be seen that this process was so fun for them and they are willing to increase their knowledge.

The teachers were so surprised that they could see after one hour of straight working, students were still sharp and looking for ways to improve the design of their café.

At this time, students were surprised by seeing an AR model of the energy café building. Although they saw a virtual 3D model of the café shown by the projector at the beginning of the workshop, this AR model captured their attention.

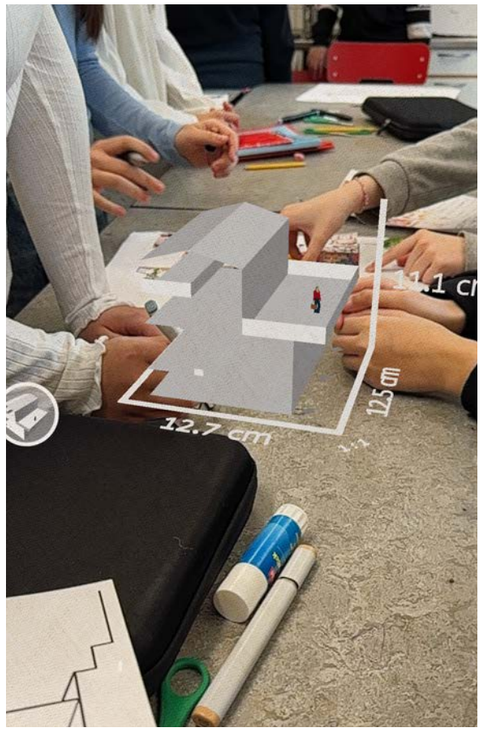


Fig.6.12. Students are working with an AR model of the café.

The workshop was terminated by a 10-minute presentation of each group's work to their classmates. As this process could be stressful for the students, he teacher held each group's final work in front of tthe class, and the groups talked about their work while sitting in their chairs.

Fig.6.13. The final discussion of each group's collage

6.1.3. Workshop learning outcome

Students had been told that they were helping an architecture student in designing a café that would impact promoting energy-saving behaviors, and they would be her colleague for one day. This definition of their role motivated them to work better to influence the Chalmer project.

Paying attention to cultural diversity was a prominent factor in engaging the participants in the workshop and motivating them to participate actively. For instance, providing food images from international cuisine and decorative elements belonging to various countries created a sense of belonging for the students and inspired even the less interested ones to join the workshop.

In addition to co-designing the energy café, one of the workshop's goals was to find an amusing way to teach and make students aware of energy-efficient behaviors and items that affect energy consumption.

Thus, instead of giving long lectures with power point, the variety of printed images and dividing them into diverse categories evoked thoughts in their minds about the effects of each picture. In this case, a spontaneous discussion arose around the table, and they started asking questions from the workshop host and their teachers. This discussion taught the participants so many things in a fun way without feeling that they had been forced to learn something.

The flexible arrangement of the chairs and putting the table with the images on it in the corner of the class gave an opportunity to the students a chance to walk around and kept them sharp and energetic for the whole two hours of workshop time.

Augmented reality was an excellent amusing tool, making the students even more excited to design a functional and stunning café.

The combination of clear role definition, letting them know they are essential for this thesis's project, collage technique, printing and categorizing a huge number of images, paying attention to diverse cultures and traditions, and adapting AR tool made this workshop successful. The teachers were so surprised that they could see even the students, who usually only stay in the class for a maximum of ten minutes and rarely participate in class activities, found this workshop exciting and engaged actively with the class. Hence, they decided to use the same technique in the future.

Their made collages have been shown on the following pages.

6.1.4.What could be improved for the next workshop?

For the next workshop, a few placards could be installed in the class to constantly remind the workshop's goal constantly to the students. In this way, they could be less distracted from the main purpose of their work and can focus more.

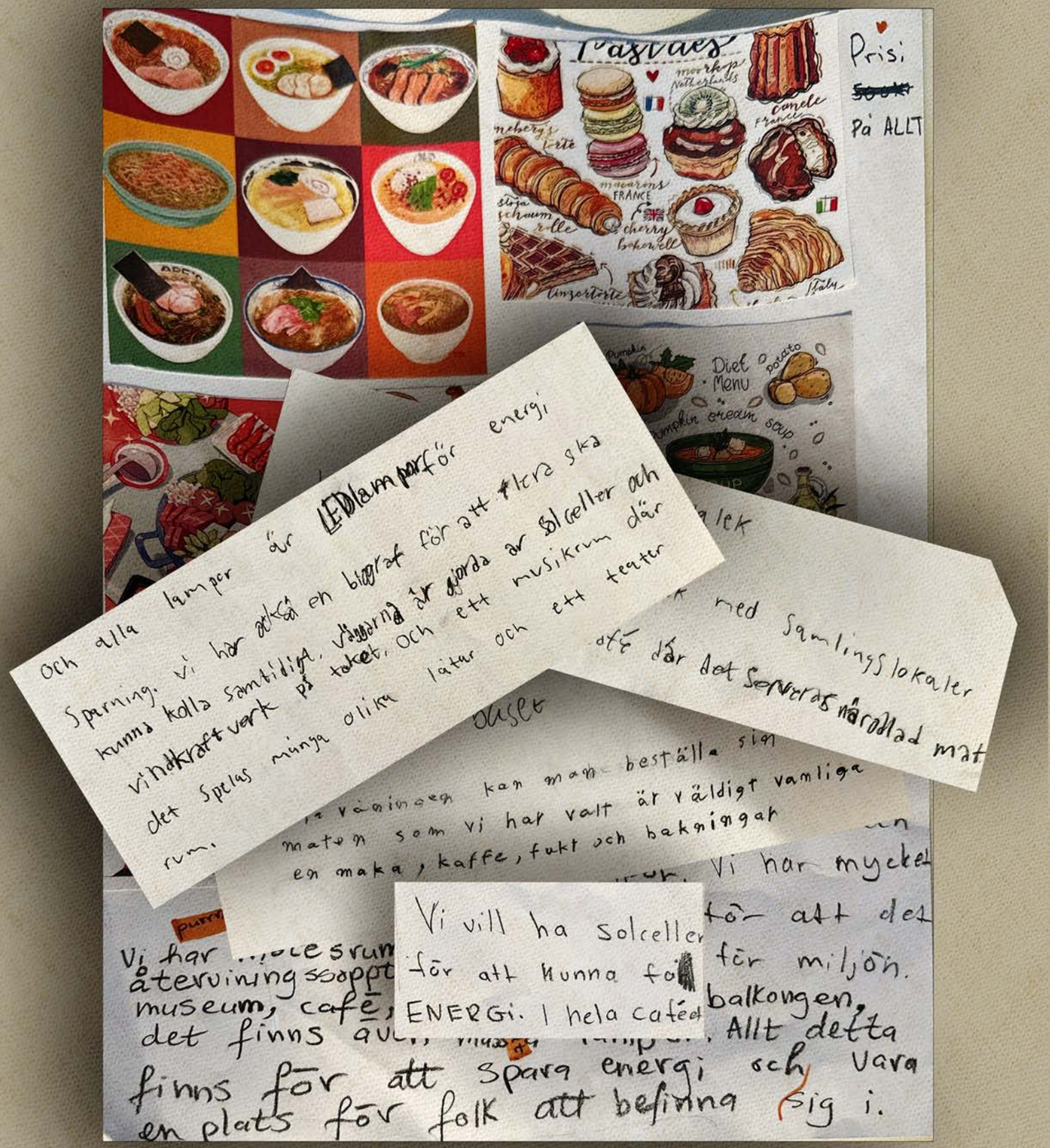


Fig. 6.14. The examples of the students' notes

Education

CO-DESIGN AN ENERGY CAFE'

'WALLS MADE OF SOLAR PANELS'
'SAVE ENERGY'
'STOP LIVING IN COLD AREAS!'
'VEGETARIAN FOOD'
RECYCLING 'CO-DISCUSSING' LAMP
'FUN MOVIES ABOUT ENVIRONMENT'
LED
'GREEN FOOD FOR THE ENVIRONMENT'
'SOLAR PANEL' 'LOCAL FOOD'
'GATHERING PLACES'
'SING SONG TOGETHER'
'RENEWABLE ENERGY'
'CONSUME LESS ENERGY'
WINDOW
'LESS-COOKED FOOD'
'WATCH MOVIE TOGETHER'
'ROOFS MADE OF WIND TURBINE'
'ENERGY-EFFICIENT BEHAVIOR'

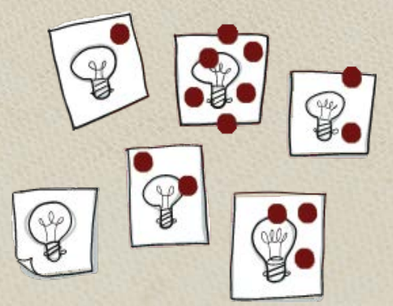
LEARNING PROCESS

'HUGE BALCONY TO BRING LIGHT'

TEACHING ENERGY-EFFICIENT BEHAVIORS

Jennifer, Tekla, Sara
7A

Fig. 6.16. The examples of the students' collages



The Second workshop
April 18, 2023

How long?

- One and half hour

Where?

- Nytorpsskolan

Who?

- 20 students of the 7th-grade

Why?

- Co-designing the Hammarkullen Center
- Testing Augmented Reality and storyboards as tools to facilitate complicated co-designing processes

Outcome

- Co-designing the future designed Hammarkullen Square and transforming it into an energy-sensitive center
- Translating complicated urban design process into an understanding one with the help of Augmented Reality and storyboard

6.2. A glance at the second work-

Using augmented reality and storyboards to enhance students' learning experiences of energy-saving behaviors and engage them with a complicated concept, such as co-designing an energy awareness hub.

The second workshop focused on an urban-scale transformation to modify the architectural proposal presented by LINK Arkitektur for Hammarkullen Square to make it a place that can increase public awareness of energy-saving behaviors. The subject of energy-efficient behaviors and reflecting it on urban areas is a challenging concept even for designers; thus, it was necessary to find a way to make it understandable for seventh-grade students. To meet this goal, a 3D model of LINK's design was simulated on an augmented reality platform, and with the help of storyboards and designing a game; the co-design process was tried to become straightforward and entertaining for the students.

The workshop started with a quick presentation on the results of the first workshop, and the students were told how their collages could help the author's thesis work. This step was necessary to rest them assured that their thoughts and ideas held significance and that these workshops were purposeful rather than arbitrary.

After that, the second workshop's goal and process were explained to the students. They had been told that today, they were going to tell the story of the future Hammarkullen Center, and by that, there would be a few characters who needed the students' help to visualize their wishes using collage.

They were asked to download the augmented reality app to find the characters and their stories to bring the 3D model into their class.

Four different models with three hidden numbers in each model had been prepared before, and the students were divided into four groups to find the numbers and use the collage technique to complete each character's wishes for future Hammarkullen.

The students had less energy than in the first workshop; however, due to their teachers' opinions, the main reasons were the Easter holidays and Ramadan. Despite not being that much energetic, the workshop lasted for approximately one and a half hours, less than the first workshop's duration but still more than the expected duration, which was fourth five minutes.

Fig. 6.17. Taken by the author

6.2.1. Workshop materials

1.Four 3D models simulated in the Aero augmented reality software

2.Printed characters and a letter about their dreams for Hammarkullen were put in a pocket Printed

3.A3 pictures of Hammarkullen to visualize characters' wishes with the aim of collage

4.Printed images to be used in collage.

As mentioned before, Hammarkullen Square will be developed in a few years, and LINK Arkitektur has designed the selected architectural proposal for future transformation.

The second workshop aimed to redesign this final proposal and visualize it as an energy awareness hub. As the documents related to the architectural proposal have not been publicized yet, it was impossible to access its official 3D model. Therefore, based on the published site plan and perspectives of the future Hammarkullen center, a 3D model of the square was prepared and simulated on two different augmented reality platforms. The first was the same as the previous workshop: Augment online platform, and the second was Adobe Aero.

Augment, in contrast to Aero, was a user-friendly platform and did not require special systems to simulate and open a 3D model. Still, the reason for switching from this tool to the Aero was that this workshop was supposed to be designed as a game, and it required adding more details and putting a few characters in the model. The Augment online tool cannot simulate details like texture, personages, and furniture. On the othre hand, Adobe Aero software has an incredible potential for adding amusing and eye-catching details to the model to make it fun and attractive for children. Thus, Aero was used to prepare the 3D model of the future Hammarkullen

Adobe Aero

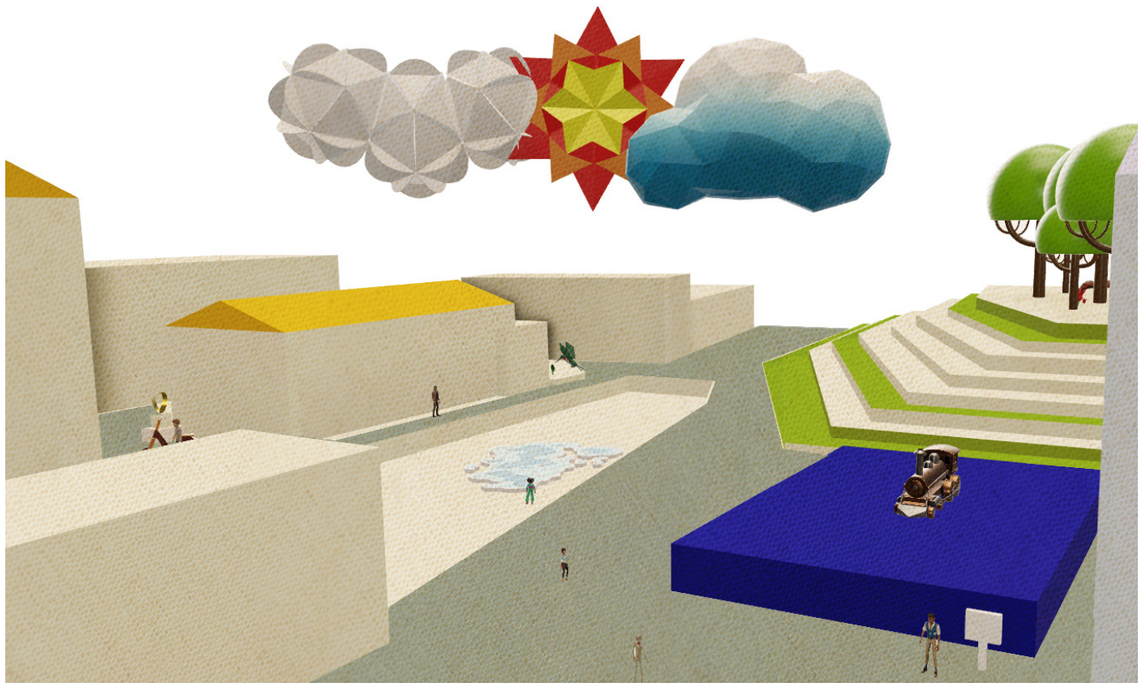


Fig. 6.18. The Link's Hammarkullen square design simulated on the Aero software by the author

Fig. 6.19. The examples of the second workshop's materials

center, and a few numbers were hidden in the model. The idea was to encourage the students to use their phones to see the 3D model in their classroom to become familiar with the LINK's proposal and find the hidden numbers to make it more entertaining. Each number belonged to one character, and after finding it, students could open the letter pocket to see the character and their wishes and dreams for Hammarkullen's future.

Fig. 6.20. The example of the characters, hidden numbers in the virtual model, and the pocket of their wishes

The students were divided into four groups, each with its own virtual 3D model and hidden numbers. They were asked to randomly pick a number from one to four, and then based on the selected number, they could scan a QR code to be led into their model. For each group, there were three hidden numbers and three characters; therefore, the students were supposed to work on visualizing the dreams of three characters.

Similar to the previous workshop, a table was allocated to the small printed images to make the collages. Another table was for the characters and printed A3 pictures of the Hammarkullen to be completed by the students with the collage technique.

After opening each letter pocket, the students could

Fig. 6.21. The students are looking for the hidden numbers in their 3D models and within their groups.

find the character alongside a printed short letter asking for help from them. For example, a character called Ali had the supermarket owner role and asked the students to help him find greener and more environmentally friendly products for his store and even allow him to produce vegetables locally.

Or another character was asking for students' ideas and opinions on changing the facade of the building in the western part of the square. All of these requests and concerns were based on the outcome of this thesis literature study section and the elements of an energy awareness hub such as gathering spaces, green facade, green food, etc.

Fig. 6.22. The students discuss with each other to visualize the dreams of the characters for future Hammarkullen

The students were instructed to think carefully about which pictures they wanted to choose to complete the story being told by the characters. To encourage this critical thinking, they were asked to write about their thoughts and reasons for selecting a particular picture in their collages.

Fig. 6.23. Writing about their reasons for choosing a particular image for the collage

Workshop learning outcome

The goal of the second workshop was to demonstrate how selecting the right tools can help simplify complex concepts, such as reflecting energy-saving behaviors in urban areas. The workshop aimed to make this process accessible and easy to understand, even for 7th-grade students. To meet this purpose, a simple game was designed in an augmented reality platform to show the detailed fancy model of the future Hammarkullen square simulated in augmented reality in addition to adopting collage and storyboard techniques. These tools had another advantage in enhancing the students' energy level and trying to engage them with a school task after a long Easter break.

Each character's story and their dreams for transforming Hammarkullen Center into an energy awareness hub was an excellent idea to evoke critical thinking skills in the students' minds and encourage them to think deeper about complicated concepts such as the scope of behaviors and activities, which

From a broader perspective, the importance of workshops like this can be analyzed from two different angles. First, by exposing children to the challenges and problems of their living areas, they can learn how to cope with these issues in the future. This is especially important regarding issues like the energy crisis, which will require a concerted effort from the next generation to solve.

Second, workshops like this can help students feel a sense of belonging to their communities and show them that they can play an essential role in shaping the future of their societies. This is key for districts to meet their future goals faster and with the help of their inhabitants. Therefore, it could be said that one crucial take a way of this workshop is to show that despite experts' and designers' confusion about communicating with people and talking to them about complicated emerged issues such as the energy crisis, innovative tools and methods could have a significant effect to engage even the youth and raise their awareness.

In summary, the second workshop showcased that creative tools and techniques can be utilized to effectively communicate even the most intricate issues, such as the energy crisis, to younger generations. Such workshops and activities raise awareness and encourage active participation of the youth in societal contributions, which is vital for creating energy-sensitive societies in the future. This emphasizes the significance of ongoing endeavors to engage and educate the younger generations about intricate problems to form a better tomorrow in which people pay attention to their energy-related behaviors as these today's kids would be the actual creators of a future energy-sensitive community.

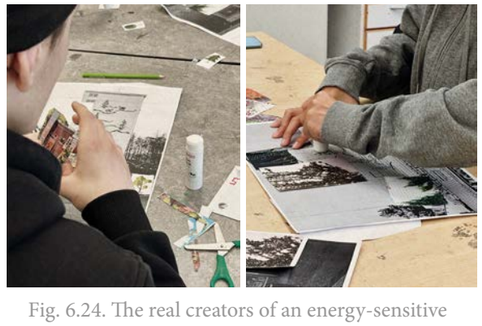


Fig. 6.24. The real creators of an energy-sensitive society

Hej kompisar,

Jag är Anna och är ark

byggnaden för att gö

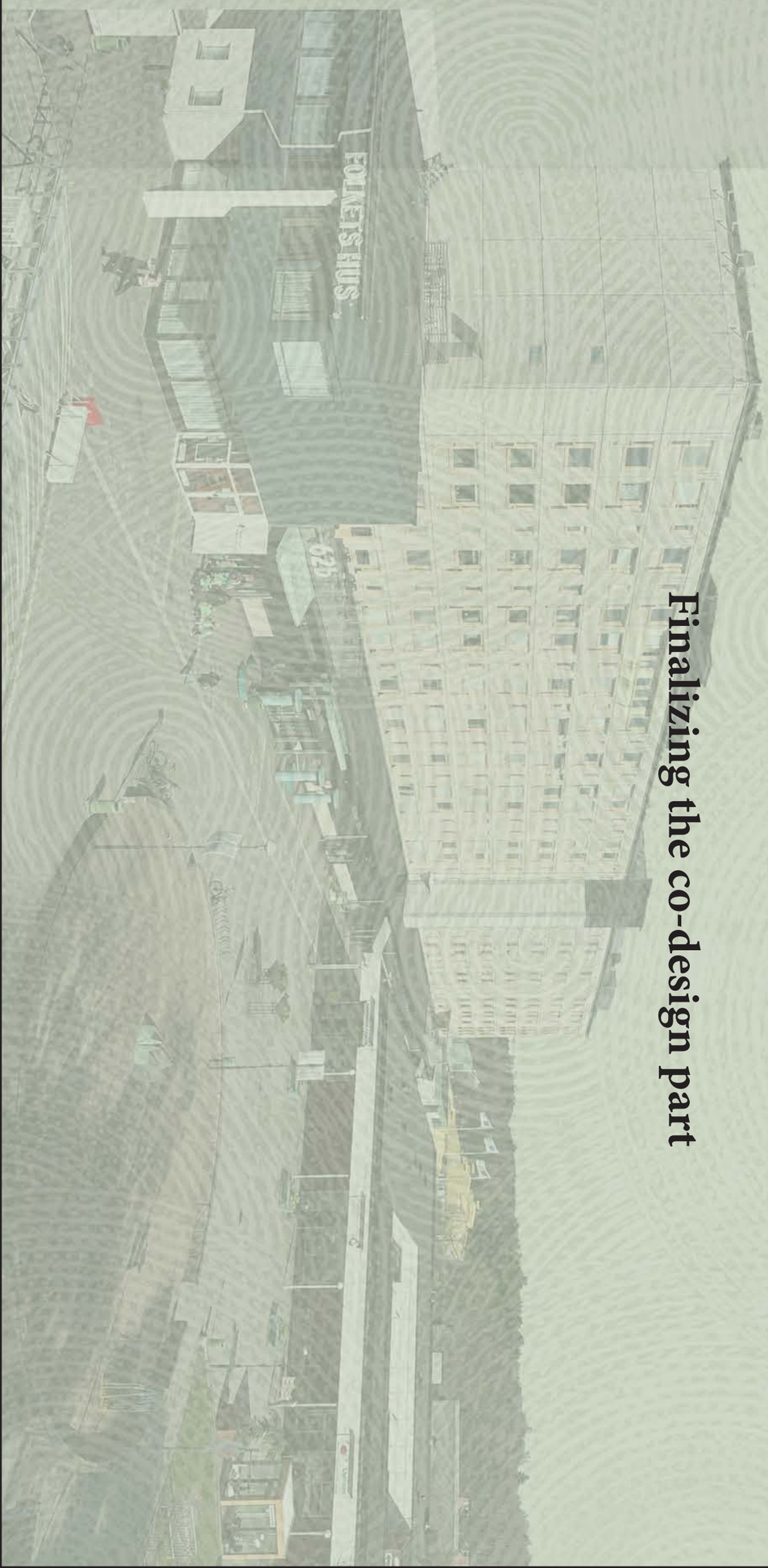
Jag funderar också

förmodligen balko

denna fasad?

ändra

Let’s get empowered against energy poverty!



Finalizing the co-design part

7.1. Co-designed energy café

The workshop, conducted to explore the concept of an energy café, utilized specific methods that fostered a spontaneous discussion among the participants. The students, their teachers, and the workshop's host engaged in a lively conversation, sharing their insights and ideas about energy conservation and sustainability. The discussion was driven by the collages that the students created during the workshop. These collages were used to visualize and articulate the students' vision of an ideal energy café.

The collages that the students produced during the workshop were diverse and unique. Each presented a unique perspective on how an energy café could function and what it could offer to the community. The collages depicted various elements, such as the physical layout of the space, the type of furniture, lighting, and decor, the menu offerings, and the educational materials that would be provided to the customers. These elements played a critical role in shaping the students' vision of an energy café that is welcoming, educational, and sustainable.

The collages, combined with the discussion during the workshop, expanded the author's understanding of the role and function of an energy café. The insights gained from the workshop helped her to rethink the traditional concept of an energy café and adapt it to the specific needs and preferences of the inhabitants living in Hammarkullen. The experience proved to be a valuable tool for the author to hybridize the learning outcomes with the needs of the neighborhood, ensuring that the design of the energy café is responsive to the local context.

The workshop's outcome is significant, as it showcases the essential contributions that students can make toward designing an energy-sensitive community. The students' collages and insights played a critical role in shaping the design of an energy café that promotes energy-saving behaviors and is also an attractive and welcoming place for the community to gather and learn.

The student's contributions, and their impact on the final design of an energy café for the neighborhood, are elaborated upon below.

The first topic raised in the workshop between the students was about how to produce energy in an environmental-friendly way. They had heard about solar panels and wind turbines as green and clean methods to generate electricity. As this workshop aimed to capture the attention of the students to sustainable ways of producing energy and the technical concerns were not in priority, they could also use wind turbines for their energy café; but, still, they were told in an understandable way that using each of the renewable energy resources would have specific technical considerations in reality, and solar panels or the wind turbines can not install everywhere.

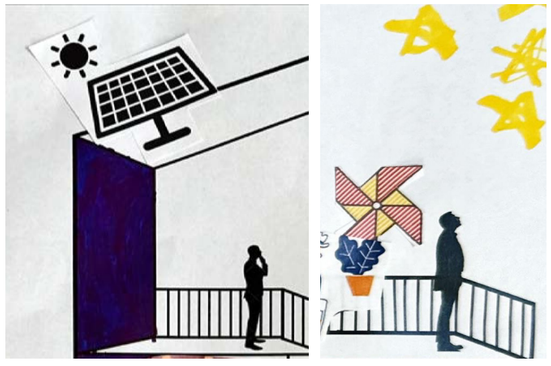


Fig.7.1. The examples of wind turbines and solar panels used in the students' collages.

The second enjoyable factor for the students was the food and drinks they wished to serve in their café. In this part, the author started asking the students which types of food could be better served in an energy café, and she started bringing up conversations between the students to inspire them to think about the footprint of diverse meals. Then, she asked the students to talk about particular food from their culture and background which they believe is a good option to be served in their café, and they were encouraged to explain the ingredients used in that specific food to their teammates. During these discussions, students started thinking of producing the ingredients of their kitchen themselves by having a greenhouse. This idea was interesting even for their teachers, and they started dreaming about planting and having their own gardens when they retired!

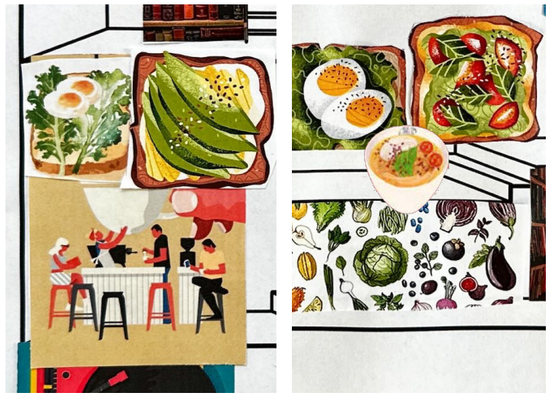


Fig.7.2. The examples of food used in the students' collages.

The greenhouse idea motivated the teachers to pick a few pictures from the table of images and ask the students to add these pictures to their collages.

Fig.7.3. The examples of greenhouse selected by the teachers

Another subject that students were asked to consider was the activities that should be done in their café to make learning about energy-saving behaviors more amusing. As this demand could be a bit complicated for the students, they were told to imagine their school courses and try to come up with ideas to entertain their class time. Therefore, they brought this idea to use a similar artistic approach used in this workshop in their café or have a cinema and theater to watch a movie about the recommended energy-efficient behaviors.

Fig.7.4. The examples of an 3D display installed by the students.

Other popular activities among students were art workshops and galleries, and weekly book clubs.

Fig.7.5. The examples of book club and art galleries

The collected collages from the first workshop and the raised discussions helped the author narrow down various activities and approaches used in other energy cafés worldwide and structure the range of the activities and ideas which could be used in Hammarkullen's energy café.

The final concepts for this café can be seen on the next page:

Images used in this collage have been inspired from: Pixtastock, Freepik, Shutterstock, The Møller Danmark, Arend's, Lieke van der Vorst's and Olena Stasiuk's artwork, The Designstac and The Vecteezy websites, Hanna Lavoie's sketch

Fig.7.6. The collage of the energy cafe

7.1.1. About the final design of the energy café

The collage on the previous page is the visualization of all the literature studies, interviews, and workshop learning outcomes for designing a successful energy café in Hammarkullen. The meaning of each element used in the collage can be read below:

The building of an energy café by itself and the way that it generates its needed energy must be environmentally friendly. For example, generating electricity with the help of renewable energy resources could be a good idea, and even the students highlighted the importance of this factor. Therefore, the first image seen in the collage is a bright sun, the heart of the café. As a bright and warm heart, the sun provides the café with light and warmth and creates a lively and dynamic flow. In the first step, this flow can produce electricity for this place.

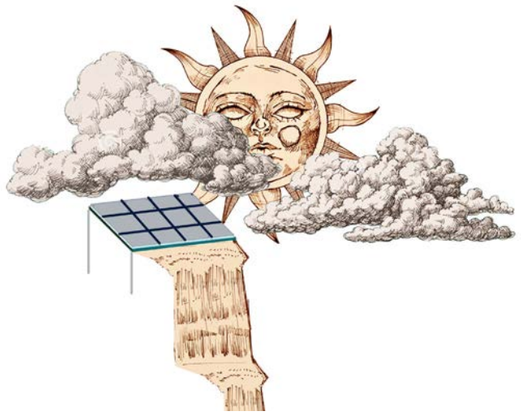


Fig. 7.7. Source of the image: Inspired from Hanna Lavoie's sketch

In this café, it could be learned how to use this generated flow in a way that could be sustainable and friendly to the environment.

Fig. 7.8. Artist of the image: M. Arend

For instance, this flow could produce vegetables in a greenhouse. The locally produced food would have less footprint, and growing and planting vegetables was an exciting activity among students and teachers who participated in the workshop. Thus, this activity could be done in an energy café, or maybe some ingredients used in the café's kitchen could be produced in this greenhouse.

Fig. 7.9. Source of the image: Artist: Lieke van der Vorst

Moreover, in an energy café, it would be a good idea to capture the visitors' attention to their diets and make them aware that different food has diverse energy demands to be produced. They need to know that some have fewer negative environmental impacts. This process could be a part of promoting energy-saving behaviors and replacing the current behaviors with greener ones.

All the mentioned factors must be explained to people, including energy-generating methods, green diets, and other factors that could raise public awareness of how to save energy and consume it efficiently. This explanation and making inhabitants more aware of their behaviors must be done through

entertaining and engaging activities such as art workshops. Raising awareness of complicated subjects, such as those related to energy, is challenging, and the concept is complex for residents. In this situation, artistically translating these concepts could facilitate the mentioned processes.

Moreover, providing an infrastructure to hold meetings and events where visitors can ask questions about their energy bills and learn more about energy-efficient behaviors is prominent.

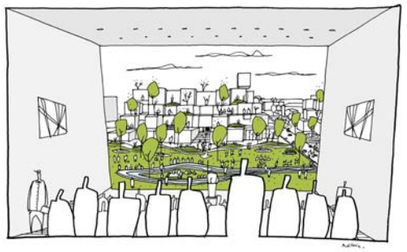


Fig.7.12.Source of the image: The Møller Danmark website

These activities and spaces in an energy café must be as inclusive as possible. This inclusivity refers to an equal learning opportunity for all visitors regardless of their age group and culture. Hence, specific workshops, such as those held during this thesis, could be considered in the café to engage the youth.

Furthermore, paying attention to cultural diversity is another important factor in engaging people in promoting energy-saving behaviors by showing them that society could see them and create a sense of belonging to the community. This could happen through simple items such as serving food from international cuisine or serving it in traditional manners. Considering cultural diversity is even more critical in Hammarkullen as many people from different countries and nations live in this district. Therefore, it is vital to rest assured that all of them can feel that Hammarkullen is their new home.

Designing cozy spaces where the visitors can spend time together and in close contact with the greenhouse or other green spaces would be another important activity in an energy café.

Fig.7.15.Source of the image: The Vecteezy website

All the mentioned concerns resulted in the final collage of Hammarkullen's energy café.

7.2. Co-designed energy center

As mentioned in the previous chapter, the students were in a game simulated in an augmented reality platform. While playing this game, they were faced with a few characters in the 3D virtual model of the Hammarkullen Center. They started transforming and redesigning diverse spots of the square by using their imagination and reading the characters' wishes. In the following the process of how the students' collages affected the final design of this thesis author could be read:

In most of the collages collected from the students, attention to more green areas and even green facades could be observed. This desire to add more greenery and vegetation to Hammarkullen Center was also a center of attention in the ''Big meeting,'' where the inhabitants shared their comments and feedback on the LINK's proposal for the square. Therefore, in the final co-designed collage of the center, this concern was tried to be answered.

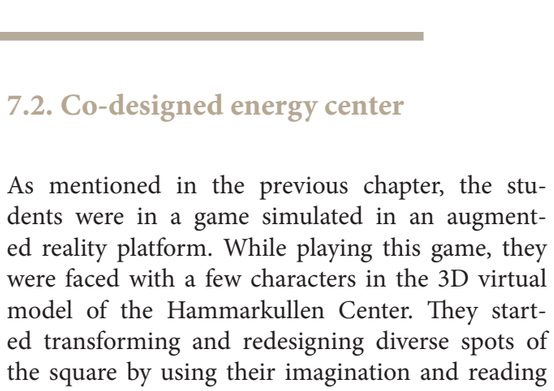


Fig.7.16. Students' passion to see a greener version of Hammarkullen center.

Another exciting activity from the student's viewpoint was urban agriculture and having the possibility to grow vegetables. Even one of the students emphasized her interest in planting her own tomato bushes to cook omelets for her grandmother!

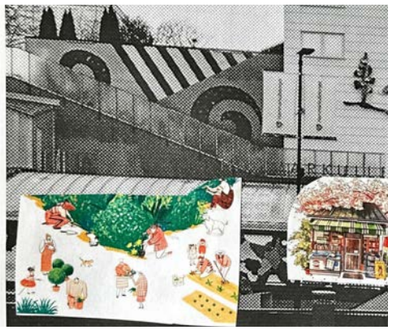


Fig.7.17. Interests for growing vegetables locally.

They also had questions about the difference between solar panels and wind turbines in generating energy. They were wondering whether they could have a turbine on their balcony!

Fig.7.18. Wind turbines everywhere!

The author gathered all these concerns to visualize the final face of Hammarkullen Center as an energy-sensitive center in combination with her learning outcome of literature studies, interviews, and her own ideas.

7.2.2. Co-designed energy-sensitive center

As mentioned in the literature studies chapter, providing economic benefits motivates people to follow energy-efficient behaviors. This motivation also has a significant impact on decision-makers to be encouraged to invest budget on involving people in energy-related projects and providing them with information about the possible upcoming developments in a neighborhood (Rist & Massodian, 2019). In this case, the design implications of this thesis are clear and uncomplicated interventions in the LINK's suggested proposal for Hammarkullen Center's future. These interventions would not disturb the main buildings as these constructions' various functions, such as offices, are supposed to compensate for the construction budget. Thus the suggested design elements of this thesis would make some changes in the main gathering spaces of the square. By that, it is more likely that decision-makers' attention will be captured as they could rest assured that nothing will be changed in the main design parts, which are supposed to bring economic benefits for them.

Furthermore, as discussed before during the ''Big meeting" held in the social inclusion studio, the residents' feedback on the LINK's presented proposal had been gathered. This thesis also attempted to consider people's comments in its design interventions. In the following, each element of the collage will be discussed:

In the background, one of the buildings designed by LINK could be seen. Still, the function of this building has yet to be decided, but in the first draft of the proposal, it was allocated to supermarkets and shopping stores. In this collage, a greenhouse has been attached to the building, which could be a place for locals to grow plants and vegetables. The reason for adding this place is to encourage people to think about their diet and eat local food, which is recommended to consume less energy and reduce CO2 emissions. In practice, this place might not be able to produce food or be considered an urban agriculture center; however, changing habits could be started by taking small steps, such as showing people that different food has diverse energy needs to be grown and transferred. Moreover, one of the places that the participants of the ''Big Meeting" would like to have in their neighborhood was more green spaces which could be beneficial for them to spend time there. Therefore, a greenhouse could be a good option.

Fig.7.22. The LINK's designed building taken from their website and the attached greenhouse inspired from Lida Ziruffo's artwork

This greenhouse could be connected to an open-air market in which the products of this greenhouse could be sold. Such gathering spaces could also be beneficial for locating information stations to talk to people and promote energy-efficient behaviors face-to-face.

Fig.7.23. Open-air market connected to the greenhouse (Inspired from David Clark's work)

The other concern that Hammarkullen's inhabitant mentioned in the ''Big meeting" was the absence of Folkethus in LINK's proposal. This center is so prominent for the residents as they hold various public meetings there and use it to communicate with each other and keep updated. In this thesis, the current place of Folkethus has been allocated to the new building of the energy café. As the residents of this neighborhood tend to spend time together and participate actively in social meetings, an energy café located in the main square near the tram station could be an excellent place to hold various activities there and use it to increase public awareness of energy-saving behaviors.

Another suggestion is to allocate the main route toward the square to pavement and bicycle paths to teach people about greener and more sustainable commuting ways.

As new ways of generating and distributing energy might be replaced with the current ones in the future, from current time, people need to get familiar with various energy-producing methods. Some ways, such as wind turbines, can not be used in Hammarkullen; still, it is a good idea to familiarize people with them and put them in daily exposure to watching the energy generation process. To meet this goal, interactive artistic monuments could be installed in the square to show people the process. For instance, simple lighting could be turned on when the visitors paddle a bike. Other sculptures can demonstrate the capability of water and wind in power generation by spinning pinwheels or miniature mills.

Fig.7.25. Interactive artistic monuments (Inspired from Freepik website and Johan Pries's work)

More green spaces, sitting areas, and pavilions also have been added to the LINK's proposal to establish a stronger tie between inhabitants and nature and promote a green lifestyle. These also were participants' demands in the 'Big meeting" as they could see that these public green spaces must be included in the current proposal.

The combination of these interventions can teach people about energy-efficient lifestyles, such as biking and eating local green food, and show them how energy could be generated by designing interactive artistic sculptures. As their comments in the ''Big meeting" have been considered, possibly these interventions and changes could be faced with a warmer welcome compared to a scenario in which people's viewpoints were in shadow.

Co-designed Hammarkullen center

Images have been inspired from:Freepik, Shutterstock, istock, itsnicethat, and LINK websites. Lida Ziruffo's, Kate Lycett's, Johan Pries's work, David Clark's, and Shou's artwork

7.2.1. Co-designed Tram Station

In the collage of the next page, the interventions co-designed with the students have been visualized. The following will discuss each element used in this collage and the reason for choosing specific images:

The tram station is the first spot for people visiting Hammarkullen. Moreover, for most of the inhabitants of this area, the station is one part of their daily life as they need to commute to other parts of the city via this place. Therefore, this station could play an important role in combining energy-efficient behaviors with an individual's daily life and exposing them to such habits.

In this case, this satiation should be representative of the neighborhood to show the visitors that Hammarkullen is an energy-sensitive society. To pursue this goal, the first step is to give new functions and meaning to the existing shop stores in the station. These shops could be transformed into an "energy station". Energy stations have been tested in various methods and forms in European countries. Locals can use multiple services at these places, including energy audits, which offer tailored recommendations for enhancing home energy efficiency. Furthermore, residents who adopt energy-saving practices, such as installing solar panels or switching to energy-efficient appliances, may also be eligible for incentives from the station, such as rebates or discounts (Inspired from European Commission, 2021).

Fig.7.19. Energy station (Artist of the images used in this collage: Angela Hao)

Co-designed Tram Station

Images have been inspired from: Florent Bodart's, Raquel Costa's, Eloise Renouf 's, Nastia Larkina's, Sewzinski, and Angela Hao' wrok. In addition to the etsy, Shutterstock and Freepik websites

Goodbye or hello?
That is the question!

Discussing the results

8.1. Discussion

This thesis adopted various methods to find the answer to the research questions. In this chapter, the answers to these questions will be analyzed, and how this thesis ended up with these specific responses will be discussed.

Research questions

This thesis had one main research question that resulted in three different clusters of operational questions:

1- Pre-start questions
2-The first cluster of the questions
3-The second cluster of questions: A bridge between theory into design

First, the answer to the operational questions will be discussed:

What is the definition of energy poverty?

The answer to this question was found by: **literature studies and interviews with experts familiar with EP.**

There are various definitions for energy poverty all around the world. In most definitions, a household's income and energy expenditure ratio are criteria for finding poor energy families. Although energy poverty refers to affordability in Sweden as it is categorized as a developed country (Spirkova et al., 2016), Sweden still needs to define its own definition of energy poverty in the future (Platten, 2022). It is the first important step that should be taken in this country as by defining EP properly, the roots of this issue in Sweden and also vulnerable groups could be found, which would lead to finding better anti-poverty approaches and possibly more efficient social support in the future and the alleviation of EP.

Setting a proper definition for EP in the Swedish context requires sufficient time and various types of research, which means that it should be considered a long-term goal.

However, as EP has already emerged in Sweden, the following research on alleviation methods can not be postponed until a proper definition is found. Therefore, in the current situation, it is recommended to focus on each context's characteristics and try to develop appropriate anti-poverty solutions based on the needs of a neighborhood and its inhabitants (Noka et al., 2019).

In this thesis, the definition of EP had been considered the need for more accurate and understandable information for the public to communicate with them about this challenge and how they can overcome it. This thesis believes that the rise in public awareness is the first step to alleviating EP in the future by engaging people with energy-related projects. In turn, this would result in social acceptance, guaranteeing the success of energy retrofitting and renovation projects, which is a critical factor in reducing EP and providing affordable access to energy for everyone (Xue et al., 2022). Moreover, knowledge would relieve the stress imposed on people by facing the current fuel cost crisis, and it is their right to become familiar with it (Thomson et al., 2017).

Possibility of further research:

1. Finding an official definition of EP in Sweden and defining vulnerable groups based on accurate analysis. 2. Finding a bridge between technical considerations and social benefits in alleviating EP.

What are the impacts of EP on people?

The answer to this question was found by: **literature studies and interviews with the housing companies.**

EP would affect the physical and mental health of the people struggling with it. Living in buildings with low energy performance and quality would cause diverse illnesses ranging from respiratory diseases to heart issues. Moreover, encountering a vague situation and facing high energy bills that do not have a reasonable balance with income would impose high pressure and stress on people (Thomson et al., 2017).

Based on the interviews with the private and public housing companies, this imposed pressure due to unwanted increases in fuel costs has had a more significant impact on the elderly. The housing companies counted a few reasons why EP has had a more major effect on older people:

1- First of all, this age group acquires their knowledge of the current fuel crisis mainly from national television, and most of them are not that expert in following the news from other sources. Moreover, their social activities are relatively limited; thus, they can not be faced with other people and see the issue from the viewpoint of actual citizens instead of the media. These factors made a big fear in the elderly's minds of the war and consequenced fuel shortage and affected them more than the other residents.

Nevertheless, if they were informed in other ways besides the TV, or if they had the opportunity to stay in touch with others during the crisis, they could observe how other people try to cope with the situation, and their stress could be relieved more.

2- The second reason is related to the first one in a few aspects: The older generation has less information about the dimension and scope of the EP crisis, and this lack of knowledge makes them terrified and forces them to live in a rough situation such as living in cold temperatures than the normal one to save more energy. Besides the burden of anxiety, living in cold accommodations would threaten their physical health.

Therefore, regarding the impact of EP, it could be concluded that both physical and mental health might be affected, and the older inhabitants might be the more vulnerable ones.

Possibility of further research:

How the impacts of EP could be measured, and how could it be relieved

The first cluster of the questions

What are the tested anti-poverty approaches in other countries?

The answer to this question was found by: literature studies and case study analysis.

Although EP is a relatively new issue in Sweden (Platten, 2022), this country's other European counterparts have been struggling with this challenge for a long time. Therefore, these nations have tested various methods and tools to reduce EP. The approaches tested in one country might not be applicable to the Swedish context; still, there are a few lessons that could be learned from them and adapted to the needs of Sweden.

This thesis used Fernandes-Jesus et al. (2020) and Noka et al. (2019) publications to acquire an overview of all the tested approaches in Europe. Then the thesis expanded this gained information by reading more articles and deepening into each of the presented methods. The result is that the scope of the anti-poverty approaches is so broad: from direct financial aid and social support to political interventions and education.

The financial subsidies could be considered quick reactions to protect vulnerable families from EP (Noka et al., 2019), and the other approaches have a more long-term impact on society.

Based on Platten et al. (2021), the approaches such as renovation and improving the energy performance of the existing buildings would be the better technical approaches to tackle EP in Sweden.

When it comes to alleviating the social impacts of EP and according to interviews with experts and housing companies and case studies analysis, raising public awareness would be an essential factor. Promoting energy-efficient behaviors and replacing current behaviors with more sustainable practices can reduce EP and its negative effects on society. Therefore, education and informing people are seen as crucial strategies for mitigating the social impacts of EP.

Therefore, in reducing EP in Sweden, the most functional attitude might be a combination of renovation, energy retrofitting projects, and social activities, which result in giving practical and informative information to the inhabitants.

Possibility of further research:

Deeper investigation on the anti-poverty approaches which can be practical in Sweden to meet both social and technical demands.

2- How could a behavior be replaced with an energy-efficient one?

The answer to this question was found by: **literature studies and interviews with the housing companies.**

Sometimes in energy retrofitting and renovation projects aiming to improve the building performance and optimize energy consumption, the main focus is technical improvements. Although these technical considerations are vital, the role of users of these buildings and urban spaces is not negligible (Xue et al., 2022). Despite designing environmentally-friendly buildings and providing an infrastructure for generating and distributing energy in a greener way, the users of these places need to be made aware of their impacts on energy consumption to bring more success for energy-related projects (Xu et al., 2020).

Success in this context has two meanings:

1. Ensuring users know how to optimize their energy consumption and ensure they know how to maximize the benefits of future installed energy systems in a neighborhood when creating energy communities (Santangelo et al., 2021).

2. Social acceptance for energy-related projects, which could be met by involving people and providing accurate and sufficient information (Xue et al., 2022).

The first mentioned point clarifies why it is essential to promote energy-saving behaviors by using behavioral models such as Fogg and Hooked models. These models have a few similarities, and both emphasize that in changing behavior, motivating people is the first step (Kouroupetroglou et al., 2015). This motivation in this thesis case study could be gained by involving the inhabitants in events that raise their awareness of upcoming development projects and possibly energy-related projects and creating an energy-sensitive society as ways to reduce EP in the future.

The reason for this conclusion could be found in the characteristic of people living in Hammarkullen: their strong desire to play an active role in society and acquire knowledge of the upcoming transformations. This motivation in the context of encouraging people to consume energy more efficiently could be various items, but specifically in Sweden and in the case study of this thesis, involving Hammarkullen's inhabitants in the development projects and transforming it into an energy-sensitive neighborhood could be a strong encouragement.

In various projects, including the one about the transformation of Hammarkullen Square, it could be observed that the residents would cooperate with the national and academic actors when they received information from their side and get involved in the process. Therefore, providing Hammarkullen's inhabitants with information and engaging them with the project would probably increase the chance of encouraging them to follow energy-efficient instructions.

The other factor that could be motivation is the economic advantages (Rist & Massodian, 2019). In Hammarkullen, decision-makers and people must rest assured that such energy-efficient behaviors would benefit them financially. Adding interventions to the current Link's proposal for transforming the square without making dramatic changes in the main design and clarifying that raising awareness of energy-saving behaviors would bring economic benefits in the long term for the housing companies could satisfy the actors to investigate the budget for promoting such behaviors. From the resident's side, consuming energy in a better way would result in less energy expenditure which would be a great motivation.

Alongside motivation, the ability is another essential item that impacts the behavioral change process. Ability means ensuring the target group has enough time to pursue a recommended habit (Kouroupetroglou et al., 2015). This could be happened by exposing people to such energy-efficient behaviors during their daily life. Thus, they can learn more about EP and energy-saving behaviors without disturbing their daily activities. One way to meet this goal is to bring these behaviors and information into urban spaces by designing energy-sensitive centers and energy cafes.

In conclusion, changing the behaviors and promoting energy-efficient ones requires motivation, which could be met by involving people in the project's context (Hammarkullen), showing them they have an essential role in society, and ensuring that all the stakeholders and people can have financial benefits pursuing the recommended instructions. Secondly, promoting energy-efficient habits should be available to everyone and be a part of their daily lives to ensure they do not need too much time (Kouroupetroglou et al., 2015) learning them.

Possibility of further research:

Analyzing other ways in addition to social involvement to make pursuing energy-saving g behaviors rewarding rather than punishing by paying more money due to consuming more energy.

Which visualization methods are more practical for communicating with inhabitants, especially the younger ones?

The answer to this question was found by: **literature studies, Case study analysis, and testing tools in the workshops.**

Adopting appropriate visualization methods is critical to effectively communicating with people (Xu et al., 2020). During the communication process for raising awareness of EP, promoting energy-saving behaviors, and engaging inhabitants with sustainable behaviors, it is essential to make sure that all the presented contents are clear and understandable for everyone to increase the inclusivity of the project and engage more people with it (Corsini et al., 2019; Liu et al., 2018). Therefore, it is essential to broaden knowledge of the existing visualization methods and adapt them to the needs of a new project and its target group. Based on Chalal et al. (2022), their main categories of visualization methods are statistical visualization, architectural, artistic, game-based, and emerging. Moreover, the other technologies discussed in the mentioned source are narrative. Regarding which of these methods is more efficient in the communication process, it highly depends on the characteristic of the project, target groups, and other stakeholders.

In this thesis, the main concern is communicating about EP and visualizing the behaviors that might result in its alleviation, which would be challenging since these concepts are intangible. Still, talking about these subjects, especially with the youth who are supposed to build the future and who would be affected by challenges arising from EP, is necessary (Thomas et al., 2021).

Artistic methods and narrative techniques could be more effective than the others in facilitating the process of explaining EP and recommended lifestyle changes as they can transfer ideas more easily (Han et al., 2022).

This thesis tested a few artistic approaches, such as collage, storyboard workshops, and game-based ones, and combined them with innovative tools such as augmented reality which successfully captured the attention of the 7th-grade students and, entertainingly, encouraged them to think about environmentally-friendly behaviors. Thus, based on this thesis's experiences and scientific publications, the mentioned tools and methods are much more functional than the traditional statistical ones in communicating about invisible issues (Thomas et al., 2021), such as EP.

Gap of this thesis's approaches:

Testing tools which could engage the adults

How can energy cafés alleviate energy poverty?

The answer to this question was found by: **literature studies, Case study analysis**

Energy cafes refer to the various activities, events, and workshops held on a neighborhood scale to increase public awareness of energy

transition projects. They are assumed to engage with energy technologies (Martiskanien et al., 2017). Such these mentioned events play a vital role in society's reduce energy poverty and also in the formation of energy communities by managing and sharing knowledge among citizens (Petersson & Danielson, 2022).

The impact of energy cafes goes beyond energy-related topics and includes various subjects ranging from promoting sustainable living manners to familiarizing inhabitants with urban agriculture. In these workshops or activities, people and experts can discuss their concerns about energy bills with each other while drinking tea and eating cakes. This friendly environment relieves the tension imposed on people, raising their awareness and promoting energy-saving habits could play a role in alleviating energy poverty; however, it would not result in the eradication of this issue (Martiskanien et al., 2017).

Therefore, these meetings and gathering time could be considered as one of the elements of an energy-sensitive community which is a way to reduce EP.

Possibility of further research:

How could the events of this place be held regularly? How could the budget for employing people be provided?

Main research question

How can architectural design alleviate energy poverty in Swedish neighborhoods?

The answer to this question was the primary purpose of this thesis. All the literature studies, workshops, and interviews aimed to find a bridge between energy poverty and its alleviation methods through design, specifically architectural ones. This thesis believes that architectural design in this context has a broader meaning than designing public urban spaces and planning for renovating existing buildings. Although these traditional functions of architecture and planning are also essential to alleviating EP, they are not the only critical factors.

Before ending up with a design proposal, an architectural manner of thinking could be practical for finding effective communication tools. These tools, as mentioned before, are the key elements of raising public awareness of EP and promoting lifestyle and habits, which result in the alleviation of EP (Xu et al., 2020). Therefore, architectural thinking could be a reliable tool to visualize the complicated concept of EP. Creating a visualization can help people understand the complexity of the energy crisis and alleviate the stress and frustration that residents may feel due to high monthly energy expenses. By presenting the data in a clear and accessible format, the visualization can provide insight into the causes of the energy crisis and help residents identify ways to reduce their energy consumption (Chalal et al., 2022; Xu et al., 2020). This, in turn, can lead to cost savings and reduce stress and financial strain, and relieve the mental effects of EP (Thomson et al., 2017).

Therefore, architects can open a dialogue between people, housing companies, and other stakeholders. This role is essential because in such a crisis like EP, housing companies and experts have more knowledge and plans to overcome the situation. However, they sometimes do not know how to transfer their knowledge to residents and share their thoughts. In these situations, architects, with their ability in design, can find an artistic way to translate an issue. This translation and putting a value on people and encourage them to engage with the decision-makers' plans. This involvement might result in a higher rate of public acceptance to motivate people to be engaged with one of the most critical factors in EP alleviation: following energy-saving behaviors.

In this step of changing lifestyles, architects can play a significant role in shaping energy-efficient behaviors. These behaviors could be designed and linked with the traditional architecture concept, which is designing public spaces and buildings. As the best way to promote energy-efficient behaviors is to make the process accessible for everyone and entertaining (Kouroupetroglou et al., 2015) , designing public buildings such as energy cafes and providing facilities such as energy or exposed recycling stations could be good ideas. Architects also could go one step forward and design the activities which could be done in energy cafes or other spaces.

In conclusion, this thesis claims that in alleviating EP in Sweden, architectural design has a vast meaning ranging from communicating with people and different groups of stakeholders to designing required public spaces and activities which result in energy-efficient lifestyles. Moreover, based on the published articles, this thesis believes that this behavior change and raising public awareness are the first step towards creating an energy-sensitive society where citizen engagement is as essential as technical interventions in alleviating EP.

8.2. A final note from the author

This thesis was a one-year journey full of up and downs, hopes and frustration, smiles and tears. Sometimes the answer to the question of the role of architects was so close and just behind the door. On the other hand, there were dark days when it seemed impossible for architects to play an influential role in alleviating energy poverty. In these gloomy days, the analyzed case studies and publications were screaming out that EP could be reduced only by engineers and data analyzers as its main alleviation methods are optimizing energy-generating and distribution systems and improving building performance. However, deep down in my heart, I knew there should be a way for me as an architecture student to find my role during this energy crisis.

The answer showed itself when I changed my viewpoint on the meaning of architecture and considered it not only as a profession but as a way of thinking and analyzing. Since then, I used my skills and passions in designing to analyze EP better and try a way to involve citizens: the ones who can play the most significant roles in creating a sustainable future, but usually, their role counts as negligible. This architectural thinking helped me translate the learning outcome of the literature studies and the knowledge gas artistically with the help of collage to make them more understandable and amusing for everyone. It was such a strong tool to capture even the attention of the 7th-grade students with limited knowledge of energy-saving behaviors and the complicated issue of EP. Their engagement with my project was about encouraging them to think about energy and how to design an energy cafe and other public spaces which can raise public awareness of an energy-efficient lifestyle.

Although there was no more time to test different tools for adults' involvement, the current outcome clearly shows how essential adopting appropriate tools is.

The collages visualizing Hammarkullen as an energy-sensitive society represent the final design outcomes of the thesis. The student's contributions in co-designing the square have made it vital to transform Hammarkullen into a place where energy-efficient behaviors and EP reduction can be learned through various public space activities, including energy cafes. To combine energy efficiency with the daily routines of inhabitants, multiple tools and interactive artworks were used as design interventions in the square, making them more conscious of their behaviors. Promoting awareness and involving inhabitants in active roles can be a significant step towards alleviating EP.

In the end, this thesis is not an ending point but a starting point to develop my role as an architect in the future in understanding energy poverty better and attempting to find methods that can promote energy-efficient behaviors. I am curious to expand this thesis by diving deep into the technical methods which result in EP reduction. By that, I hope to find a bridge to new ways combining both social and technical aspects to alleviate energy poverty in Sweden.

Need more information?

Appendix

The First Case Study

Rental buildings in Jättesten, Gothenburg, Sweden
The neighborhood is linked to an ongoing project called DigitalTwins4PEDs

Why Sweden?

In Europe, between 1950 and 1975, the building sector encountered dramatic changes and construction. Nowadays, many buildings require being renovated to optimize their energy consumption and provide more comfort for the residents (Mangold et al., 2018). One of these countries is Sweden which is also a pioneer in being sustainable due to the usage of renewable energy sources and low carbon dioxide emissions (The Sweden.se website, 2022). However, even this country struggles with the energy poverty issue, and like its other counterparts, the most investigated solution is renovation. Thus, it becomes clear how crucial it is to thoroughly research this subject and consider the several possible practical approaches in this country.

Why Gothenburg?

Gothenburg is the second biggest city in Sweden, and has been called as the most sustainable city in the world a few times. To keep this fame, Gothenburg has a long-term development plan until 2035. For Gothenburg, growing in a sustainable manner is not only about energy transition and providing clean energy for all the citizens but also about involving residents in the decision-making process and building a democratic society (Göteborg Stad, 2014). These concerns are close to the subject of this thesis; hence, Gothenburg could be an excellent case study.

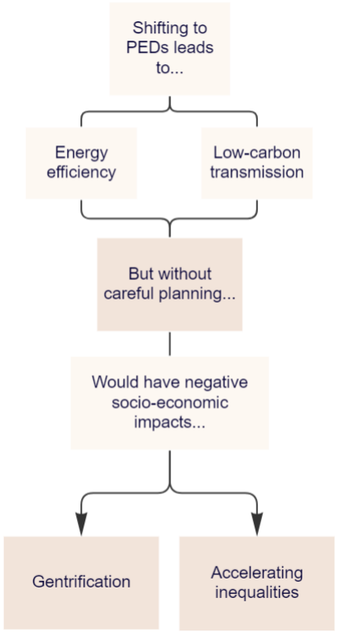
Gothenburg on the Sweden map (Redbubble website)

Gothenburg City (Göteborg Stad, 2014)

Why a PED project?

Today's cities need help with diverse problems, such as the amount of CO2 emission and optimizing energy consumption. Paying attention to the mentioned concerns is prominent and would lead to a more sustainable and greener future. However, the actions which result in this promising future might worsen social issues such as inequality and segregation (Sareen et al., 2022).

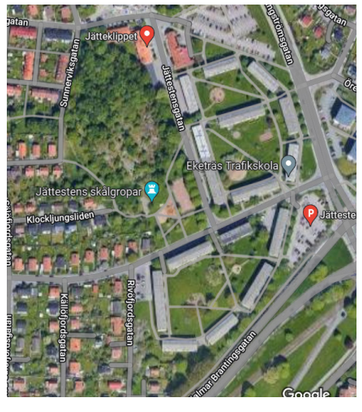
PEDs, positive energy districts, are one of the actions which might create a more sustainable future; but, alongside considering and analyzing their technical requirements, evaluating their effects on social sustainability and people's lives is also crucial (Sareen et al., 2022). In this case, as this thesis's primary focus is to involve inhabitants in the energy transition projects and create a sustainable society with them, it seemed that working in an area that is going to be a part of PED projects is relative, this is why Jättesten was selected on the first step.



The possible negative impacts of PED projects (inspired from Sareen et al., 2022)

Why Jättesten?

As energy poverty alleviation is also about renovations and the performance of energy generation and distribution systems, collecting data in these fields is necessary (Platten et al., 2020). In this case, the Jättesten neighborhood in Gothenburg sounds like an excellent case study for this project. As it is supposed to be a part of the DigitalTwins4PEDs project, the data and information of this project could be used for this thesis. Moreover, this thesis assumes that the success of energy projects such as PEDs depends on raising inhabitants' awareness and engaging them with the project. Thus it aims to fill the existing gap in the DigitalTwins4PEDs project regarding social consideration and inhabitants' engagement. Furthermore, in addition to technical considerations, another assumption of this thesis is that the neighborhood should also promote energy-saving behaviors. Thus designing some urban areas sounds necessary to complete the PED project in this district.



Jättesten on the map (Google maps)

Why did Jättesten not work to be this thesis's case study?

As it was mentioned in previous sections, the purpose of this thesis is to create an energy-sensitive community through a co-design process. Therefore, the selected neighborhood should have the potential to hold meetings and workshops with the residents.

After conducting a few interviews with the staff working in Poseidon, the housing company in the area, it became clear that this neighborhood does not have active associations. Furthermore, holding co-discussing and co-designing meetings, workshops, and events was less practiced in this district. This was another barrier for this thesis as it could take time to encourage inhabitants to participate in this thesis's events.

Moreover, it was challenging and time-consuming to access the documents related to the area, such as detailed maps and 3D models. Thus, the case study was shifted to another neighborhood: Hammarkullen.

Jättesten neighborhood (Poseidon website)

References

Aalto, P. (2016). The new International Energy Charter: Instrumental or incremental progress in governance?. Energy Research & Social Science, 11, 92-96.

Abbasi, M. H., Abdullah, B., Castano De la Rosa, R., Waseem Ahmad, M., Rostami, A., & Cullen, J. (2022). Planning energy interventions in buildings and tackling fuel poverty: Can two birds be fed with one scone? Energy Research & Social Science, 93, [102841].

Apergis, N., Polemis, M., & Soursou, S. E. (2022). Energy poverty and education: Fresh evidence from a panel of developing countries. Energy Economics, 106, 105430.

Arnold, S., Fujima, J., Karsten, A., & Simeit, H. (2013, December). Adaptive behavior with user modeling and storyboarding in serious games. In 2013 International Conference on Signal-Image Technology & Internet-Based Systems (pp. 345-350). IEEE.

Banerjee, R., Mishra, V., & Maruta, A. A. (2021). Energy poverty, health and education outcomes: evidence from the developing world. Energy economics, 101, 105447.

Bendell, J., & Ellersiek, A. (2009). Noble networks? Advocacy for global justice and the" network effect".

Bedi, H. P. (2018). 'Our energy, our rights': national extraction legacies and contested energy justice futures in Bangladesh. Energy research & social science, 41, 168-175.

Bloem, S., Swilling, M., & Koranteng, K. (2021). Taking energy democracy to the streets: Socio-technical learning, institutional dynamism, and integration in South African community energy projects. Energy Research & Social Science, 72, 101906.

Boeri, A., Gianfrate, V., Boulanger, S. O. M., & Massari, M. (2020). Future design approaches for energy poverty: users profiling and services for no-vulnerable condition. Energies, 13(8), 2115.

Boucher, M. (2016). Decentralized energy: prospects, justice, and transition. Energy Research & Social Science, 11, 288–293.

Boulanger, S. O. M., Massari, M., Longo, D., Turillazzi, B., & Nucci, C. A. (2021). Designing collaborative energy communities: A european overview. Energies, 14(24), 8226.

Capaccioli, A., Poderi, G., Bettega, M., & D'Andrea, V. (2017). Exploring participatory energy budgeting as a policy instrument to foster energy justice. Energy Policy, 107, 621-630.

Ceglia, F., Marrasso, E., Samanta, S., & Sasso, M. (2022). Addressing Energy Poverty in the Energy Community: Assessment of Energy, Environmental, Economic, and Social Benefits for an Italian Residential Case Study. Sustainability, 14(22), 15077.

Chalal, M. L., Medjdoub, B., Bezai, N., Bull, R., & Zune, M. (2022). Visualisation in energy eco-feedback systems: A systematic review of good practice. Renewable and Sustainable Energy Reviews, 162, 112447.

Chen, C. W. (2021). Clarifying rebound effects of the circular economy in the context of sustainable cities. Sustainable Cities and Society, 66, 102622.

Churchill, S. A., & Smyth, R. (2022). Local area crime and energy poverty. Energy Economics, 114, 106274.

Cludius, J., Noka, V., Hünecke, K., & Schumacher, K. (2019). Energy poverty: an interplay of energy and social policy. ECEEE 2019, panel3: policy and governance.

Doukas, H., & Marinakis, V. (2020). Energy poverty alleviation: Effective policies, best practices and innovative schemes. Energy Sources, Part B: Economics, Planning, and Policy, 15(2), 45-48.

Dubois, U., & Meier, H. (2016). Energy affordability and energy inequality in Europe: Implications for policymaking. Energy research & social science, 18, 21-35.

English, L. M., & Carlsen, A. (2019). Lifelong learning and the Sustainable Development Goals (SDGs): Probing the implications and the effects. International Review of Education, 65, 205-211.

Ewald, D. R., Orsini, M. M., & Strack, R. W. (2023). The path to good health: Shifting the dialogue and promoting social ecological thinking. SSM-Population Health, 22, 101378.ma

Felmer, G., & Yannas, S. (2021). Designing naturally-conditioned dwellings for warm and cold-temperate regions of Chile. Architectural Science Review, 64(3), 275-292.

Fernandes-Jesus, M., Brendon, B., & Diniz, R. F. (2020). Communities reclaiming power and social justice in the face of climate change. Community Psychology in Global Perspective, 6(2/2), 1-21.

Foulds, C., Royston, S., Berker, T., Nakopoulou, E., Bharucha, Z. P., Robison, R., ... & Živčič, L. (2022). An agenda for future Social Sciences and Humanities research on energy efficiency: 100 priority research questions. Humanities and social sciences communications, 9(1), 1-18.

Francesco, F., Salvatore, E. P., Giuseppe, D. F., Edoardo, C., Daniele, C., Alberto, D., ... & Massimo, D. M. (2022). Extreme citizens science for climate justice: linking pixel to people for mapping gas flaring in Amazon rainforest. ENVIRONMENTAL RESEARCH LETTERS, 17, 1-16.

Frantál, B., & Dvořák, P. (2022). Reducing energy poverty in deprived regions or supporting new developments in metropolitan suburbs? Regional differences in the use of subsidies for home energy efficiency renovations. Energy Policy, 171, 113250.

Fuller, S., & McCauley, D. (2016). Framing energy justice: perspectives from activism and advocacy. Energy Research & Social Science, 11, 1-8.

Galvin, R., & Terry, N. (2016). Selling energy savings in the United Kingdom: a case study of top–down pro-environmental behaviour change in commercial office buildings. Energy Research & Social Science, 11, 155-163.

Grossmann, K. (2019). Energy efficiency for whom? A conceptual view on retrofitting, residential segregation and the housing market. Sociologia urbana e rurale, (2019/119).

Ha, S., McCann, J., Liu, C.K., & Popović, J. (2013). Physics Storyboards. Computer Graphics Forum, 32.

Han, D. I. D., Abreu e Silva, S. G., Schröder, K., Melissen, F., & Haggis-Burridge, M. (2022). Designing immersive sustainable food experiences in augmented reality: a consumer participatory co-creation approach. Foods, 11(22), 3646.

Hanke, F., Guyet, R., & Feenstra, M. (2021). Do renewable energy communities deliver energy justice? Exploring insights from 71 European cases. Energy Research & Social Science, 80, 102244.

Hansen, A. R. (2016). The social structure of heat consumption in Denmark: New interpretations from quantitative analysis. Energy Research & Social Science, 11, 109-118.

Hermwille, L. (2016). The role of narratives in socio-technical transitions—Fukushima and the energy regimes of Japan, Germany, and the United Kingdom. Energy Research & Social Science, 11, 237-246.

Herrero, S. T. (2017). Energy poverty indicators: A critical review of methods. Indoor and Built Environment, 26(7), 1018-1031.

Hutchinson, P., Mirzoyants, A., & Leyton, A. (2019). Empowering youth for social change through the Shujaaz multimedia platform in Kenya. International Journal of Adolescence and Youth, 24(1), 102-116.

Kjeang, A. E., Palm, J., & Venkatesh, G. (2017). Local energy advising in Sweden: Historical development and lessons for future policy-making. Sustainability, 9(12), 2275.

Kotsopoulos, D., Bardaki, C., Lounis, S., & Pramatari, K. (2018). Employee profiles and preferences towards IoT-enabled gamification for energy conservation. International Journal of Serious Games, 5(2), 65-85.

Kouroupetroglou, C., Piso, M., Derguech, W., Curry, E., Mink, J., Recupero, D. R., ... & Coakley, D. (2015). Engaging users in tracking their water usage behavior. Procedia Engineering, 119, 788-797.

Mackintosh, N., Sandall, J., Collison, C., Carter, W., & Harris, J. (2018). Employing the arts for knowledge production and translation: Visualizing new possibilities for women speaking up about safety concerns in maternity. Health Expectations, 21(3), 647-658.

Madlener, R. (2020). Sustainable energy transition and increasing complexity: trade-offs, the economics perspective and policy implications. In Inequality and Energy (pp. 251-286). Academic Press.

Malin, S. (2014). When is 'Yes to the Mill'environmental justice? Interrogating sites of acceptance in response to energy development. Analyse & Kritik, 36(2), 263-286.

Marlin-Tackie, F. A., Polunci, S. A., & Smith, J. M. (2020). Fracking controversies: Enhancing public trust in local government through energy justice. Energy Research & Social Science, 65, 101440.

Martiskainen, M., Heiskanen, E., & Speciale, G. (2018). Community energy initiatives to alleviate fuel poverty: the material politics of Energy Cafés. Local Environment, 23(1), 20-35.

Martiskainen, M.; Speciale, G. 'The Fuel Bill Drop Shop': An Investigation into Community Action on Fuel Poverty; Final Report to Chesshire Lehmann Fund; South East London Community Energy (SELCE): London, UK, 2016; Available online: http://tinyurl.com/huxverc (accessed on 10 January 2020).

Mehibel, M., & Pitts, A. (2017, July). Analysis of sustainable collective housing in Jijel, Algeria: evaluation of resident satisfaction. In 33rd Passive Low Energy Architecture International Conference: Design to Thrive (pp. 4180-4187).

Middlemiss, L. (2017). A critical analysis of the new politics of fuel poverty in England. Critical Social Policy, 37(3), 425-443.

Moore, S., & Hackett, E. J. (2016). The construction of technology and place: Concentrating solar power conflicts in the United States. Energy Research & Social Science, 11, 67-78.

Moss, Tim & Francesch-Huidobro, Maria. (2016). Realigning the electric city. Legacies of energy autarky in Berlin and Hong Kong. Energy Research & Social Science. 11. 225-236. 10.1016/j.erss.2015.10.002.

Neacsa, A., Panait, M., Muresan, J. D., & Voica, M. C. (2020). Energy poverty in European Union: Assessment difficulties, effects on the quality of life, mitigation measures. some evidences from Romania. Sustainability, 12(10), 4036.

O'Neill-Carrillo, E., Santiago, R., Méndez, Z., Vega, H., Mussa, J., & Rentas, J. (2017, October). Capstone design projects as foundation for a solar community. In 2017 IEEE Frontiers in Education Conference (FIE) (pp. 1-9). IEEE.

Orji, R., Tondello, G. F., & Nacke, L. E. (2018, April). Personalizing persuasive strategies in gameful systems to gamification user types. In Proceedings of the 2018 CHI conference on human factors in computing systems (pp. 1-14).

Ottinger, G. (2017). Making sense of citizen science: Stories as a hermeneutic resource. Energy research & social science, 31, 41-49.

Purvis, O., & Evans, R. (2020). A Behavioral Change Intervention System to Support the Hydration Habits of Nurses in Hospital Wards. Sustainability, 12(22), 9391.

Ramos, C., Alvargonzález, M., & Moreno, B. (2022). Study of energy poverty in the European Union: the effect of distributed generation. Energy Sources, Part B: Economics, Planning, and Policy, 1-24.

Sandhaus, S., Ramírez-Andreotta, M. D., Kilungo, A., Wolf, A. M., Sandoval, F., & Henriquez, P. (2018). Combating climate injustices: An informal science and popular education approach to addressing environmental health disparities. Pedagogy in health promotion, 4(4), 260-269.

Santangelo, A., Tondelli, S., & Yan, D. (2021). Investigating the Role of Occupant Behavior in Design Energy Poverty Strategies. Insights from Energy Simulation Results. Smart and Sustainable Planning for Cities and Regions: Results of SSPCR 2019 3, 525-537.
Santangelo, A., & Tondelli, S. (2017). Occupant behaviour and building renovation of the social housing stock: Current and future challenges. Energy and Buildings, 145, 276-283.

Schmid, E., Knopf, B., & Pechan, A. (2016). Putting an energy system transformation into practice: The case of the German Energiewende. Energy Research & Social Science, 11, 263-275.

Shortall, R., Mengolini, A., & Gangale, F. (2022). Citizen Engagement in EU Collective Action Energy Projects. Sustainability, 14(10), 5949.

Sorman, A. H., Turhan, E., & Rosas-Casals, M. (2020). Democratizing energy, energizing democracy: Central dimensions surfacing in the debate. Frontiers in Energy Research, 8, 279.

Sovacool, B. K., & Tambo, T. (2016). Comparing consumer perceptions of energy security, policy, and low-carbon technology: Insights from Denmark. Energy Research & Social Science, 11, 79-91.

Spirkova, D., Zubkova, M., Babelova, J., & Caganova, D. (2016). Socio-Economics Aspects of Housing Quality in the Context of Energy Poverty. In Smart City 360°: First EAI International Summit, Smart City 360°, Bratislava, Slovakia and Toronto, Canada, October 13-16, 2015. Revised Selected Papers 1 (pp. 617-626). Springer International Publishing.

Sullivan, J. (2019). Three More Voices Papers for This Special Issue of New Solutions—Environmental Justice in the US Gulf Coast Region. NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy, 28(4), 617-621.

Sunikka-Blank, M., & Galvin, R. (2016). Irrational homeowners? How aesthetics and heritage values influence thermal retrofit decisions in the United Kingdom. Energy Research & Social Science, 11, 97-108.

Sy, S. A., & Mokaddem, L. (2022). Energy poverty in developing countries: A review of the concept and its measurements. Energy Research & Social Science, 89, 102562.

Thomas, Merryn & Giannoulatou, Ioanna & Kocak, Ethan & Tank, Wes & Sarnowski, Ryan & Jones, Peter & Januchowski-Hartley, Stephanie. (2021). Reflections from the team: Co-creating visual media about ecological processes for young people. People and Nature. 3. 10.1002/pan3.10241.

Thomson, H., Snell, C., & Bouzarovski, S. (2017). Health, well-being and energy poverty in Europe: A comparative study of 32 European countries. International Journal of Environmental Research and Public Health, 14(6), 584.

Torabi Moghadam, S., Di Nicoli, M. V., Manzo, S., & Lombardi, P. (2020). Mainstreaming energy communities in the transition to a low-carbon future: A methodological approach. Energies, 13(7), 1597.

Vitéz, B., & Lavrijssen, S. (2020). The energy transition: Democracy, justice and good regulation of the heat market. Energies, 13(5), 1088.

Von Platten, J., de Fine Licht, K., Mangold, M., & Mjörnell, K. (2021). Renovating on Unequal Premises: A Normative Framework for a Just Renovation Wave in Swedish Multifamily Housing. Energies, 14(19), 6054.

Von Platten, J., Mangold, M., & Mjörnell, K. (2020, November). Energy inequality as a risk in socio-technical energy transitions: The Swedish case of individual metering and billing of energy for heating. In IOP Conference Series: Earth and Environmental Science (Vol. 588, No. 3, p. 032015). IOP Publishing.

Von Platten, J., Mangold, M., & Mjörnell, K. (2020). A matter of metrics? How analysing per capita energy use changes the face of energy efficient housing in Sweden and reveals injustices in the energy transition. Energy Research & Social Science, 70, 101807.

Whitton, J., Parry, I. M., Akiyoshi, M., & Lawless, W. (2015). Conceptualizing a social sustainability framework for energy infrastructure decisions. Energy Research & Social Science, 8, 127-138.

Xue, Y., Temeljotov-Salaj, A., & Lindkvist, C. M. (2022). Renovating the retrofit process: People-centered business models and co-created partnerships for low-energy buildings in Norway. Energy Research & Social Science, 85, 102406.

Zhang, Z., Shu, H., Yi, H., & Wang, X. (2021). Household multidimensional energy poverty and its impacts on physical and mental health. Energy Policy, 156, 112381.

References of the Images

Energy poverty is coming (Page: 9):

Hands (Sketch). Retrieved from: https://occhiciechi.tumblr.com/post/10853038966

Hodgson, R. Monster in the background (Digital Painting). Retrieved from: https://www.robhodgson.com/images

Houses (Illustration). Retrieved from: https://www.shutterstock.com/fr/image-vector/vector-illustration-simple-minimal-geometric-flat-1114910576

Jungke and wind turbines (Digital Painting). Retrieved from: https://www.freepik.com/premium-vector/public-contributions-concept_2546572.htm

Sustainable development (Illustration). Retrieved from: https://www.freepik.com/free-vector/taking-care-earth-concept-illustration_11637995.htm#query=sustainable%20development&position=6&from_view=keyword&track=ais

The person sitting near solar panels (Illustration). Retrieved from: https://pngtree.com/freepng/co2-gas-plant-pipes-global-warming_5333121.html

yuRomanovich. Solar panels (Illustration). Retrieved from: https://www.shutterstock.com/fr/image-vector/alternative-sources-energy-hand-drawn-sketch-678260236?consentChanged=true

Project timeline (Page: 17):

Hammarkulletorget designed by LINK (Renders). Retrieved from: https://linkarkitektur.com/se/projekt/hammarkulletorget

Jensen, J. Hammarkullen (Photograph). Retrieved from: https://goteborgsstadsmuseum.se/nyheter/nu-slapps-fotoboken-jens-s-jensen-samlat-verk/

Shirodkar, S. (2014). At the supermarket (Sketch). Retrieved from: https://sketchaway.wordpress.com/2014/12/12/drawing-busy-places-at-the-supermarket/

Syaifudin, Z. Hands holding flower (Sketch). Retrieved from: https://www.vecteezy.com/vector-art/5306521-continuous-line-drawing-of-a-hand-holding-bouquet-flower-hand-s-woman-with-a-flower-isolated-on-white-background-give-a-sign-of-love-for-someone-minimalism-style-vector-sketch-illustration

Puzzle Collage (Page: 52):

Blue, J. Reading poster (Illustration). Retrieved from: https://fineartamerica.com/featured/2-read-jazzberry-blue.html?product=poster

Brad, G. (2019). Mountain village (Sketch). Retrieved from: https://www.artstation.com/artwork/dOPVKe
The flying girl (Illustration). Retrieved from: https://www.tumblr.com/bibliolectors/?offset=255

Project process (Page: 55):

Briggs, A. (2014). Man analyzing the lamp (Illustration). Retrieved from: http://vozwords.blogspot.com/2014/07/austin-briggs-on-illustration.html

DeLorenzo, C. Welcome to the jungle (Illustration). Retrieved from: https://agentpekka.com/artist/christopher-delorenzo/welcome-to-the-jungle-7

Dove, C. (2013). Life of the dining table (Sketch). Retrieved from: https://89dove.tumblr.com/post/87510200667/life-of-the-dining-table-line-drawing-as-part

Girls reading books (Illustration). https://www.freepik.com/premium-vector/students-are-working-group-nature-team-work_9872378.htm

Mayani, R. Rediscovered hobbies (Sketch). Retrieved from: https://www.rafaelmayani.com/illustration/vignettes

Peng, L. (2013). People talking to each other (Sketch). Retrieved from: https://www.flickr.com/photos/leifpeng/8470058289

Peng, L. (2008). Frustrated man (Sketch). Retrieved from: https://www.flickr.com/photos/leifpeng/2294920560

People with dialogue box on top of their head. Retrieved from: https://elpais.com/elpais/2019/12/17/opinion/1576606899_448379.html

Sasek, Z. Candle and broken light bulb (Sketch). Retrieved from: https://www.dreamstime.com/candle-broken-light-bulb-no-electricity-energy-poverty-concept-vector-cartoon-illustration-no-electricity-candle-broken-image233613982

Energy café (Page: 83):

Arend, M. The story of waterfall (Illustration). Retrieved from: https://www.designstack.co/2021/10/living-in-magic-illustrations.htmlv

Asian traditional cuisine (Illustration). Retrieved from: https://www.pixtastock.com/illustration/96975243
Bookshelves (Painting). Retrieved from: https://www.redbubble.com/fr/shop/bookshelf+prints

Lieke van der Vorst. Bloemenstruik (Painting). Retrieved from: https://sebastianfoster.com/artists/lieke-van-der-vorst/bloemenstruik-by-liekeland

Olena Stasiuk. Children Playing (Illustration). Retrieved from: https://studioalternativi.com/products/vector-png-playground-front-side-view

Personnes assises dans des tasses et s'occupant de leurs propres affaires (Illustration). Retrieved from: https://fr.depositphotos.com/506360228/stock-illustration-vector-illustration-people-sitting-cups.html

The drawing character a man in cup of coffee (Illustration). Retrieved from: https://www.freepik.com/premium-vector/drawing-character-man-cup-coffee_6589062.htm

yuRomanovich. Solar panels (Illustration). Retrieved from: https://www.shutterstock.com/fr/image-vector/alternative-sources-energy-hand-drawn-sketch-678260236?consentChanged=true

Hammarkullen center (Page: 89):

Clarck, D. Saturday market (Sketch). Retrieved from: https://globalvoices.org/2017/03/26/art-in-transit-meet-the-commute-sketchers-of-singapore/

Farmer cartoon characters with butternut squash plant harvest in farm (Illustration). Retrieved from: https://www.freepik.com/free-vector/farmer-cartoon-characters-with-butternut-squash-plant-harvest-farm-poster-illustrations_16293039.htm

Hammarkulletorget designed by LINK (Renders). Retrieved from: https://linkarkitektur.com/se/projekt/hammarkulletorget

Shou, Vegetaion (Painting). Retrieved from: https://www.sohu.com/a/422914352_656119

Windmills (Illustration). Retrieved from: https://www.istockphoto.com/se/vektor/landskap-p%C3%A5-landsbygden-med-en-kvarn-handritad-illustration-konverterad-till-vektor-gm1201426631-344541049

Ziruffo, L. JARDIN D'HIVER (Painting). Retrieved from: http://www.lidaziruffo.com/2020/09/23/jardin-dhiver-2/
Lycett, K. The Vine House (Painting). Retrieved from: https://www.katelycett.co.uk/original-work/

Tram station (Page: 93):

Bodart, F. MOKA FLOWERS POSTER (Illustration). Retrieved from: https://www.juniqe.se/moka-flowers-premium-poster-portrait-4821243.html#step=design&productId=4821243

Costa, R. Vegetaion. Spring welcome committee (Painting). Retrieved from: https://www.behance.net/gallery/55110039/Personal-project-SPRING-WELCOME-COMMITTEE

Girls reading books (Illustration). Retrieved from: https://www.freepik.com/premium-vector/students-are-working-group-nature-team-work_9872378.htm

Librairie Imprimer (Illustration). Retrieved from: https://www.etsy.com/fr/listing/694240474/librairie-imprimer-o-illustration-a?epik=dj0yJnU9STJEaU80djRZWHR2QmxPczNpbnp0YkZEMjVBX1ZnRlAmcD0w-Jm49QzlUR1NKRGdfdi1FSXZ3SUFrcjBWUSZ0PUFBQUFBR1I1OS1n

Renouf, E. Fall trees (Illustration). Retrieved from: http://tabithaannthelostsock.blogspot.com/2014/05/construction-paper-trees.html?m=1

Sewzinski. Sun Drawing Gold and Blue (Painting). Retrieved from: https://society6.com/sewzinski

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