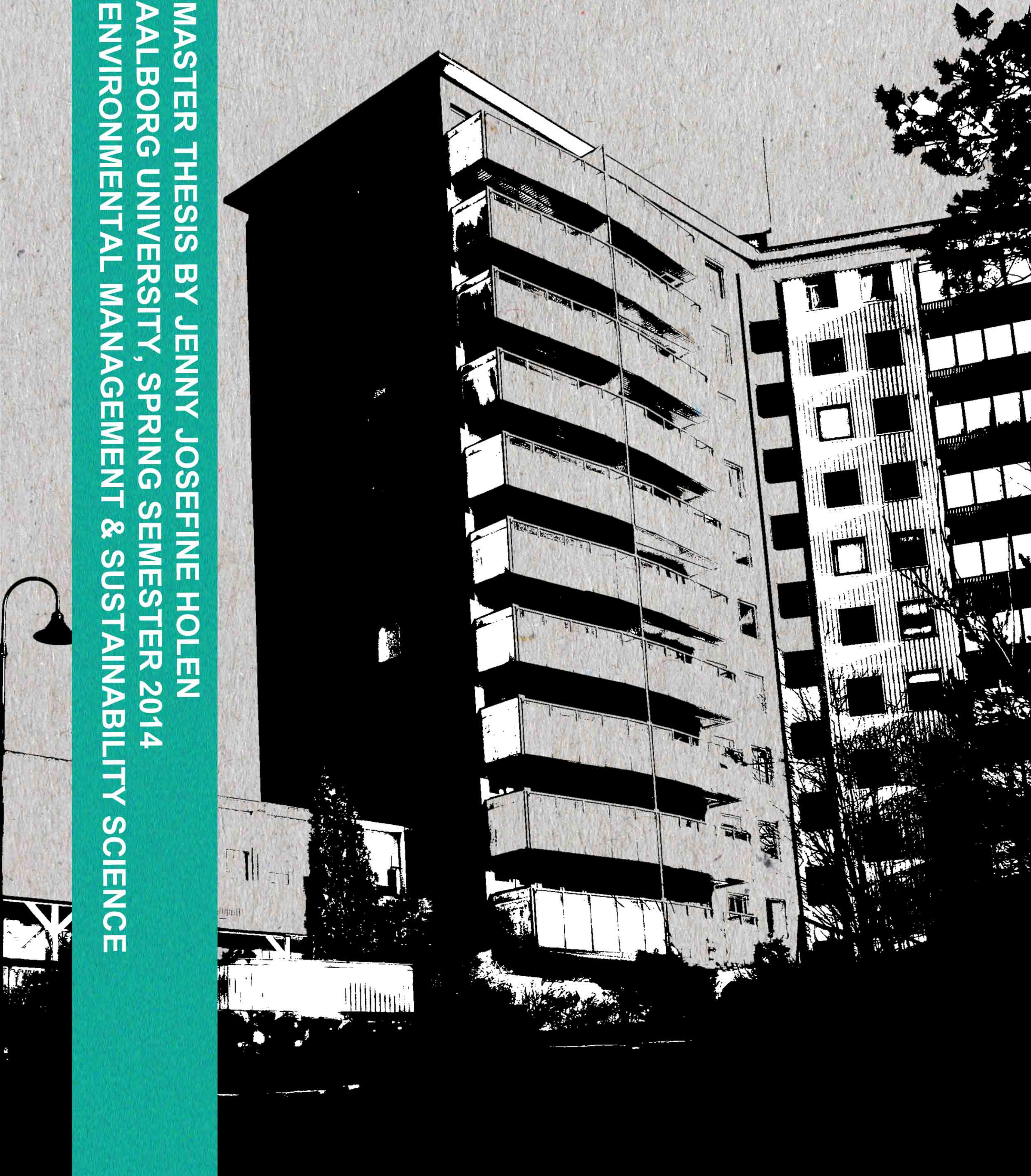
CASE STUDY OF A RETROFITTING PROJECT

GHG CALCULATION & STUDY OF DECISION MAKING PROCESSES



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SYNOPSIS

This report is intended to focuses on the environmental impacts of a retrofitting of an older apartment building and the importance of decisions-making processes during the project.

The case study deals with an apartment building called Stjernehus Borettslag located in Kristiansand. The Norwegian firm Kruse Smith AS, was chosen as the main contractor to perform the retrofitting and has together with several other organizations worked on the project since 2011.

Due the Norwegian governmental goal to reduce the GHG in Norway, action within this type of construction work has been taken, in accordance with the governmental program "Framtidens Bygg"(Future Buildings). This program is an initiative that aims to promote energy saving through efficient solutions. The Stjernehus Borettslag project was chosen among others, as a pilot project for this governmental program and therefore has abided by the requirements laid down within the program. Calculating the GHG emissions from the project by use of Klimagassregnskap.no is one of the requirements laid down in this program. Calculation shows an emission 25,2kg CO^2-eq/m2/year after the retrofitting of Stjernehus Borettslag.

Since the decision making throughout the project influence the result and quality these aspects are also studied and evaluated. The so called “garbage can model” theory is used as a framework within the study. After analyzing the process of Stjernehus Borettslag the conclusion is that both the practice and theory stresses the randomness in decision-making, and the difficulty of achieving changes in within organizations.

SYMBOLS & ABBREVIATIONS

CEN TC350	Comité européen de normalization, The Technical committees for “Sustainability of construction works”.
CO_2-eq	Carbon dioxide equivalents
EPD	Environmental Product Declarations
Framtidens Byer	Future Cities
Framtidens Bygg	Future Buildings
GHG	Greenhouse Gasses
GDP	Gross Domestic Product
GWh	Gigawatt hours
h	hour
HOA	Home Owner Association
HVAC	Heating, Ventilation, and Air Conditioning
ISO	International Organization for Standardization,
kg	kilograms
kWh	kilowatt hours
l	liter
LCA	Life Cycle Assessment
m	meter
m^2	Square meter
m^3	Cubic meter
MWh	Megawatt hours
NOK	Norwegian Kroner
NS	Norwegian Standardization
%	Percentage
TEK10	Teknisk Forskrift 2010 (Technical Regulations 2010)
TWh	Terrawatt hours
TØI	Transportøkonomisk institutt
RUV	Den nasjonale reisevaneundersøkelsen (Norwegian Travel Survey)
SBBL	Sørlandet Boligbyggelag (South of Norway Housing Association)

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1

PREFACE

This report was conducted in the period 2nd of February 2014 to 4th of June 2014, during the final semester of the master program Environmental Management and Sustainability Science at Aalborg University. The final semester is themed "Dimensions of environmental management and sustainability science".

The written report is directed at supervisors, pairs and employees at Kruse Smith AS, that are involved or have an interested of the project.

Harvard method is used as the reference system for this report, which means that author and then the year for the reference, is used throughout the report e.g. (Jensen, 2008). In the end of the report a bibliography of all references used is provided. Direct quotes from sources, are signified with quotation marks and italic font.

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PROJECT STRUCTURE

Chapter.3 provides a framework of the Norwegian GHG emissions and the governmental actions done to reduce the negative environmental impact.
Chapter.4 introduce the case study of Stjernehus Borettslag and the contractor Kruse Smith AS.
Chapter.5 present the research question along with the sub questions.
Chapter.6 gives the used research methodology for the study.
Chapter.7 introduce the tool klimagassregnskap.no, which calculates the GHG emission from building projects.
Chapter.8 explains how klimagassregnskap.no was used to calculate the GHG emission from Stjernehus Borettslag and presents the results of the calculation.
Chapter.9 presents the used theory to understand decision-making processes, which is called the garbage can model.
Chapter.10 delivers an overview of the process and participants involved and the findings of the project are elaborated along with a discussion.
Chapter.11 gives the conclusion for the project, by answering the research question.
Chapter.12 concerns reflections of the project.
Chapter.13 gives the references used in this report

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NORWAY HAS POTENTIAL FOR REDUCING GHG EMISSIONS

Oil, gas, wind and water are Norway's four main sources of energy. Most of the oil and gas is exported out of the country to other European countries (Bergesen et al. 2013). 58% of Norway's energy use today is renewable hydroelectricity and even more water and wind energy is currently being developed (Bøeng 2010, Bergesen et al. 2013). It is expected that the European energy demand will grow drastically in the near future. In order to prevent this increasing demand, the Council of Europe and the European Parliament signed the Energy Efficiency Directive in June 2012. The directive aims for a 20% energy reduction in the union within 2020 (Bergesen et al. 2013). In response to this directive Norway aims for a CO2 reduction with 30% according to the level from 1990, within year 2020. This means a reduction form 17million ton to 15million ton CO_2 per year (Bøeng 2010). 2/3 of the planned reductions are to be done in Norway, and the rest will be bought as emission allowances.

In article in the Norwegian paper Verdens Gang January 2014, political scientist Martinussen writes "*We can continue Stoltenberg's quota strategy until 2020, or we can develop a new policy with greater emphasis on technological restructuring here at home*. " (Martiniussen 2014).

The Norwegian Environmental Agency writes in March 2014 "*The longer we wait, the more difficult and expensive it can be. Emissions reductions can be implemented in a more flexible manner if the measures are started early*."(Miljødirektoratet 2014)

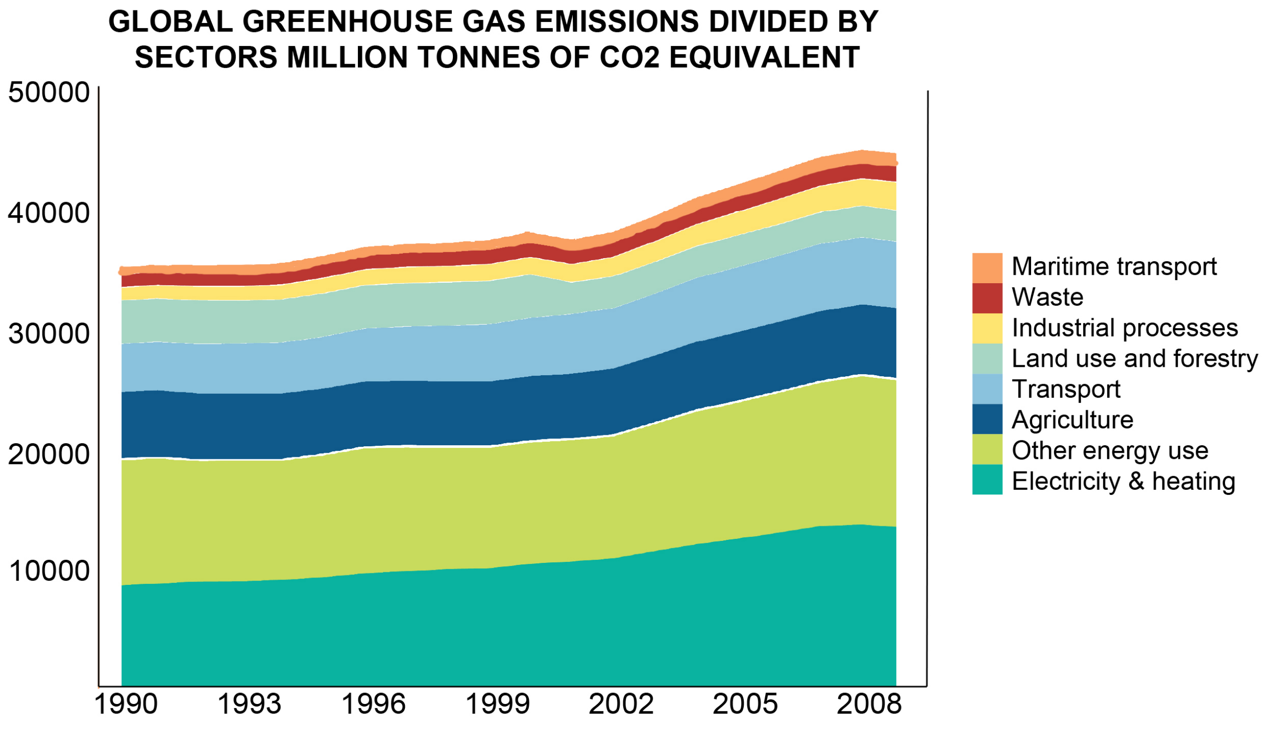


Figure 3-a: Emissions of CO2 equivalents divided on eight sectors (Miljødirektoratet 2014).

Figure 3-a, shows that electricity and heating is a major part of the GHG emission cause. The Norwegian Environment Agency has formed an agency group called KlimaKur, which focuses on the strategies of CO_2 reduction (Miljodirektoratet 2013). These covers founding and incentives for initiatives that contribute to energy efficiency, energy savings and also a further restriction of the present technical regulation (Bøeng 2010). Increasing the renewable energy sources, reducing the transportation sector and increasing the public transportation. Furthermore the agency group has also conducted a report that focuses on the energy conservation in buildings and within the field of industry. Today, some actions to prevent or decrease the energy use in the built environment are implemented, such as;

(1) All buildings for sale or rent, must be energy market according to the EU construction directive (also been applied by Norway).
(2) The governmental agency Enova is established, which promotes energy conservation and use of renewable energy sources. Enova is also responsible for distribution of an energy fund.
(3) 21 cities are appointed by the municipal and regional ministry to become “green energy cities”. The project aims for the selected cites to focus on energy efficiency, renewable energy and decrease their overall GHG footprint (Bøeng 2010).

Buildings cause 6% of the GHG emissions, and this is excluding the energy consumption (Miljødirektoratet 2014). In total the households are behind approximately 20% of Norway’s energy use, which also is behind a huge part of GHG emission (Bergesen et al. 2013). Figure 3-b shows that the two major consumers of energy in Norwegian households are heating of area and water.

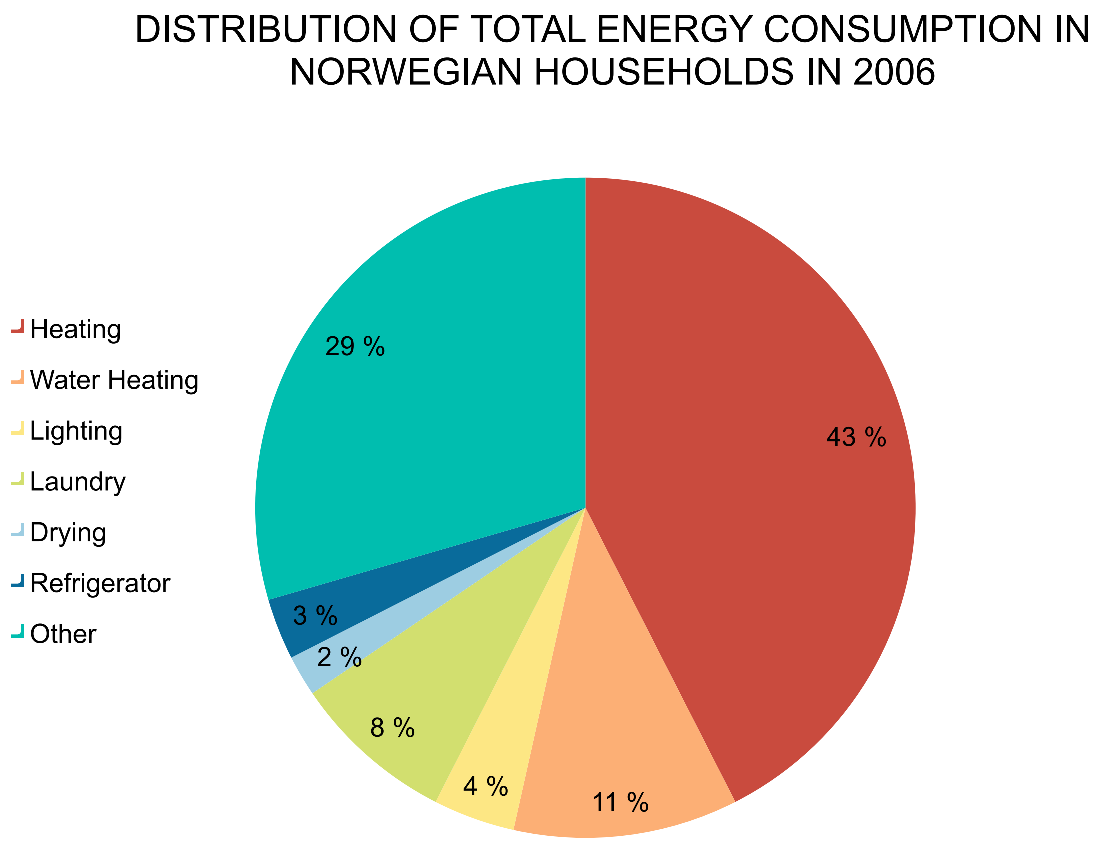


Figure 3-b: Distribution of energy in Norwegian Households (Dalen and Larsen 2009)

3.1 BUILDINGS AS PART OF THE SOLUTION

By 2050 it is reported that over 80% of today's constructions are expected to still exist (Framtidens byer 2013). Some of these buildings already need to be upgrader and the rest will most likely need it in the future. There is an increasing demand for comfortable housing, and this demand needs to be supplied wisely by the contractors considering the climate change. To act wisely is be described by the Oxford Dictionary as "Having or showing experience, knowledge, and good judgment" (Oxford University Press 2014). These are exactly the features need both for now and in the future of the world's built environment.

Moreover, Norway has one of the world's highest GDP per Capita, and is also in top of the list of countries with highest electricity use. This could indicate that Norway has resources to change this arrangement.

Country	Electricity use per Citizens Including Industries [kWh] in 2006	GDP per Capita (2012)
Iceland	31 306	115
Norway	24 295	195
Finland	17 178	115
Sweden	15 230	126
USA	13 515	152
France	7 585	109
Germany	7 175	123
Denmark	6 864	126
Poland	3 586	67

Table 3-a: Showing various electricity consumptions for countries and their GPD per Capita in 2012 (Statistics Norway 2012).

There is a paradigm shift towards greener buildings and today there are many different drivers for the sustainability within the construction sector, but the Building Guide from Sustainia (2012) lists seven of them; (1) Policy, (2) Legislation, (3) Markets, (4) Standards, (5) Technology, (6) Rating Systems and (7) Investment capital. Greener buildings are not only helpful for the climate, but are adding value to the building, community, nation and world. Most of the existing buildings will not last for their full life cycle, which gives an opportunity for retrofitting. Windows, walls, roofs and systems for heating often have a shorter lifetime, than the rest of the building. Retrofitting opens up for environmental aspects to be taken into consideration. Such as improving building by using resource efficient materials, upgrading to renewable energy systems for heating and improving the building envelope. The end results of an energy retrofitting will give the user an increased comfort and also money back from energy savings (Sustsainia 2012). Since 1990s the household energy consumption has decreased of 14.5%, from 210kWh to 180kWh. This decrease can be explained by general improvements in existing and new housing constructions, due to stricter requirements in the technical regulations. Furthermore heating systems has been improved in later years(Bergesen et al. 2013). Heating is a crucial part of energy consumption in Norwegian buildings, as shown in the Figure XX. Jorgen Randers one of the authors behind Limits to Growth wrote in his book 2052 "Thus sooner or later, the industrial revolution will be followed by the sustainable revolution" (Randers 2012). Randers also commented in his book that a paradigm shift could be compared to an earthquake, once it is over the situation is changed, but also stable (Randers 2012).

PARADIGM SHIFT IN THE CONSTRUCTION SECTOR

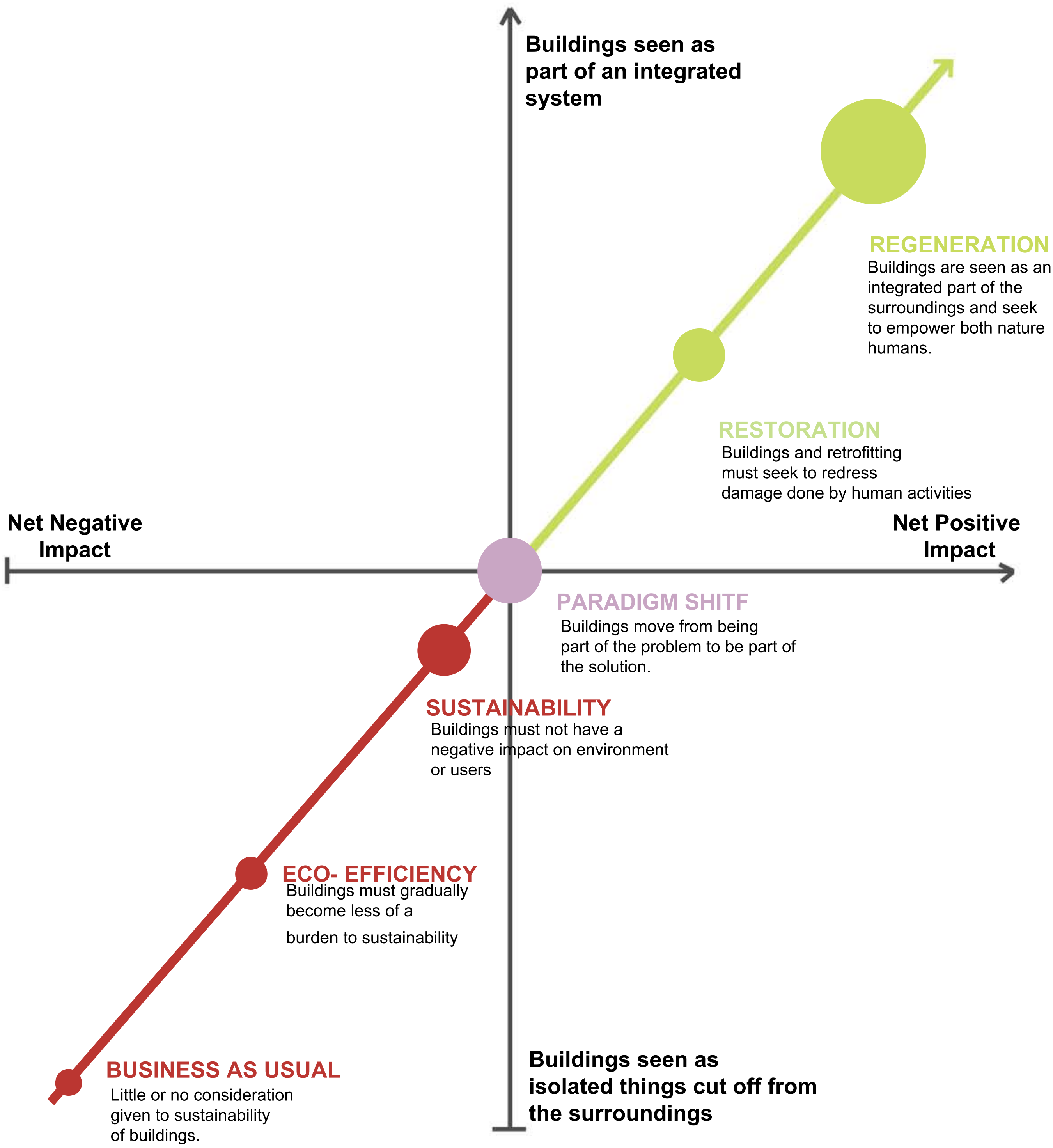


Figure 3-c: by Stustaina (2012) present the ongoing paradigm shift.

4

THE CASE OF STJERNEHUS BORETTSLAG

This report is based on a case study concerning an energy retrofit project. The project is located in Norway's fifth largest city; Kristiansand and it is concerning an apartment building from 1965. Stjernehus Borettslag is the name of the building and it has ten stories, accommodating 60 apartments of respectively 42m^2 to 80m^2. In total there are 87 people living in Stjernehus Borettslag, which means that there are in average 1.5 people per apartment. Furthermore there are 13 garages and 16 parking lots, which means that only 33% of the residents have the possibility to have parking available at all times. Added there is a common parking lot for several apartment buildings in the area, which can be used by the residents if needed. But the Home Owner Association (HOA) confirms that there are vacant parking garages; since few of the residents have their own car (Lunden, Rønninge et al. 2014, a.Moen 2014).

AREA	4000m^2
VOLUME	11440m^3
HEATED AREA	3750m^2
STORIES + BASEMENT	11
STORIES HIGHT	1.6m

Table 4-a: Geometric values for Stjernehus Borettslag.



Picture 4-a: Stjernehus Borettslag before retrofitting started taken by Jenny Josefine Holen.

In 2011 the building was announced Kristiansand's coldest apartment building. Stjernehus Borettslag needed an upgrading and Kruse Smith A/S won the bidding and is now the main contractor for the upgrading. Both due to the economic and health benefits from doing an energy retrofitting, the residents decided to perform this type of upgrading. Even though it took several meetings and discussions among the residents to convince all of them that energy retrofitting was the best option(Lunden, Rønninge et al. 2014). ENOVA has given a grant and the Norwegian Husbanken allocated a loan and a grant of 100 000 NOK to the project, this is considered to be a favorable loan compared to private loans (a.Moen 2014). Husbanken is a governmental agency that strives to implement the policy of that everyone should have a safe place to live (Husbanken 2014).

For Stjernehus Borettslag the grants and loans connected to the energy retrofit has a total sum of 40 350 000 NOK, as the Table 4-b shows. Originally the upgrading cost was 18 000 000 NOK, but this sum was increased when the energy retrofitting project was accepted (a.Rønningen 2014). This means that each apartment has an added debt of 633 333 NOK, which is a significant amount of money. This is considered to be between 20-40% of an apartment in Stjernehus Borettslag value (Norges Eiendomsmeglerforbund 2013).

GRANTS & LOANS	
Husbankentrinn 2 (Grant)	100 000 NOK
ENOVA (Grant)	2 250 000 NOK
Husbanken loan	38 000 000 NOK

Table 4-b: shows the grants and loans given to the project (a.Rønningen 2014) .

Retrofit of residential buildings often includes various incentives, such as reducing maintenance, energy bills, improving the aesthetic and comfort, increasing the market value, the safety and the employment and to avoid CO_2 emissions (Martinaitis, Kazakevičius et al. 2007). Today, there has not been any relator willing to give Stjernehus Borettslag an estimated market value for the apartments after the retrofitting. But the residents are accounting for an increased market value, decreased energy use and an increased value of their health and comfort (Lunden, Rønninge et al. 2014).

In 2013 Stjernehus Borettslag was accepted as a pilot project in the governmental program Framtidens Bygg. This requires the project to be a frontrunner within energy efficiency, new solutions, GHG reduction from transportation and material resource efficiency. The project's status before retrofitting and its ambitions after retrofitting is presented in Table 4-c.

AMBITIONS
Energy Effciency
Greenhouse gas reduction when changing from heating oil to district heating
Enhanced comfort and indoor air quality
More durable facade pannels in regars to materials

SITUATION BEFORE RETROFITTING
Significant thermal bridges in concrete structures
Large heating needs
Need for maintenance

NEEDED INITATIVES
Additional insulation of walls, floors and ceilings
Remove / minimize thermal bridges
Asbestos removal of facade panels
New clothing for facades
Replacement of windows and doors for devices with low U-value
Phasing out oil furnaces transition to district heating
Mounting balanced ventilation with heat recovery
Adaptation of universal design
New glazed balconies

Table 4-c: taken from the agreement between Framtidens Bygg and the project team of Stjernehus Borettslag available at their web page (Framtidens Bygg 2013)

4.1 PRESENTING THE CONTRACTOR KRUSE SMITH AS

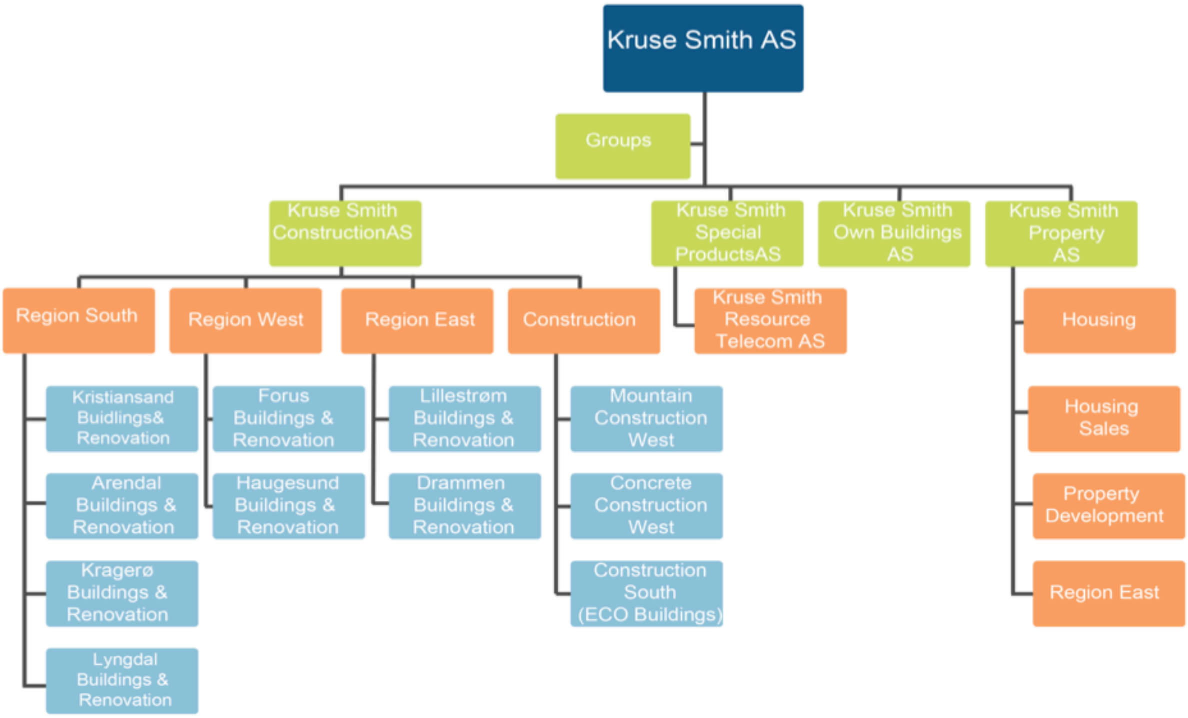


Figure 4-a: Presents the organization map of Kruse Smith AS (Kruse Smith AS 2014).

Kruse Smith AS is the main contractor for the retrofitting of Stjernehus Borettslag and the organization that allowed this thesis to present an insight in the project. The company has over 690 employees and has been functional within contracting and real state since 1935. In 2012 the company had a turnover of NOK 4.1 billion. Throughout 2015, the company has sat leadership, development and risk management as main areas of focus. These efforts are going to contribute to make better conditions for the productions and organization, which hopefully will lead to a better outcome for Kruse Smith's customers and employees (Kruse Smith AS 2014). Figure 4-a shows the organization map, which consists of four different fields of focus; (1) contractors, (2) special products, (3) own buildings and (4) real estate.

4.1.1 ENVIRIONMENTAL ASPECTS

Kruse Smith AS recognizes their responsibility as a contractor in the Norwegian construction field to contribute to decrease the country's total GHG emission. Moreover, Kruse Smith AS also describes the environmental challenges as an opportunity for the construction field to contribute with solutions that will lower the emission. They aim for a positive development of the future solutions, which will decrease the GHG. Stating that Kruse Smith AS wants to be a part of the solution not the problem. Kruse Smith AS is aiming to increase the energy efficiency in buildings, both in new and existing structures. The firm has a lot of experiences with energy efficient projects and retrofitting projects (Kruse Smith AS 2014). Additionally Kruse Smith AS is involved in the construction and adjustment of the BREEAM system to fit the Norwegian environment (Kruse Smith AS 2014).

5

RESEARCH QUESTION

In this report GHG emissions form Stjernehus Borettslag is calculated by using the tool kilmagassregnskap.no. This tool can be used as input in a decision making process. Therefore a theory for how an organizational decision process is executed is studied and used as a framework for the case study.

This project is going to examine and then answer the following questions:

KEY QUESTIONS:

1. What are the environmental impacts of Stjernehus Borettslag shown by klimagassregnskap.no?

2. How should Kruse Smith AS improve their potential for retrofit projects?

- SUB QUESTION PART 1:

How should the tool klimagassregnskap.no be used?
What are the potential of klimagassregnskap.no?
How klimagassregnskap.no be included in a decision making process?

- SUB QUESTION PART 2:

How can one optimize the decision-making processes of a retrofitting project?
What are the major challenges in retrofit project's decision-making processes?

6

RESEARCH METHODOLOGY

There are several types of research; the conducted research for this project can be categorized as exploratory research, where the objective is to gain knowledge of a case in order to gain insight (Kumar, Phrommathed 2005). This research has both a qualitative and quantitative approach, where the motive of human behavior is studied in regards to decision making and the environmental performance of a retrofitted building is documented. Furthermore the report takes a conceptual approach where a theoretical concept is used to guide the analysis and interpretation. Using theory as a framework for a case study can improve the research. Finn (2000) stressed the importance of theory in research and wrote (p.14): *"Research needs theory as a framework for analysis and interpretation, and theory needs research to constantly review/modify/challenge theoretical details".* The research result is meant to indicate whether there should be change in regards to the decision-making processes, in order to achieve an improved environmental performance. Data collections, analysis and interpretations are meant to advice participants of the project, but could also be applied for conduction of further research.

6. 1 RESEARCH PROCESS

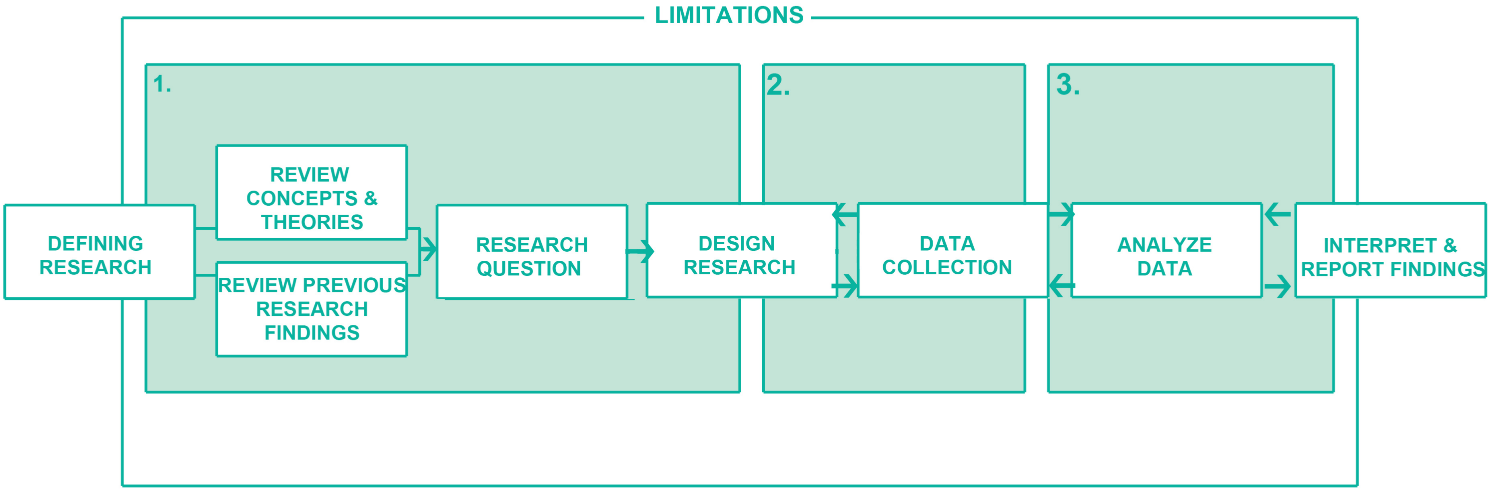


Figure 6-a: Explaining the research process with phase 1, 2 and 3 explained under.

Figure 6-a seeks to describe the research process for this report. In Fall 2013, I contacted Kruse Smith AS and asked for possibilities regarding collaboration for final thesis project. Due to Kruse Smith's previous collaborations with students, experience as a leading contractor in Norway and involvement in environmental issues they seemed to be an attractive organization for thesis collaboration. This collaboration appeared to be a good match, and was suiting to the semester theme for the final thesis and my interest in structural engineering. During fall 2013, Kruse Smith AS offered three possible research fields; all were directed towards environmental aspects in ongoing or planned construction projects. Since the existing building mass has a huge potential I chose the case study offering insight in a retrofitting project. The process of this project can be divided into three phases that are depending on each other, since the next phase is constructed on learned knowledge form the previous phase.

6.1.1 THREE PHASES

1) THEORETICAL PHASE

After the research was defined, a review of existing relevant theories, investigation of case studies, and learning of software for environmental assessment and other relevant methods started. This was done to open up the field of study, and to shape an overview of the research field. During this process the research questions and an overview of the design was formed, and feedback from Kruse Smith and supervisor was taken into consideration.

2) EMPIRICAL PHASE

Since klimagassregnskap.no requires input data form several participants, this process was started already in January, in order to collect all necessary data. In order to have realistic data for the transportation section in klimagassregnskap.no, a survey was made to collect data concerning residents' transportation habits. But was not distribute before the final thesis report was due. Since it has to be done during an information meeting held by the board of Home Owners Association. The Survey is attached in Appendix 1. Data collection for klimagassregnskap.no was an ongoing process throughout the project. While qualitative data collection, was performed from March throughout May. Interviews were conducted with both internal and external employees that had a link to Stjernehus Borettslag and decisions taken in project process. Meeting and workshops were attended where qualitative data were collected. Appendix 2 provides a list of personal communication with different actors.

3) ANALYTICAL PHASE

Qualitative data were used as input in klimagassregnskap.no and results were analyzed. Feedback on the calculation was given from both external supervisor Rønningen and consultant Selvig and modifications in the calculation were done several times. Studied theory was observed in practice and used as a framework to analyze the qualitative data. In the end findings were interpreted and conclusions were drawn.

6. 1. 2 HERMENEUTIC APPROACH

Even though the process is presented as a linear process in Figure 6-a, there are arrows both back and forward in the empirical and analytical phase, since the feedback and added knowledge made it necessary to move back and forward from the phases. The theory of the hermeneutic spiral is essential for this report; this spiral explains how the initial understanding is constantly improved by access to information such as workshops events, site observations and interview. Later this information is interpreted and then added to the knowledge base. This process continues throughout the study period. By having a hermeneutic approach the research is constantly refined(Andersen 2012).

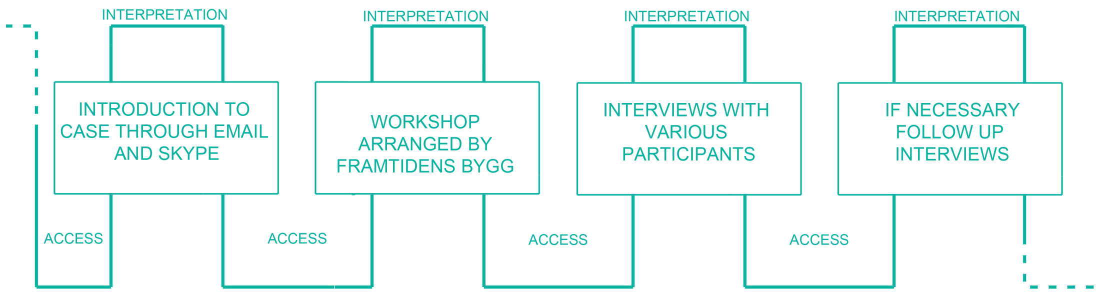


Figure 6-b: Hermeneutic spiral for qualitative data in this case study.

6.2 RESEARCH METHODS

Methods for data collection varied throughout the project, due to different data was needed to construct the project. Both secondary data and primary data was collected, methods for collection is explained under.

6.2.1 SECONDARY DATA

This is data in form of literature, which contributes to give the researcher an overall understanding of the research field. For this report's articles, previous case studies regarding energy retrofitting, reports of GHG emissions from buildings, guidelines for klimagassregenskap.no were used as secondary research data. This contributed to gather a general knowledgebase of relevant information, which was used to further identify aspects that could be examined in more detailed for the final thesis.

6.2.2 PRIMARY DATA COLLECTION METHODS

Both qualitative and quantitative data have been collected for this project. Quantitative data was used to calculate the GHG emission using the tool klimagassregnskap.no. While, qualitative data were used to analyze the project process and its decision making processes. Five methods for collection of data were used for this report (Yin 2011).

1. DIRECT OBSERVATION

In January 2014 a meeting was held in Oslo, here the developer of klimagassregnskap.no taught the concepts behind the tool. This was an informative meeting where questions could be asked frequently and the training was focused on the actual case study.

In March Framtidens Bygg had a startup seminar in Kristiansand, which was organized as a workshop where several participants from two pilot projects were represented (Stjernehus Borettslag was one of the pilot projects). Both project was presented and previous pilot projects were discussed. This workshop was an opportunity to learn more about the project as well as the governmental programs Framtidens Bygg and Framtidens Byer and to network with different involved participants. List of participants that was presented at the workshop is given in Appendix 3.

Construction began in mid April, and in the end of the month a visit to the construction site was arranged, where opportunities for questions and observation were offered. In order to collect a data for all involved participants. Eivind Torsvik did a walkthrough of different sub-suppliers and sub-contractors at the site.

Furthermore, some of the research for this project has been done at Kruse Smith's offices in Kristiansand. This was done to have easy access to competence and knowledge about the project, and also have an opportunity for observation.

2. INTERVIEWS

During the project period several interviews were conducted in order to collect qualitative data. These were done in person, through Skype/phone or as questionnaires by email. Interviews were recorded or stored as documents. Essentials from the interviews in regards to the research questions were analysed and interpreted. Interviewees were carefully picked, and questions were constructed to achieve answers, which could contribute to an overall understanding of the work and construction practice. Interviewed subject are listed in Appendix 2, interview guide in Appendix 4 and record is given in digital format in Appendix 5.

3. ARCHIVAL RECORDS

Data from Norwegian Statistics have been used to form a context for the project. This data was collected to communicate information about Norway's energy use, GHG emission and energy sources. Furthermore quantitative input data in klimagassregnskap.no were gathered from various participants such as; energy companies, from workshop drawings, sub suppliers/contractors and transportation surveys, drawings are given in Appendix 6 and calculation of measurements in Appendix 7.

6. DOCUMENTS

Especially for the quantitative data collection documentation was essential, since measures from different participants were needed as input in klimagassregnskap.no. This information was collected mostly through email and some measures were taken from workshop drawings. Emails have also been a helpful tool for communication with different participants and data have been communicated frequently through email. Articles, web pages etc. have contributed to complete the data collection. Web pages introducing the different participants have established an overview of the organizational goals and objectives, which have been used to prepare interviews. Articles, journals and reports are all documents that have contributed to build the data collection.

7. PARTICIPANT-OBSERVATIONS

Since this thesis also has been undertaking a calculation of GHG emission from the retrofit building, the researcher has also been recognized as a participant in the project, and has therefore filled in a role in the project. During the project time observations have been done at informal meetings, seminars and working with the project at Kruse Smiths AS's offices. This has allowed the researcher to convey comprehensive data, gain access to participants and achieve an overview of the project process.

6.2.3 TRIANGULATION FOR VALIDITY

Data consistency has been constantly checked and rechecked throughout the project period. To confirm data, triangulation was used as a method for validation of data sources. This enables collected data to be reviewed from different approaches. Additionally, it can contribute to provide a more accurate and complex data, since different sources can add and clarify the data(Yin 2011). An example is that data from the literature study for klimagassregnskap.no were confirmed in the education meeting at Civitas and then again at the workshop with Framtidens Bygg, the data was also elaborated further, which allowed the researcher to gain a more complex data collection. Triangulation could also result in conflicting data, which then again allows the researcher to investigate the data further (Yin 2011).

7

BUILDING'S GHG EMISSION

The objective of this chapter is to present the Norwegian tool klimagassregnskap.no and discuss its functions and uncertainties. The tool is an environmental indicator for GHG form buildings, which is developed to be a part of designers' decision-making processes in Norwegian construction projects.

7.1 INTRODUCTION TO KLIMAGASSREGNSKAP.NO

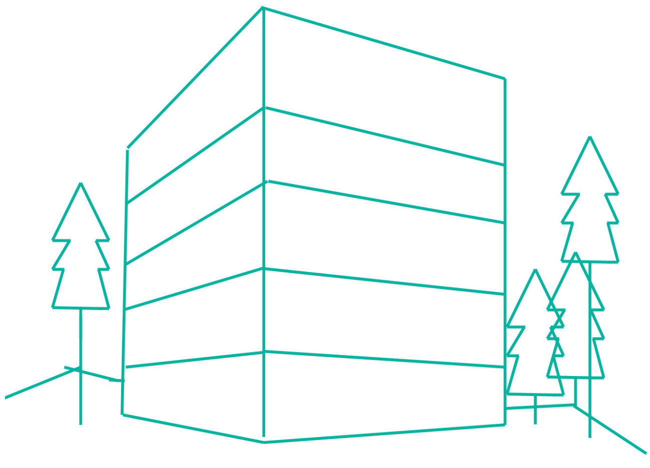
The Norwegian governmental firm Statsbygg is the developer and founder of klimagassregnskap.no, while the key designer is Eivind Selvig from the consulting firm Civitas(Statsbygg 2013). Since 2007 four versions of the tool has been developed, the last version was available in 2012. Klimagassregnskap.no is based on and in line with both international and national standardizations, such as requirements that concern Life Cycle Assessment and the construction sector from CEN TC350, ISO and NS (Statsbygg & Civitas 2013) . Klimagassregnskap.no is a free web based tool, which is available for everyone. The only use requirement is to be registered at the web page. Guidelines are free for download and available at the same web page as the tool. Klimagassregnskap.no can be used as a tool for documentation, planning and discussion. The building model identifies hot- spots and documents the carbon footprint from building projects, which can be used for comparison of various projects scenarios (Statsbygg 2013).

Both of the governmental programs; Future Built and Framtidens Bygg require their pilot projects to use klimagassregnskap.no. This tool is meant to be an integrated part of the planning, design and construction phase in all pilot projects. Pilot projects should achieve at least 50% reduction from a reference-building model to the designed building model. A reference building is a supposed building that is in line with present regulations and based on data for minimum requirements and generic data. Models for reference buildings are using the same project descriptions as the designed building, such as square meters, type of building, region for location and number of residents. However, it presents a building model that is not ambitious in regards to reducing the GHG beyond what is required in Norway. Therefore it is used as a reference for GHG reduction for pilot projects, since these projects are expected to be more ambitious (Statsbygg 2013).

Picture 7-a: Illustrates the “thought” building/ reference building to the left and the designed building to the right.

7.2 LIMITATIONS AND FUNCTIONAL UNIT

Klimagassregnskap.no performs a limited life cycle assessment, since it only takes the buildings GHG footprint into account, and does not consider other environmental impacts caused by buildings. It determines all of the CO_2 equivalent from the gasses presented in FN’s climate convention, Kyoto protocol (Selvig 2012). Carbon dioxide (CO_2), Methane CH_4, Nitrous Oxide (N_2O), Hydrofluorocarbons (HFC), Perfluorocarbons (PFC) and Sulfurhexaflouride(SF_6). Projects are calculated as a whole, and the outcome is given as building’s total CO_2 equivalents emission. This is including construction phase, operation phase and maintenance phase trough a lifetime of 60 years. Moreover Klimagassregnskap.no is not meant to be a tool that calculates the exact GHG emission of a building project, but more as an indicator for a discussion of projects environmental impact. The designers of the tool encourage the user to study the; projects emission sources, emission sources origin, various action alternatives, uncertainties in calculation and report opportunities for improvements. There is also an opportunity to include the klimagassregnskap.no calculations in the building scheme Building Research Establishment Environmental Assessment Method Norway (BREEAM-NOR), which is a ranking system to determine the environmental impact of a building (Statsbygg & Civitas 2013)



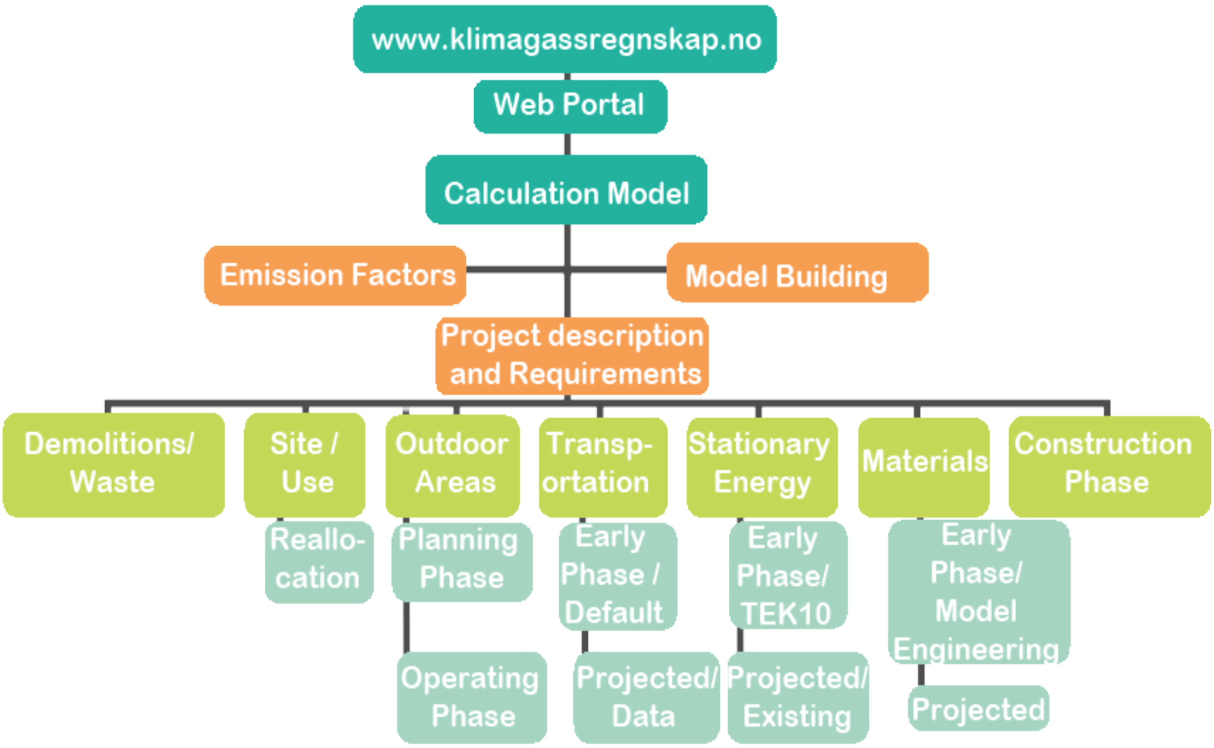
7.3 BRIEFLY HOW KLIMAGASSREGNSKAP.NO IS CONSTRUCTED

Figure 7-a: shows a systematic map of klimagassregnskap.no web portal with the different modules in lime green (Statsbygg & Civitas 2013) .

In klimagassregnskap.no modules are used to calculate the different parts of the building model. Each of these modules presents various elements in the project. In total eight different modules are developed to build the model (Statsbygg & Civitas 2013) . Figure 7-a shows the different modules in klimagassregnskap.no and Figure 7-b shows the accounted modules for the calculation of Stjernehus Borettslag. For each module the user has to specify the data according to the projects data. This is version number four of the tool and according to Civitas the tool is constantly improving (b.Selvig 2014).

7.3.1 MATERIALS

Early Stage is the module that specifies the material use for the building model. In total the database consist of emission factors for 120 materials, divided over 11 categories. There is also an option to view the default data that satisfy the Technical Regulations 2010 (TEK10) and the Passive House Standard, Technical Regulations 2010 are used to construct the reference-building model.



Designed is the module that allows the user to implement detailed data information of each building component. This module consists of nine categories, which each has several sub categories. Data such as the weight or volume for each building component are used as input, and klimagassregnskap.no calculates the total CO_2-equivalents emission form the component. Additionally the module allows the user to modify the lifespan of the various building components (Statsbygg & Civitas 2013)

7.3.2 STATIONARY ENERGY

Existing is the module that calculates the GHG emission from the energy consumption in the existing building model. This is done by implementing energy use data of heating, cooling and electricity, from the current building (if it is a retrofit project) or according to the initial design (if it is a new building).

Energy- New is the module where input data from the final designed building model is calculated. SIMIEN (which is an application that performs energy calculations) can be used to determine the amount of needed energy for a designed building. SIMIEN calculates the total energy use based on the final design, and uses inputs such as the u-values, thickness of the wall and roof.

7.3.3 TRANSPORTATION

This is the module where the GHG emission is based on six factors:

1. The building total floor space and number of residents
2. Number of trips done per day per residents, these are trips concerning different purposes.
3. Trips per day done by different transportation modes.
4. Car use, modified by available parking lots in the building.
5. Transportation work done per year with use of different transportation modes.
6. Gas usage and emissions factors of the different transportation modes and in total.

7.3.4 CONSTRUCTION, SITE AND OUTDOOR

These are all modules that are not used to calculate a retrofit project and they are not completely developed yet either.

Figure 7-b: the modules included in klimagassregnskap.no.

7.4 KLIMAGASSREGNSKAP.NO SYSTEM BOUNDARIES

Both the direct and the indirect emissions are accounted for in klimagassregnskap.no. Since the construction phase of the building, the maintenance and operation phase are taken into consideration.
The data collection in klimagassregnskap.no is based on three scope levels, which are described under:

(1) Direct emission each year linked to the buildings physical location.
(2) Indirect emission linked to the electricity, heating, cooling etc. these are emissions that take place at another location than the building, but still need to be accounted for in the total GHG footprint.
(3) Indirect emission from activities, products or services that are linked to the buildings construction phase, operation phase or maintenance.

Since Klimagassregnskap.no is meant as a communication tool, the designers have listed two important factors that should be taken into account when communicating the GHG footprint calculated in klimagassregnskap.no.

- The results include all GHG emissions, independent of the any management boundaries. This means that the calculation cannot be used in other GHG emission calculations, which have other system boundaries.

- All results that give a reduction of the GHG emission will result in a reduction of global GHG emission, but might increase the GHG emission in Norway. An example for this would be even though a producer in Norway is chosen due to their product has a lower GHG emission than another producer in Europe. This would increase the GHG production in Norway, but overall reduce the GHG in in Europe.

7.4.1 SYSTEM BOUNDARIES: ENERGY MODULE

Default data in the energy modules are based on the Norwegian Standard 3031 for calculation of building's energy performance. In the energy module for new buildings the net energy needed for the building is calculated. Net energy does not take the energy systems efficiency coefficient or energy loss into account. For existing buildings energy module the delivered energy is used as input data. Delivered energy is also including the loss of energy during the distribution.

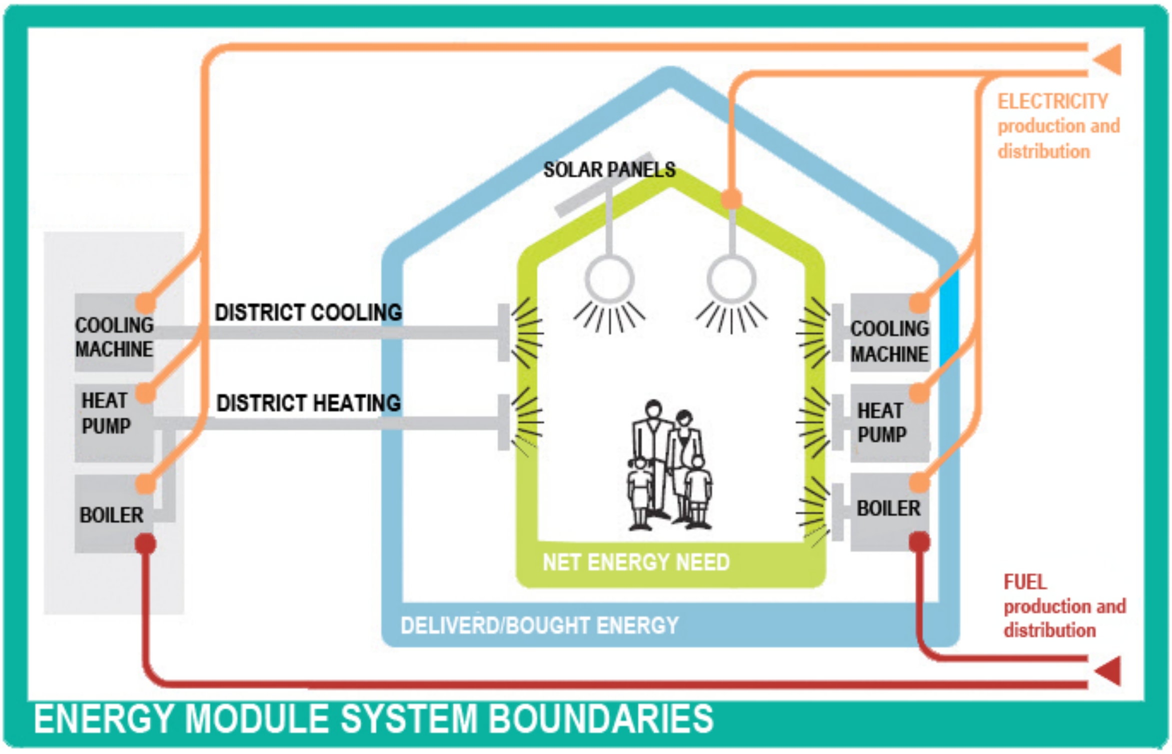


Figure 7-c: Shows the system boundaries for the net energy need and the delivered energy (Statsbygg & Civitas 2013) .

Incorporated in emission calculations is direct emission form the production and the transport of the energy from production site to user. Emissions from infrastructure and production equipment are excluded form the calculation. The energy system boundaries are explained in Figure 7-c. There are three alternatives for emission factors in klimagassregnskap.no; these are the EU-goal, the EU reference and the Kyoto. As a default the EU-goal is chosen in klimagassregnskap.no, this alternative is recommended by the designers to use (Statsbygg & Civitas 2013) .

7.4.2 SYSTEM BOUNDARIES: MATERIALS

In Klimagassregnskap.no the system boundaries for the data included in the database is set to be from cradle to gate. This is defined as from the raw material extraction to finished product at the factory gate, as shown in figure 7-d. Which means that data for GHG emission form materials caused by; transportation to site, installation, operation, maintenance and end- of-life is not included in the calculation. Material data in version 4 of klimagassregnskap.no is generic, reviewed and compared to LCA according to the ISO 14040-44. All technical installations are excluded from klimagassregnskap.no (Statsbygg & Civitas 2013) . When materials are recycled or reused to build a new building or in a retrofit project, lower emissions factor are calculated in in klimagassregnskap.no (Selvig 2012).

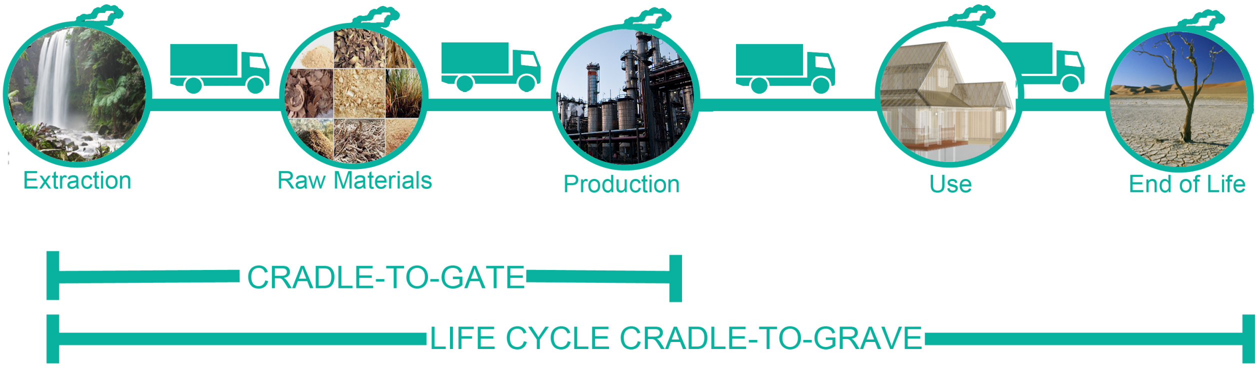
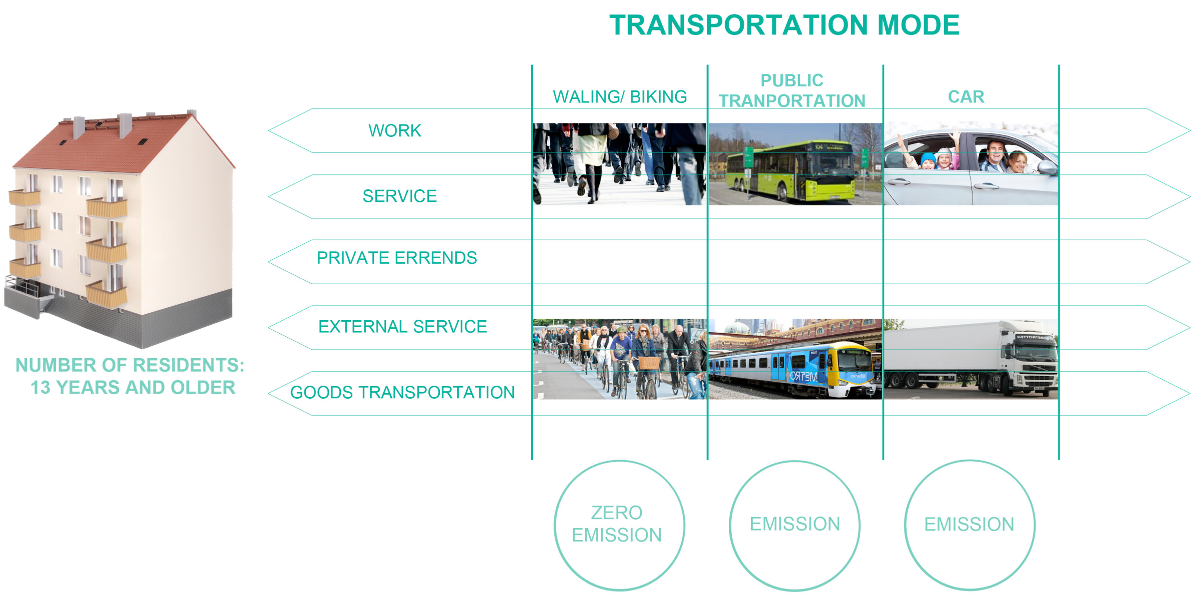


Figure 7-d: Explains the difference between the system boundaries cradle to gate and the full life cycle of a product.

7.4.3 SYSTEM BOUNDARIES: TRANSPORTATION

Only commutes that are under 100km are accounted for in the transportation module, the tool wants to capture the daily travel pattern and therefore only accounts for shorter commutes. Moreover the transportation module only account for half of the emissions from the transportation, this is done to avoid double calculating of emissions. Therefore half of the commute emissions for an employee commute to work are accounted for in their homes



and the other half in their workplace. Transportation modes included in modules for transportation in operation are shown in Figure 7-e (Statsbygg & Civitas 2013) .

Figure 7-e: Shows the system boundaries for the transportation module in klimagassregnskap.no (Statsbygg & Civitas 2013) .

7.5 UNCERTAINTIES & DATA QUALITY

Klimagassregnskap.no consist of both an integrated database and input data specified for each project. There are uncertainties connected to both of the datasets. There are several sources for the data used in klimagassregnskap.no, each of these data points are connected to an uncertainty. Moreover different data is set together in the total calculation, which increases the uncertainty. The designers of klimagassregnskap.no stress two types of uncertainties. First are the uncertainties in the data available and second are the uncertainties that are result of missing links in the data. The latter can be due to unviable data form a life cycle of a product or service. Today uncertainties tests of klimagassregnskap.no calculations are not performed. But the designers recommend to perform an evaluate the calculation by asking two question (Statsbygg & Civitas 2013) :

1) How much the end result will transform by a 10-25-50% change
2) And then discuss if the change has any significance in the choice of input data

7.5.1 ENERGY

Emission factor for the energy module is EU-mål= 2 degrees measure, which is fixed to 361g/kWh in 2010 and it follows a linear function until 2054, where the emission is expected to be 0. This is in line with EUs Road map and the 2-degrees measures. The energy module for the designed building is calculated with four factors. In this calculation two of them are specified for the project (net energy needed and heated floor area), one of them can be (system efficiency) and the third is included in klimagassregsnakp.no database (Statsbygg & Civitas 2013) .

Emission = $\dfrac{\textit{(Net energy needed) x (emission factor) x (heated floor area)}}{\textit{(System efficiency)}}$

The energy module for the existing building is calculated with three factors. Only the bought energy is specified for the project, the two others are included in the klimagassregsnkap.no database (Statsbygg & Civitas 2013) .

*Emission = (bought energy) * (energy content) * (emission factor)*

7.5.2 MATERIALS

NTNU made an updated database in the time period 2009-2012,which is used in version number four of klimagassregsnkap.no. This database is presented in Appendix xx, this table shows that the database is collected form various sources. Neither the date for when the data was collected nor the used technology for production of material is given in the database table, which is given in Appendix 8 (Statsbygg & Civitas 2013) .

7.5.3 TRANSPORTATION

In 2009 the Norwegian Institute of Transportation Economics (TØI) published a national travel behavior report TØI-report 1190/2012. Transportation modules in klimagassregnskap.no are based on data from this report. Peoples daily travel habits, such as why they travel, how far they travel, what transportation mode is used, transportation of goods and roads speeding limits, construct the data form the report. This information is combined with projects specifics and it is recommended to perform a local survey, in order to have more specific and qualified data for the project (Statsbygg & Civitas 2013) .

7.5.4 POSSIBILITES FOR IMPROVEMENT

Version number four of klimagassregnskap.no is a result of research for more than seven years and constantly improvements based on feedback and new findings. To be able to perform a GHG calculation for Stjernehus Borettslag by using the tool, both a walk-through with the developer Selvig, study of the guidelines and email communication with Selvig was necessary (a.Selvig 2014). It is important to remember that this tool is not a finished product, but an attempt to offer a free tool that can function as an input when decisions are performed in a construction project.

8

GHG EMISSION FROM STJERNEHUS BORETTSLAG

Since Stjernehus Borettslag is accepted as a pilot project in the program Framtidens Bygg, they are required to do a GHG calculation of the project using klimagassregnskap.no. This chapter contains calculations for a reference building, the retrofitted building and the existing building. This means that three different GHG calculations have been complete in klimagassregnskap.no:

Reference Building: is of the same building type and have the same geometrical measures as Stjernehus Borettslag, but is built according to minimum requirements from technical regulations. This model does not emphasize the environment beyond what is required in Norway.

Retrofitted Building: is the designed building, this model accounts for planned materials, actual location and the specific area's transpiration habits.

Existing Building: is the existing building as it was before construction started. This model is essential for the energy use during operation, since heating was changed from oil to district.

Statsbygg's web based tool klimagassregsnakp.no version four is used to perform the calculations. Appendix 10 contains a copy of the calculations done in klimagassregnskap.no. Emissions are calculated for material use, energy use during operation and transportation of people and goods during operation. The calculations are performed as a part of the final thesis and in cooperation with Environmental Manager Rønningen from Kruse Smith AS. Energy data is collected from Agder Energi og Varme. Material data is collected from Project Manger Øyvind Jensen and Eivind Torsvik from Kruse Smith AS, while transportation data is provided by TØI in cooperation with Civitas.

8.1 TOTAL GHG EMISSION FOR STJERNEHUS BORETTSALG

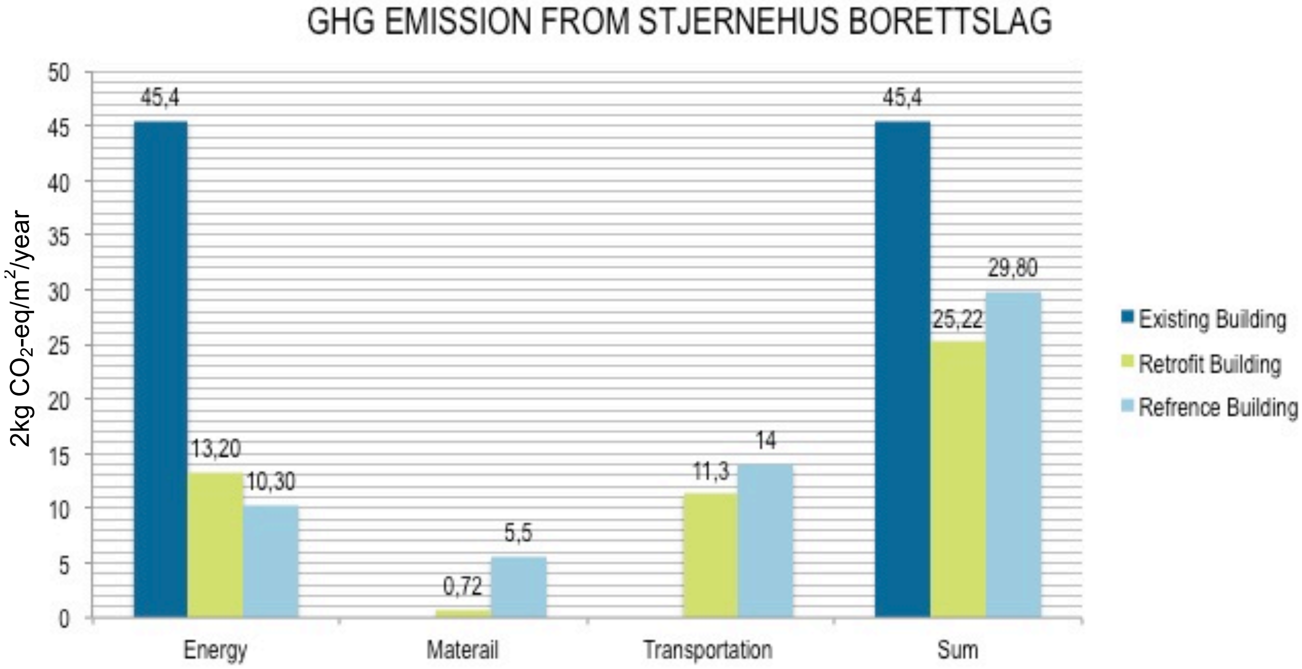


Figure 8-a: Total GHG emission from the three building models in klimagassregnskap.no of Stjernehus Borettslag.

Figure 8-a and Table 8-a, shows a total GHG emission for Stjernehus Borettslag of 25.2kg CO_2-eq/m^2/year after the retrofitting. A reference building is set to 29.8kg CO_2-eq/m^2/year year. Stjernehus Borettslag only achieved a GHG footprint reduction of 15% from the reference building to the retrofit building. Since the emission from the existing building is only relevant for the energy module, only this is accounted for and gives a total of 45.4 kg CO_2-eq/m^2/year. The energy module shows a 75% reduction from the existing building to the retrofit building. Since Framtidens Bygg requires pilot projects to have a 50% reduction, 15% reduction is not satisfying. The existing building is constructed on data from Stjernehus Borettslag before the retrofitting started. And the reference building is calculated by using the same geometric values as the designed building. Finally the designed building is constructed on data collected from drawings and estimations for the retrofit building. Finally the reference-building model is based on a hypothetical scenario, based on intergraded data in klimagassregnkap.no, which meets the Technical Regulations 2012 (TEK10).

MODULE	EXISTING BUILDING	RETROFIT BUILDING	REFERENCE BUILDING
ENERGY	45.4	13.2	10.3
MATERIAL	-	0.7	5.5
TRANSPORTATION	-	11.3	14
SUM	45.4	25.2	29.8

Table 8-a: Total GHG emission from each building model.

8.2 STATIONARY ENERGY USE

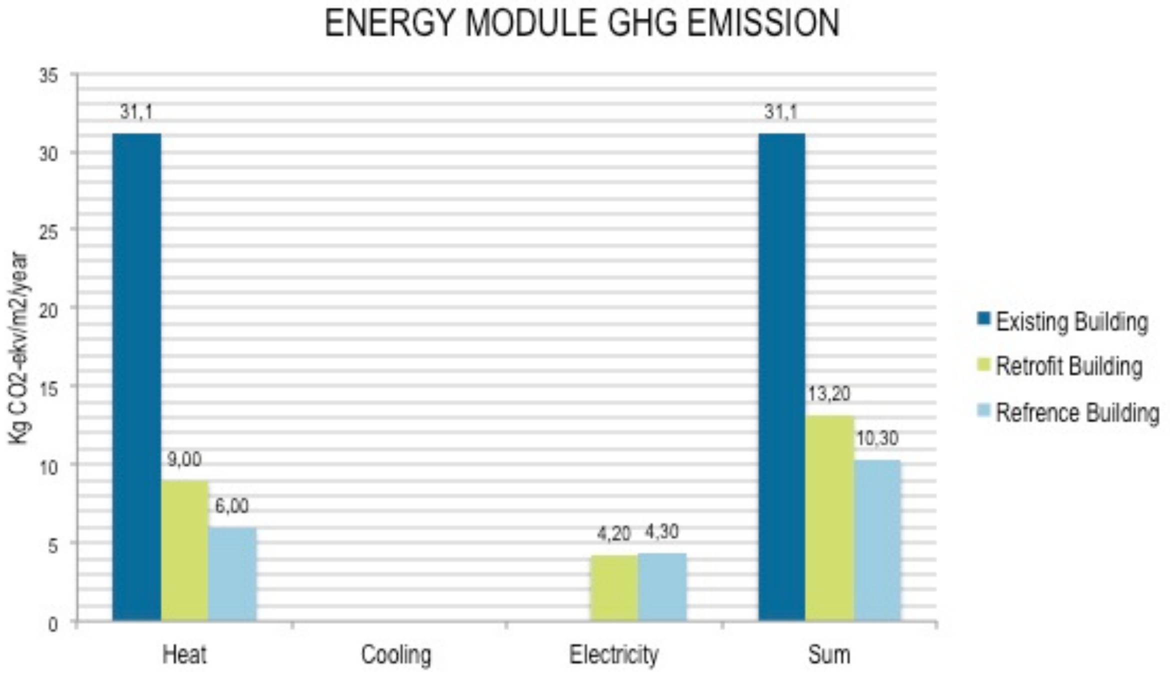


Figure 8-b: Emission from the energy modules.

Based on the data input from klimagassregnskap.no, the calculated GHG emission from the energy module equals 10.30kgCO_2-eq/m^2/year for the reference building, versus 13.20kg CO_2-eq/m^2/year after the retrofitting and 31.10kg CO_2-eq/m^2/year for the existing building; the results are shown in Figure 8-b. Since there is no energy used for cooling in both buildings, this bar is presented by 0%. Compared to the reference building, the retrofit building has a total GHG addition of 28%. From the existing building to the retrofit building there is a 58% reduction of the CO_2 footprint, which is a major accomplishment. Data for each building is described in more detail under.

The energy module for the reference building is meant to represent minimum requirements in TEK10, which in this case is an unfortunate reference. Even though the retrofit building are fulfilling TEK10 and uses less kWh, the reference building is provided with 60% energy from heat pump, which has a better system efficient factor than the district heating used for Stjernehus Borettslag. Selvig, developer of klimagassregnskap.no was contacted in order to investigate the possibility of modifying the reference building energy module to equal the scenario with the retrofit building. This was not possible, since the reference building needs to be constructed on default values, in order to have an objective comparison with the retrofit building model (a.Selvig 2014). Even though the retrofit building is fulfilling the requirements in TEK10 this is not allowed.

8.2.1 EXISTING BUILDING

YEAR	LITER(l)	kWh
2008	34173	No data
2009	34572	No data
2010	44157	No data
2011	33209	439 953
2012	32221	429 539
AVERAGE	**35666**	**434746**

Table 8-b: Showing the average use of oil and electricity before the retrofitting of Stjernehus Borettslag.

Stjernehus Borettslag operated with oil heating till 2013 and the amount of oil bought by the cooperative is presented in Table 8-b (a.Moen 2014). The average value of 35666 l is used as data input in klimagassregnskap.no. This gives 31.1kg CO_2-eq/m^2/year as a result for the existing building's energy module. In addition Stjernehus Borettslag had an average electricity use of 434746 kWh per year calculated from delivered electricity in 2011 and 2012 (a.Rønningen 2014).

8.1.2 REFERENCE BUILDING

NET ENERGY	ENERGY SOURCES	kWh/m^2/YEAR
Heating	60% Heating Pump 40% Electrical Boiler	73
Cooling	-	0
Electricity	100% Electrical Network	38
	Sum	111
Emission		**10.3 [Kg CO_2-eq/year]**

Table 8-c: Energy sources for the reference building

Needed energy for the reference building is calculated according to TEK10, which is limited to a yearly energy use of 115 kWh/m^2 per year (Lovdata 2010). Default settings in klimagassregnskap.no for TEK10, were used to estimate the net energy use for the reference building. The total value of energy use was 111kWh/m^2 per year and the total emission was estimated to be 10.3 kg CO_2-eq/ m^2/ year.

8.2.2 RETROFIT BUILDING

ENERGY SOURCES	DISTRICT HEATING MIX (%)
Incineration of waste	81
Waste Heat nickel plant	17,5
Bio	0,4
Oil	1.1
Electricity	0

Table 8-d: Energy mix for retofitted building

NET ENERGY	ENERGY SOURCES	kWh/m^2/YEAR
Heating	100% District Heating	53.9
Cooling		0
Electricity	100% Electrical Network	37.4
	Sum	91.3
	Emission	**13.20 [Kg CO_2-eq/year]**

Table 8-e: Energy sources for the retrofitted building.

Needed net energy after retrofit is calculated in SIMIEN by energy consultant Skogheim (Appendix 9). This calculation shows a distribution of the net energy use as shown in Table 8-c. In 2012 Stjernehus Borettslag changed to district heating. Their supplier Agder Energi og Varme AS specified the data for the energy mix as shown in Table 8-d (Melhus 2014).

8.3 MATERIALS

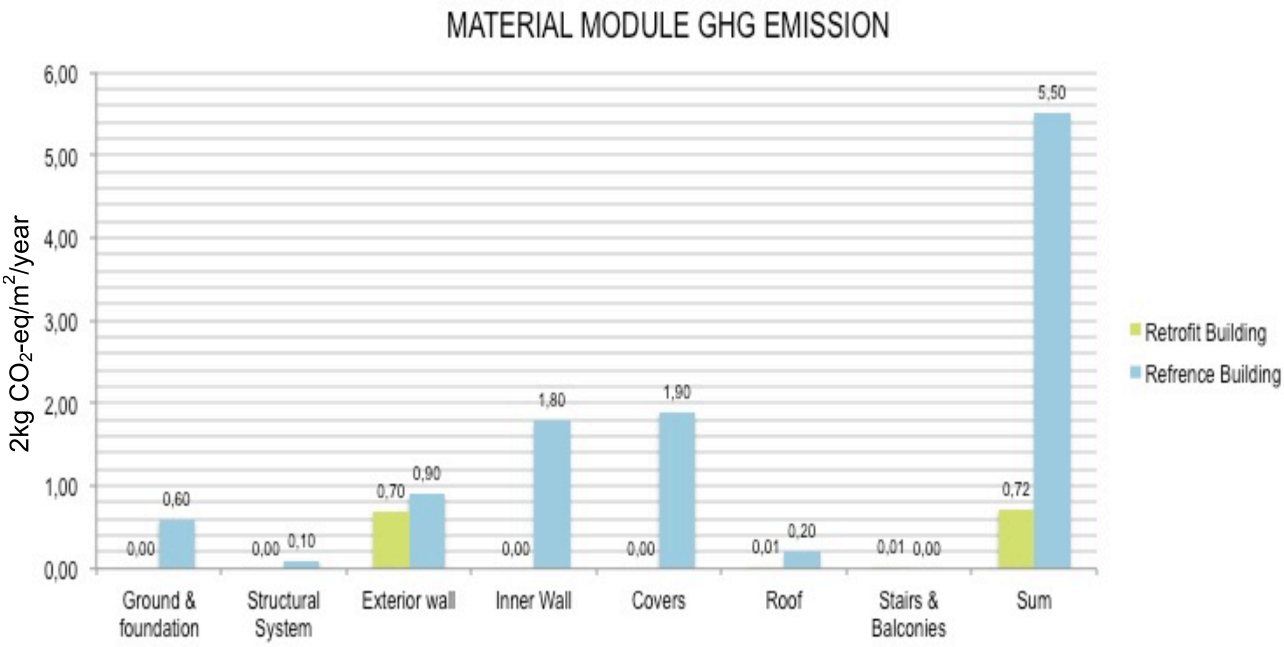


Figure 8-c: Emission from the material modules.

Based on the data input from klimagassregnskap.no, the calculated GHG emission from the material module equals 5.50 kg CO_2-eq/m^2/year for the reference building, versus 0.72 kg CO_2-eq/m^2/year after the retrofitting; the results are shown in Figure 8-c. This was expected, since there is less material added in a retrofit, than in a new building. Compared to the reference building, the retrofitted building has a total GHG reduction of 87% in the material module.

In retrofit projects, the bearing structure is often kept, such as the foundation, concrete floors and concrete walls. Structures that are kept will equal zero in the calculation of the retrofit building in klimagassregnskap.no. Only the added materials are accounted for in the calculation of the GHG footprint. Renovated buildings will therefore show a smaller GHG footprint, than new constructions, since less material is added in the calculation.

8.3.1 REFERENCE BUILDING

As mentioned the reference building is calculated as a new building and with default values according to TEK10 integrated in klimagassregnskap.no. Overall this gives a higher emission than for the retrofit project, due to more materials are added in the GHG calculation, than in the reference building.

8.3.2 RETROFIT BUILDING

For the retrofit building, materials are added to improve the energy efficiency of the building envelope. Materials that are actually used for the retrofit and materials that were the best fit in klimagassregnskap.no are shown in Table 8-f. The amount of material used for the retrofit of Stjernehus Borettslag was calculated according to guidelines from klimagassregnskap.no, these are attached in Appendix 7. It is only possible to choose certain materials in klimagassregnskap.no (120 alternatives for materials). Some of the actual used materials for the retrofit project were not offered as a choice, and therefore materials with the closest qualities were chosen in klimagassregnskap.no. This was evaluated in collaboration with project manager Jensen (2014) and tool developer Selvig (2014).

	MATERIAL USED	CALCULATED IN KLIMAGASSREGNSKAP.NO
EXTERIOR WALLS	Jackfoam, XPS [200mm] from Jackon AS under grown	XPS[150]
	Redair Flex System from Rockwool	Glass wool insulation
	Insulation between [200mm and 150mm] the wooden structures from Rockwool	Stone wool insulation
	Wooden structure [48x178 and 48x48] in spruce	Wooden Structure
	Wind membrane from Isola	Vapor barrier 0.2mm PE foil
	Zenit [8mm] facade panels from Cembrit	Fiber cement panels [8mm]
	60 Exteriordoors and 20 floor-entrence doors from Nordlock	Glass (70%) and aluminum (30%) doors with a aluminum frame 4.3kg/m^2
	Windows and Sixty Baloniy Doors [u-value=0.8] from Sør Vidnu	3 layers (U-value = 0,8) windows with a frame of 5.4 kg aluminum
ROOF	Asphalt cardboard from Isola	Asphalt cardboard 6,8 mm with a cover% of 103.
	Insulation injected from [50mm] Rockwool.	Glass wool
BALCONIES	30 double Steel Balconies from Balco	Steel Balcony - 2 kg / BTA

Table 8-f: List of material that were used in the left column and materials that were chosen in klimagassregnskap.no in the right column.

8.4 TRANSPORTATION

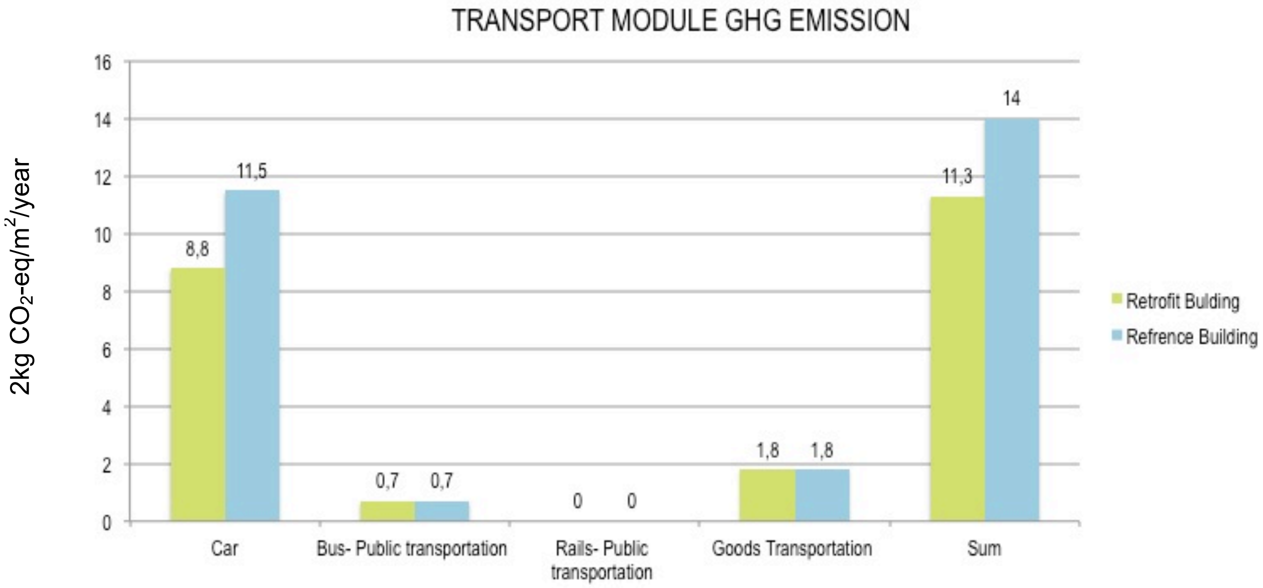


Figure 8-d: Emission from transportation modules.

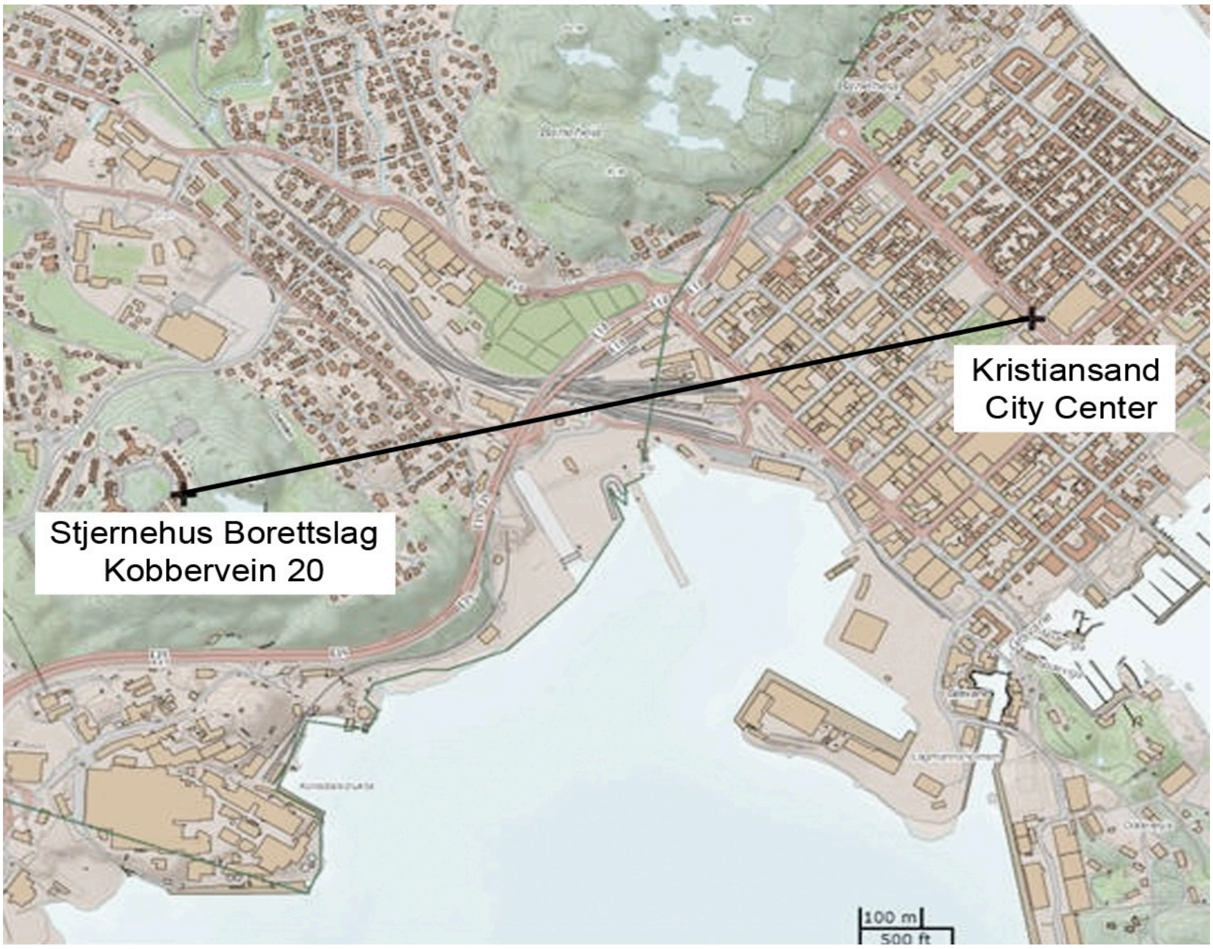
Based on the data input from klimagassregnskap.no, the calculated GHG emission from the transportation module equals 14.00kgCO_2-eq/m^2/year for the reference building, versus 11.30kg CO_2-eq/m^2/year after the retrofitting; the results are shown in Figure 8-d. Since there is no public transportation operating on rails in the area, this bar is presented by 0% for each case. Compared to the reference building, the retrofitted building has a total GHG reduction of 19%. The database that is used for the transportation module is constructed on results from the 2009 Norwegian Travel Survey (RVU). Transportation data from the RUV is then combined with number of residents.

8.4.1 RETROFIT BUILDING

TRANSPORTATION MODE	WALK/BIKE [%]	PUBLIC TRANSPORT [%]	CAR [%]
Work/School	35	10	55
Service	19	3	78
Procurement & Service	40	5	55
Other	49	5	46

Table 8-g: Shows the values for the retrofit building transportation module.

Since Stjernehus Borettslag is located close to 2km from Kristiansand city center, data provided from Civitas (a.Selvig 2014) for buildings close to the city are used to calculate the retrofit building model. These measures are shown in Table 8-g. The municipalities' maps were used to calculate the distance between Stjernehus Borettslag and the city center of Kristiansand. As the crow flies the distance is less than 1.495km as shown in Picture 8-a, while the distance by foot and car is according to goggle maps 2.5km and 2.8km.



Picture 8-a: shows the distance from Stjernehus Borettslag to the city center of Kristiansand.

8.4.2 REFERENCE BUILDING

TRANSPORTATION MODE	WALK/BIKE	PUBLIC TRANSPORT	CAR
Work/ School	21	9	70
Service	11	3	86
Procurement & Service	25	5	70
Other	33	5	63

Table 8-h: Shows the values for the reference building transportation module.

Location for the reference buildings is based on a hypothetical and generalized location within Kristiansand. Transportation data is shown in Table 8-h given in the user guide appendix for klimagassregnskap.no; this data is for Kristiansand area and based on the 2009 Norwegian Travel Survey (2009 RVU).

8.5 REALIBILITY OF STJERNEHUS BORETTSLAG GHG FOOTPRINT

Results that are given from Stjernehus Borettslag GHG calculation may be received as hard numbers (hard numbers are results from calculations that reflect accuracy). This is the danger with environmental indicators such as this; the purpose of klimagassregnskap.no is to create a medium for discussion. Therefore, the developers recommend that results are tested of a 10-20-50% change, in order to see if this would change the result reception. Table 8-i, shows that only a 50% reduction of the retrofit building result would fulfill Framtidens Bygg requirement, to achieve a 50 reduction from the reference-building model.

kg CO_2-eq/m^2/year		-10 %	10 %	-20 %	20 %	-50 %	50 %
Energy Module	**13,2**	11,88	14,52	10,56	15,84	6,6	19,8
Material Module	**0,7**	0,63	0,77	0,56	0,84	0,35	1,05
Transportation Module	**11,3**	10,17	12,43	9,04	13,56	5,65	16,95
Result	**25,2**	22,68	27,72	20,16	30,24	12,6	37,8
Reduction	**-15 %**	-24 %	-7 %	-32 %	1 %	-58 %	27 %

Figure 8-i: Sensitivity analysis for the GHG emission results. The values for the designed building listed in the first column are tested of a 10-20-50% change and compared to the reference building model.

8.5.1 COMPLETENESS, SENSITIVITY & CONSISTENCY

Both in the integrated database and in the specified input data, uncertainties should be taken into consideration. Especially due to limitations of alternatives in klimagassregnskap.no, the specified project data is not representing the full truth. Moreover, there are several aspects in the life cycle of the building model that are not accounted for such as the HVAC systems. Since the system boundaries are set to cradle to gate, there is also missing links in GHG emission from the gate to cradle. There are some problems with the methodology of the klimagassregnskap.no, due to the system boundary is set to cradle to gate. This only covers the GHG emission from the building's material, but does not cover the emission from the transportation to the site, operation, maintenance and the end of lifetime. This means that there are some emissions from the life cycle that is not communicated through the result. In general the integrated database in klimagassregnskap.no is sensitive because it is based on both generic data values, which can vary and perhaps not be relevant to the realistic situation, and specific data, which is either correct or incorrect. GHG emission results from klimagassregnskap.no should be tested for percentage changes, as shown in Figure 8-I (Statsbygg 2013).

The specified input data are primary data collected by suppliers for the building, SBBL, Kruse Smith AS, Kruse Smith AS's sup suppliers, energy suppliers and travel surveys from TØI. Since the databases in klimagassrgenskap.no are based on various data sources and generalization it is hard to tell the age of the databases. But since the software have been running since 2007 it is expected that there can be some data that is outdated. Since the environmental qualities of products and services have improved over the last years, it needs to be accounted for a margin of uncertainty concerning the data age. Furthermore the system boundaries of the databases are unknown to the user, which caries out furthermore uncertainties in the calculation. All the calculations in klimagassregnskap.no involve differences in databases and most likely some assumptions, cut offs and missing links either in the integrated database or in the input data. This means that the results are conveying these aspects as well and even though this is an absolute number there are several uncertainties connected to the number. Overall there is a challenge to use this tool as a guide for a decision making process, when there is numerous uncertainties connected to the results. Furthermore, there is also a risk connected to the comparison of the reference building model and the retrofit building model. Since the result may be based on different compositions of the databases, which again can contain different levels of data details.

9

THEORY FOR DECISION MAKING PROCESSES

Projects are often a result of several decisions, perhaps done by various decisions makers. Stjernehus Borettslag retrofit project is results of multiple decisions, and the decision-making processes are fundamental for the project quality. By whom these decisions are done, in what point in the project process and how much resources are delegated to perform the decision are all important influences for a project.

Today, most organizations depend on some sort of process to make the optimal business decisions. Organizational decisions have a tendency to be made according to the organization's beliefs, codes, conventions, routines and rules (Kørnøv, Christensen 2007). One often like to consider the decision making process in firms as a rational procedure. Nerveless studies shows that it is hard to distingue the human sense of fairness and unfairness in decision-making process. Human decision makers' will have underlining ideas of ethics, social policy, legal practice and personal morality, which can be argued that will influence the decision making process (Sanfey, Rilling et al. 2003). Furthermore the non-consequential theory for decision-making processes is stressing the aspects of randomness at the time a decision is done.

Decision-making processes are often concerned with the economic aspects of a project. Recently a trend of including non-financial metrics in decision-making processes is becoming more normal, for business in the Nordic countries. This is due to an emerging market of green products (Nordic Innovation, 2012). Traditionally the process of decision-making is started by the need to solve a problem, then by reviewing alternatives, which leads to an examination of the different alternatives. Then, to perform an evaluation of the various consequences, in terms of the overall objectives and lastly the final decision is made. The decision- making model called the garbage can model is used in this report to give a theory framework to how decision- making processes can be understood. This theory is not based on the traditional logic for a decision-making process. It is not the meaning to claim that all decisions are done according to the logic of the garbage can model. But this report will seek to emphasis the aspects taken into account in James G. March and his colleague's decision- making model(Cohen, March et al. 1972). Since the model is flexible it is possible to practice the model in various context and organizations and it makes a good fit when real life practice of decision-making processes are studied.

9.1 INTRODUCTING THE MAIN CONCEPT OF THE GARBAGE CAN MODEL

Professor James P. March and his colleagues presented the logic of decision-making theory by showing the process in the garbage can model in 1979 (Cohen, March et al. 1972). This was a radical approach and various academic fields received the garbage can model differently. The concept was based on a different rationality than then what was seen before(Workiewicz, Dong 2013).

In an interview Professor March(2013) explains two different logics related to decisions making, which explains the main differences of the traditional logic and those of the garbage can model(Workiewicz, Dong 2013). First is the traditional logic, where the decision maker asks him/her self three questions;

1. What are the alternatives?
2. What are the consequences?
3. How do I value the consequences of the alternatives and then choose the one that generates most value?

The second logic is used to form the garbage can model, here the decision maker asks him/her self;

1. What kind of person am I?
2. What kind of situation is this and
3. What is a person in my poison, suppose to do in a situation like this?

The last logic does not ask about the consequences, which is the main difference between the two. Professor March(2013) explains that people have both of the logics available and usually they use both of them as well, but at different times and they can create conflicting senses(Workiewicz, Dong 2013). The garbage can model theory has been an essential influence for the non-consequntialist apporche of decision-making (Knudsen, Warglien et al. 2012). Professor March and his colleagues describe the choice opportunities within in an organization as a garbage can(Cohen, March et al. 1972). This can is available for different participants and through it runs different solutions and problems. The mix of garbage in this can depends on the current scenario. Which is situated by the combination of the used can, its label, the garbage and the speed for collection and removal of the garbage. The garbage can model describes four different variables, which each is a function of time. These seek to describe the independent streams that affect a decision process within an organization. The four streams are presented in the Table 8-a (Cohen, March et al. 1972).

FOUR STREAMS
1. Stream of Choice
Where the organization is anticipated to perform decisions. This could be a scenario where the organization has to sign a contract, fire someone, hire someone, allocate responsibility or spend money.
2. Stream of Problems
A stream of concerns both in internal and external context for the organization, which can trigger a decision making process. These can arise from a very individual detailed level to a more common open level. But they have all in common that they crave attention and are often looking for a fitting solution.
3. Stream of Solutions
This is an answers that might are looking for questions, even though they are separated from problems solutions can be requested to solve them. In an organization you often don't know the problem before you know the answer.
4. Stream of Energy from Participants
A stream that is expected to be change over time; participant often come and go, and can vary from problems to solutions.

Table 9-a: Describes the four streams (Gunter Krumme 2002, Cohen, March et al. 1972).

Picture 9-a: Illustration of garbage can with four streams running through.

Overall the garbage can model refers to the four streams as independent components that float through the structure. The four streams are connected depending on the arrival and departure time and other stream constrains. Since a garbage can lack structural constrains the problems are linked to the solutions and the participants to the choices. Even though the streams are independent they deal with each other constantly(Cohen, March et al. 1972). To enable these four variables to connect, three assumptions are identified. First the *Energy Allocation Assumption*, which declares that each choice requires as much effective energy as the total of all problems devoted to the choice. Second, the *Participant Allocation Assumption,* which clarifies those participants, should only allocate their energy to one choice at each time period. Last the *Problem Allocation Assumption*, which assume that only one choice is connected to a problem at each time(Cohen, March et al. 1972)

9.2 ORGANIZATIONAL STRUCTURE

The organizational structure is essential for the result from a decision-making process. Elements such as the time pattern in regards to arrival of decision makers, problems choices and solutions are affecting the decision making process. Additionally the distribution of energy to participants, required energy to perform a decision and the connection between the four streams is fundamental for the outcome of the process. Organizational structure changes with the context, and external factors such as the market demand can contribute to change the elements that shape the structure(Cohen, March et al. 1972, Knudsen, Warglien et al. 2012).

9.2.3 ORGANIZATIONAL ARRANGEMENTS

In real life organization the settings are often complex and can be a mix of structures (Cohen, March et al. 1972).

NET ENERGY LOAD

When more problems are attached to the choice more energy is needed to solve the problems. An organization has a sum of total energy available over a fixed amount of time. The difference between available and required energy to solve the problem defines the net energy load of an organization. If less energy is available and the problems connected to a choice is heavy, the more difficult is the resolving.

ACCESS STUCTURE

The access structure of an organization seeks to describe the relationship between problems and choices within decision-making processes. To present an idea of what access structures represent, Cohen, March et.al (1972) explains three different access structures;

1. UNSEGMENTED ACCESS
All the active problems have access to any of the active choices.
2. HIERARCHICAL ACCESS
Important problems have access to many choices, while the important choices only have access to important problems.
3. SPECILIZED ACCESS
Each choice only has access to a set of problems, and each problem only have access to one choice.

ENERGY DISTRIBUTION

Total time spent on organizational problems is reflected in the allocation of energy between the decision makers. This varies in organizations, important participants can have less energy allocated or more, or all participants can have equal energy available (Cohen, March et al. 1972).

DECISION STRUCTURE

Equally as the access structure, does March (1972) model explain three different decision structures within an organization. The decision structure deals with the participants' allocation to the various decision opportunities. This can vary for each organization and the scenario, and are often a complex structure, which can be a mix of the three arrangements explained under (Cohen, March et al. 1972);

1. UNSEGMENTED DECISIONS
All choice opportunities are available to any participant.
2. HIERARCHICAL DECISIONS
Important participants are part of important choices, and the important participants can influence many choices.

3. SPECIALIZED DECISIONS
Choices are specified to participants. Which means that one choice is delegated to one participant and the participant only represent one choice.

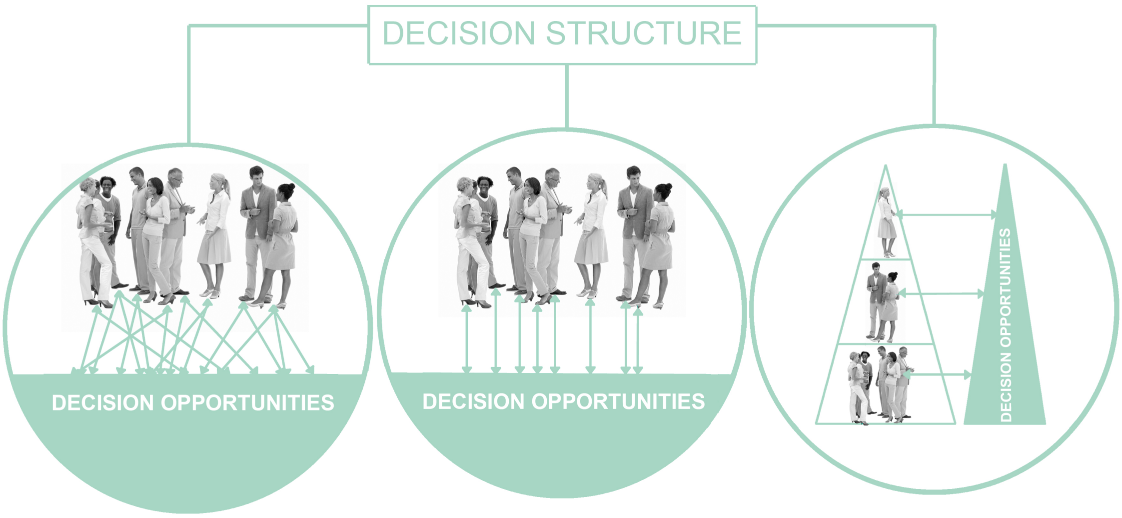


Figure 9-a: Seeks to explain the there types of decision structures explained under

9.3 MEASUREMENTS FOR DECISION PROCESSES

Decision style: There are according to Cohen, March et.al (1972) three different styles for how to conduct a decision. In real life organizations, these three styles are often combined and organizations use different styles to determine different choices.

(a) By resolution (problem-solution): the participants allocate a joint effort in terms of resources to the choice. This enables the requirements to be met, and the problems connected to choice are therefore solved(Knudsen, Warglien et al. 2012).

(b) By oversight (false/ Pseudo- resolution): when decisions makers perform choices that are not connected to any problems. This decision style does not solve any problems(Knudsen, Warglien et al. 2012).

(c) By flight (empty decision): Problems are shifted from the original choice and over to other choices, to reduce the needed effort to solve the problems connected to the choice(Knudsen, Warglien et al. 2012).

The two last decision (b,c) styles are not solving avoiding to solve relevant problems, research of the garbage can theory, shows that these two decisions styles are the most common used (Knudsen, Warglien et al. 2012).

Furthermore, four different activity measures are used in the garbage can model:

Problem Activity: to what level problems are active within and organization is reflected in the conflicts represented in the organization.

Problem Latency: If a problem is active but not connected to a choice, the problem is recolonized but not relevant to any of the choices. Level of problem latency is will have an impact on the organization.

Decisions Maker Activity: To measure an organizational systems decision makers' activity March (1972) lists four methods:
(a) For how many time periods a decision maker is connected to the choice, calculated over all decision makers.
(b) Amount of time decision makers shift choices
(c) Total effective energy accessible and used
(d) How much energy is used to performed a choice at the specific time

Decision Difficulty: All outcomes of a decision process are related to the included participant's individual behavior. The three outcomes of a decision making process is shown in Figure 9-b, these are connected to decision styles, which is explained above.

Segmentation of decision structure can reduce the problem latency, but increase the problem activity and the overall decision effectively. Meanwhile segmentation of access structure can reduced the number of unsolved active problems, but will increase the latency time for each problem and the time devoted to achieve the decision. Organizational arrangement has their compromises and will affect the decision process in an organization. If the problem latency increases and the problems that are neglected are essential and can damage the organization, it can have serious affects(Knudsen, Warglien et al. 2012).

Figure 9-B can be used to understand the process of decision-making. The four streams are used as input, and furthermore the decision process consists of four elements and at last the output is assumed to be one of three. Overall there are three main elements that influence any outcome of the decision process(Cohen, March et al. 1972). First is the time pattern, which is connected to the arrival of any choices, solutions, problems and participants. Second is the element of allocation of any energy to participants and third is the connection between the four streams.

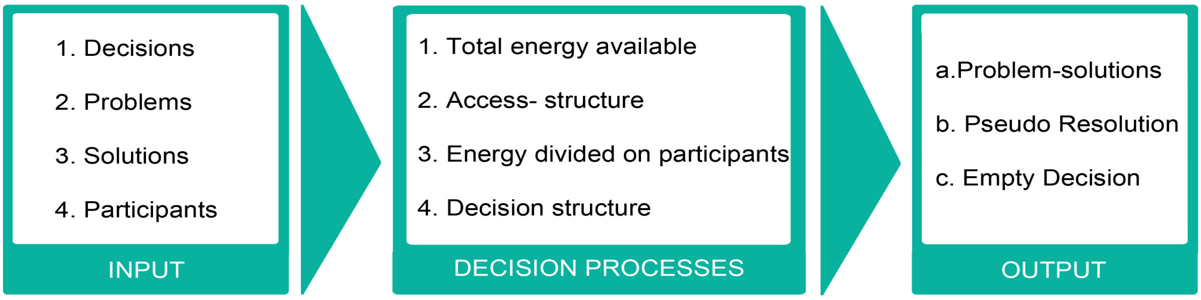


Figure 9-b: the decision making process (Bogason 1988)

9.4 THORY WRAP UP

By studying an organizations decision making-processes results can be interpreted and understood. This can then be used to optimize an organizations production in terms of organizations common objectives. There are several participants in this projects and there are even more decisions that have been or will be done. Therefore it is relevant to use the theory for decision-making process to understand the practice of this case study and to answer the research question of this report.

10

SOLUTIONS, PROBLEMS AND CHOICES

Designers, developers, owners etc. are all participants in the retrofitting of Stjernehus Borettslag. Multiple decisions are done to accomplish this project, and various participants have been included in different decision-making processes. All of these choices have impact on the project result, and these decisions can also affect the GHG emission from the project (Statsbygg 2010). According to the garbage can model, a decision-making process involves four streams; (1) participants energy, (2) choice alternatives, (3) problems and (4) solutions. It is possible for the streams to be linked, but initially they are represented as independent streams. In the case of Stjernehus Borettslag participants are either by first hand communication or by having a common interest to accomplish the retrofitting project. Decisions done in a project are often interlinked to the mix of participants; therefore it is important to be aware of all the participants involved to be able to understand the decision-making processes and evaluate the result. Decision makers evaluate their choices according to their motivations.

This chapter will give an overview of the Stjernehus Borettslag process, which includes both a mix of participants, motivation and decisions. The intention of this chapter is not to criticize current decision-making processes, but to understand the reality and seek opportunities for improvement. This is done in the theory framework of the garbage can model developed by Chone, March et. al (1972) and the decision-making processes in practice is observed through qualitative data collection. The retrofitting of Stjernehus Borettslag contains numerous of participants that are crucial for one or more phases of the project and therefore affect the end result. One choice by one participant can result in limited alternatives for another decision maker. List of participants and dates of communication are presented in Appendix 2.

10.1 PROCESS STJERNEHUS BORETTSALG

Figure11-a presents a process; it shows the various participants involved in the retrofitting of Stjernehus Borettslag and their entry and exit time in the project. In order to present the process of the retrofit project in a systematic figure, this figure divides the process into five phases. The project was not a linear process in the way that one phase was complete before the next started. Therefore, some phases have arrows pointing both back and forward. Since decisions done in the planning phase have been revaluated and changed in the later phases, such as during the contraction. This could be because some alternatives have become more attractive since the context is changed or other alternatives have become available. This is an attempt to divide the process into various phases, a short description of what the five phases contain is presented under:

START UP:
This is the phase where the project begins; this project was started by some of the residents and SBBL. Here is the context is figured out and the project boundaries are shaped.

FRAMEWORK:
This is the phase where the energy consultant and the main contractor are engaged. And together the participants figured out the essentials of the projects are decided.

PLANNING:
This is the phase where the designers in collaboration figure out the finer details of the project with the other participants.

CONSTRUCTION:
This is the phase where the execution of the project on the site starts.

AS BUILT:
This is the phase when the project is finished, and some of the participants need to approve the result, this is often done by documentation, such as drawings or reports.

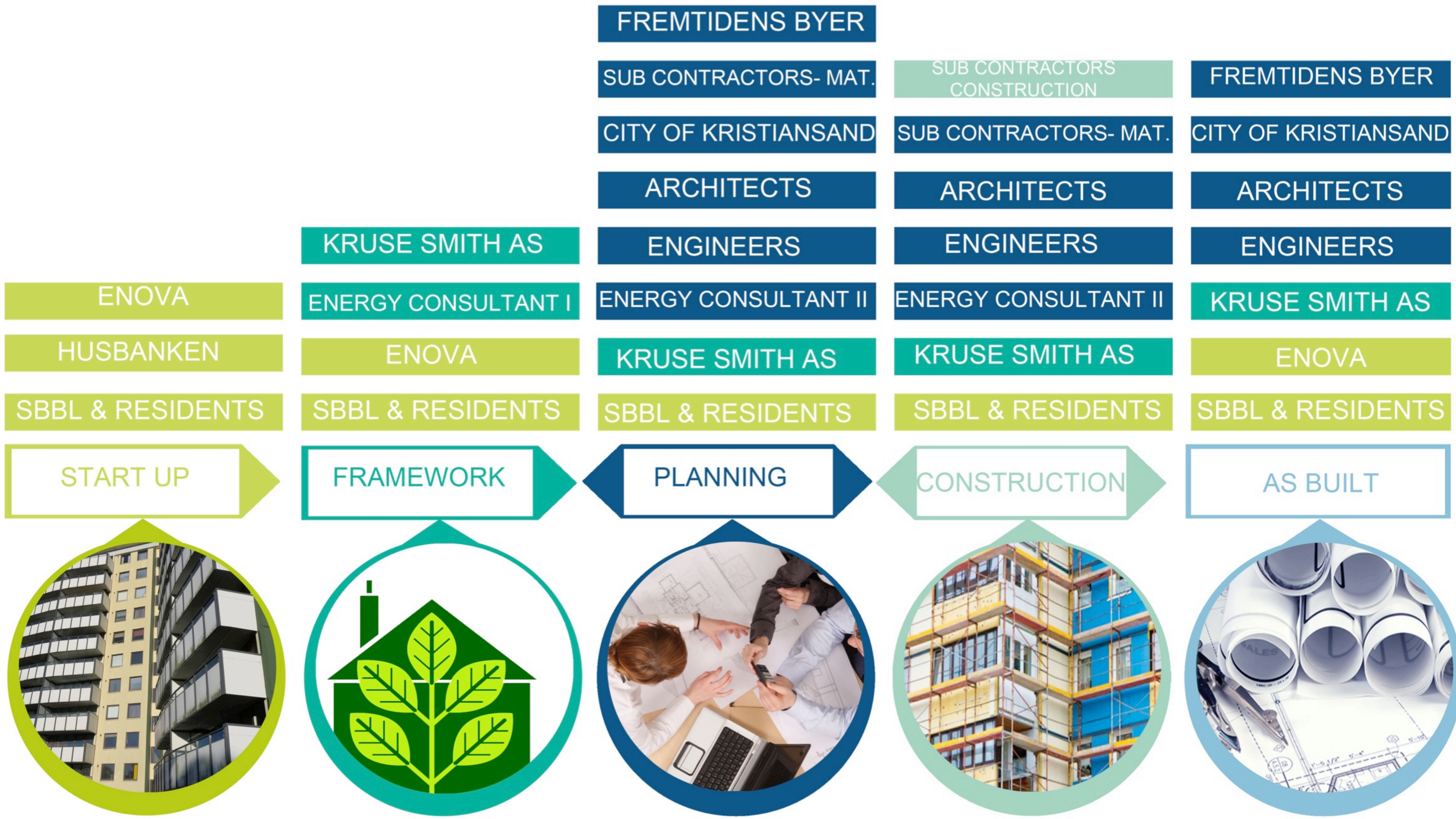


Figure 10-a: giving the participants exit and entry time in the project process.

10.2 PARTCIPANTS IN THE PROCESS

Banks, developers, contractors, energy utilities, energy consultants etc., can have conflicting interests in retrofit projects. Even the government and the municipality might have conflicting interest in construction projects, due to tax money or different motivations nationally and locally (Martinaitis, Kazakevičius et al. 2007). Motivation is essential for how a decision maker evaluate their choices. During interviews different objectives were mentioned from different participants. But all the participants want to deliver as expected to their customers. This sub chapter gives an introduction to the participants; their interests and reasons for involvement in this retrofit project.

10.2.1 KRUSE SMITH AS

Kruse Smith AS calculate a full cost and the necessary profit percentage, factors such as the current market and the risk is also implemented in the calculation. Normally an organization would aim for at least 10% profit for a project. The accountant does the estimation of the project costs and revenues. Later it is discussed in a panel, which include the bidding responsible and the district manager. For Stjernehus the calculation process was slightly different. Since this project needed to be modified to fit a tight budget, the project manager and the accountant had to find new solutions to lower the original cost. Therefore the project manager together with the accountant did a major part of the calculating process. The project manager and the accountant explained that there are several reasons why Kruse Smith AS decided to perform this project (Ulstein, Skarpeid 2014).

Customer relationship, since Stjernehus Borettslag is a part of SBBL, which is a major customer of Kruse Smith's services.

Green Branding, this project takes environmental aspects into account and is a good marketing project for the firm.

Knowledge Base and Niche Expertise, there is a market within renovation of 60s-70s apartment buildings in Kristiansand and Kruse Smith whishes to specialize within the filed and build a competitive knowledge base.

Quiet Market, the market for new constructions in Kristiansand currently experiencing a downfall, and Kruse Smith AS has resources at the moment to offer this service.

10.2.2 SBBL & RESIDENTS OF STJERNEHUS BORETTSLAG

In 2011, when the Stjernehus Borettslag won the price for Kristiansand's coldest apartment building, they realized it was time for change (Lunden, Rønninge et al. 2014). Since the apartment building is a part of the SBBL, they are together involved as the developer of the project. SBBL is an experienced developer as the south of Norway's Housing Association. They have been involved in several retrofit projects during the past decade (Skogheim 2014). While the residents are less experienced and the project manager have given an effort to include and engage them in the retrofitting decision making process. Determination and hard work from the board of the Home Owner Association have been essential for the project success(Eikeland 2014) Residents often have different motivations for doing a retrofit project, and with a total of 87 residents there has been conflicting interest at times. Understanding and convincing skills from the contractor is important when a project such as Stjernehus Borettslag is undertaken, but after tree years of intense work the retrofitting has now started (Eikeland 2014).

10.2.3 FRAMTIDENS BYER AND FRAMTIDENS BYGG

Stjernehus Borettslag is a pilot project in the governmental program Framtidens Bygg. Framtidens Bygg a sub organization of Fremtidens Byer that is a partnership between the Norwegian Government and the thirteen largest cities in Norway. Their aim is to reduce GHG emission from the cities and make them a better place to live. Today cities are behind a major part of the energy consumption, and 80% of all GHG in the world originates from the cities. The program started in 2008 and ends in 2014. Fremtidens Byer aim for a GHG reduction by developing new strategies for transportation, stationary energy use, recycling and for future climate change. Secondary, Fremtidens Byer has objectives such as improving the physical space in regards to ecology, safety, health, experiences and commercial development (Framtidens byer 2013). Their four main focuses are listed below.

1. Land Use and Transportation
2. Stationary Energy Use in Buildings
3. Consumption patterns and waste
4. Adapting for Climate Change

Both new and retrofitted buildings can be pilot projects for Fremtidens Bygg. All pilot projects need to fulfill the requirements set by Fremtidens Bygg and ENOVA. And they need to design solutions for the building, the facilities and the outdoor space that takes todays and future climate into consideration. Moreover, it is expected that the projects have; good architecture, inclusive design, environmental qualities and preserve important cultural values. To achieve these qualities the program encourages cooperation, interdisciplinary work and good processes. All pilot projects need to be controlled and evaluated after the construction phase by Framtidens Bygg. Framtidens Byer along with Framtidens Bygg enables a pilot project team to have numerous of resources available. Today the program has some of Norway's best consultants within energy, transportation, materials and climate adjustment available for free use by the pilot projects. Framtidens Bygg stresses the importance that contractors are given a chance to prepare for changes that are already happening in the construction field. Additionally pilot projects have the opportunity to work closer with the municipality. The program considers the existing building mass to be important in their work towards reducing the GHG emission. Today, the building mass is not increasing drastically and there is a huge potential in present building mass for improvements. Framtidens Bygg requires all pilot projects to complete a GHG emission calculation of their project through klimagassregnskap.no. Additionally the program contributes to make a list of ambitions for each pilot project, which takes sustainability into account (Hansen 2014).

To achieve the measurements for Low Energy Class 1 is minimum requirement for the energy efficiency of retrofitted such as Stjernehus Borettslag. These are listed in Table 11-b, additionally there are requirements concerning efficiency of the ventilation and heat recovering systems too. Energy for heating should be provided by an alternative energy source that is not considered as direct energy sources. This could be renewable energy such as solar, heating pump or district heating(JM Norge AS 2014)

Standard	Heat loss number	Approximately needed
Low Energy Class 2	0.80 $W/m^2/K$	20cm wall insulation
Low Energy Class 1	0.65 $W/m^2/K$	25cm wall insulation
Passive House	0.50 $W/m^2/K$	35cm wall insulation

Table 10-a: Showing the approximately needed wall thickness to accomplish the standards (JM Norge AS 2014).

10.2.4 THE CITY OF KRISTIANSAND

The City of Kristiansand is involved in the retrofit of Stjernehus Borettslag both in connection with Framtidens Bygg and through the department of planning and development (Sandsmark 2014). Together with six other municipalities in the south of Norway, the city of Kristiansand has formed the plan “Klimaplanen”, which is a strategy for how the municipalities are going to get a GHG reduction of 30% by 2020 (Knutepunkt Sørlandet 2009). Initiatives such as participation in Framtidens Bygg, ENØK and a reduction in price for passive house building permits are done to achieve their goals within the construction sector (Sandsmark 2014).

10.2.5 ENOVA

Enova is a public participant that aims for a consumption and energy change in Norway and was involved already in the start up phase for Stjernehus Borettslag. They promote efficient energy use and increased production of renewable energy by supporting projects such as Stjernehus Borettslag. Enova distributes financial support to project, which can document saved, converted or generated clean energy. Their overall goal is to contribute to improve an energy efficient and renewable Norway, by developing solutions. This is to be done by testing new solutions, to gain experience and spread knowledge through illustration projects (Enova SF 2014).

10.2.6 HUSBANKEN

Husbanken is a government agency; they were involved in the early phase of the project. Their support was crucial, since they issue favorable loan to projects. The project needs to support their goals, which is to create buildings that meets future challenges, satisfy the needs of people with disadvantages and creates innovation within the construction sector (Husbanken 2014).

10.2.7 ENERGY CONSULTANT I & II

In the framework phase an energy consultant was engaged by SBBL to figure out the essential need of Stjernehus Borettslag. Summer of 2013 the second energy consultant Skogheim from Sweco was involved by Kruse Smith AS. In this case a good relationship and experience from previous collaboration with Kruse Smith AS, was most likely the reason why Skogheim was involved(Skogheim 2014).

10.2.8 SUB CONTRACTORS AND SUB SUPPLIERS

Cost and previous experience with sub contractors and suppliers are often the inputs used by Kruse Smith AS, to decide whom to use for a project. After the materials and the work from sub contractors are ordered, these are suppose to deliver according to the signed contract. If there are any modifications from the original contract, this needs to be confronted to the main contractor’s project manager (Ulstein, Skarpeid 2014).

10.2.9 WHEEL OF ORGANIZATIONAL MOTIVATION

To construct an understanding of the different participants' motivations in the retrofitting project, figure 11-c was made. Three questions were asked to construct the wheel; (1) what is the aim for this project, (2) why is this the aim (3) how is the aim going to be achieved? Information to make the Figure 11-a, was collected from interview, mail and web pages (see Appendix 2). Communication between participants both external and internal is crucial to avoid conflicting goals within a project, which again will be reflected in the decision-making process input and output. Sharing knowledge and information between participants in a decision-making process is important to achieve competent evaluation of various choice alternatives (Kørnøv, Christensen 2007). Hence, it is important to remember that various employees in the organizations can present bias towards the motivations of their organization. Thus, some of the participants have overlapping motivations; there are conflicting interests as well as shown in the "motivation wheel". The conflicting inter3ests are especially between private at public sector, which is to be expected. Because the public sector is founded by tax money and the sector is not concentrated in a competition context to earn profit. During the interview with the municipality employee, he assumed that the private sector had to be the main driver towards sustainable buildings (Sandsmark 2014). In the case of Stjernehus Borettslag the public sector is the main driver with the program Framtidens Bygg. This conflict in interest, could indicate that there is a conflict in who should take responsible, to ensure that the built environment accomplish a reduced negative impact on the environment.

Figure 10-b: This figure describes seven of the participant's aim for the project, why this is the aim and how they are going to achieve the aim.

10.3 “THAT'S A GARBAGE CAN PROCESS”

After all the process of Stjernehus Borettslag might not be exciting or exceptional from any other retrofit projects. But the logic of decision-making process as described in the garbage can model can be recognized. Quoting March on his description from when people realize the garbage can model in practice, taken from his interview in 2013 (Workiewicz, Dong 2013) *“meaning it's an understandable process in which things are connected by their simultaneous presence more than by anything else, even though they look all mixed-up.”*

10.3.1 OBSERVING DECISIONS

One can try to explain Stjernehus Borettslag as a result of numerous rational decision-making processes. But it is not to be mistaken for, that some of the decisions happened due to simultaneous presence of either problems, solutions, choices or participants. A decision can appear to be rational, and perhaps it is in the context of the available information for the decision-maker at the given time. Framtidens Bygg arranged a workshop in March, several organizations were present and the agenda were arranged. Yet, the discussion of how to plan for storm water drains in a sustainable fashion, winded up starting an argument concerning the Stjernehus Borettslag faced panels' esthetic qualities. This is typical according to professor Maister (2005), which has studied decision-processes in organizations. Meeting such as these, assume a common set of preferences and shared objectives in order to resolve problems, organizations often have conflicting goals, vague described preferences and several objectives. Thus, agenda topics drift off, and discussions concerning other aspects (than what is on the agenda) emerge.

The process of Stjernehus Borettslag is a unique process, even though there are some consistencies in how retrofit projects are done, there are disparities for each project. Kruse Smith AS has a manual for how to conduct decisions; the employees follow these procedures (Ulstein, Skarpeid 2014) .

Participation as shown in Figure 11-a can indicate that all actors are equally interested in the decisions, when they are involved in the process. Meanwhile the practice is usually depending on the participants' interest in the decision-making, this can be related to timing, personality and what sort of choices and issues are presented. How much energy participant devotes to the project is highly influencing the decision-making process. Sine there are many participants in the retrofitting of Stjernehus Borettslag and several decisions to be taken, many of the decisions are insignificant to many participants. Throughout the project there have been variations of devoted energy from participants to the project and the decisions, which is natural since the process develops and different evaluations needs to be performed. Maister (2005) explains if practice is going to change, participant need to offer a significant amount of energy to a decision process, which makes it difficult to adopt changes. In Stjernehus Borettslag the decision to be part of Framtidens Byer was evaluated and accepted by the various participant. It can perhaps be blamed on the late involvement in the program, that klimagassregnskap.no was never used as a tool to consider the GHG footprint of materials, but it can also implicate that this process went on as “normal”, since no participant allocated enough energy to change the process.

During the construction phase it was discovered that the original planned solution for the insulation between the basement and the first floor, was an inconvenient solution, due to all the basement storage rooms. This led to a second evaluation of the alternatives and it was decided to insulate the vestibule walls instead and increase the window's u-values. This decision was taken in accordance with project manager and energy consultant. During the interview this appeared to be a reasonable choice for both the project manager and the energy consultant, but no other choice alternatives were mentioned. When a project is under construction and time is essential, decision-makers have a tendency to act intuitively and less rational (Maister 2005). This means that less choice alternatives are evaluated, than in the planning phase.

Involvement in Framtidens Bygg by Stjernehus Borettslag was initiated by SBBL and then later Kruse Smith AS was encouraged by the municipality to contribute in the application process. Kristiansand Municipality recommend the retrofitting of Stjernehus Borettslag to the secretary and at last the decision by Framtidens Bygg to accept Stjernehus Borettslag as a pilot project was done in 2013 (Moen, Rønningen 2014). Kruse Smith AS listed a set of requirements that needed to be fulfilled if Stjernehus Borettslag were going to be a pilot project. This implicates that Kruse Smith AS also could have decided not to be part of Framtidens Bygg, if their requirements were not met. Furthermore the list of requirements also created a "third" choice alternative, which can be recognized as one of the two most common results of a decision-making process according to Cohen, March et. al (1972).

1. Kruse Smith AS cannot bear responsibility for ensuring that the program objectives are achieved (optimism is great though).
2. Kruse Smith AS does not bear the financial risks of changes that may be needed to achieve the program objectives, the choice of materials and solution principles in relation to the basis of our calculations and contract.
3. Kruse Smith AS get free counselor assistance, including training / education from the program in CO_2 calculation. We assume that this happens in Kristiansand and that we get to participate with unlimited participants within practical limits.
4. This also applies for necessary control documents, such as custom designed quality checks.
5. SBBL has started the work on an application / registration form and we assume that this work is completed and that our work is limited to information relating to our delivery.
6. We also assume that reporting does not fall on Kruse Smith AS alone, but that SBBL do this job. We will carry out information concerning our deliveries.
7. Energy Reporting required by both Enova and the Framtidens Bygg seem to be in connection to the grant from Enova and the responsibility is not with Kruse Smith AS.
8. We also assume that Kruse Smith AS can access profiling where the project is exposed.

Table 10-b: Requirements by Kruse Smith AS to the City of Kristiansand for their involvement in Framtidens Bygg.

"Pseudo resolution" is the result of a decision-making process, where all problems connected to the choice is removed to another choice. This is a decision style that transforms the original choice into a choice alternative that requires less effort. It is criticized to be an empty or a false decision, where the problem is not actually solved. Framtidens Bygg wants to spread environmental awareness among contractors and developers. The program contributes with their expertise for solutions and challenges for the pilot projects to reflect even more about sustainability than originally planned. The choice alternative taken by Kruse Smith AS implicates that the major difficulties; challenged by Framtidens Bygg will not be resolved during this retrofit project. This issue is a familiar ghost within decision-making theory; the major choices often resolve fewer problems, due to the difficulties connected to the problems. Results often become a "pseudo resolution" or "empty decision" according to the garbage can theory, which means that problems did not get resolved. Therefore easy choices, resolve more problems (Cohen, March et al. 1972).

10.3.2 IMPROVEMENTS IN DECISION MAKING

March, Cohen et al. gives suggestions of areas, where organizations could seek improvements to optimize a decision processes. Allocating resources to have participants gathering knowledge, and improve the information base can improve the decision results(Cohen, March et al. 1972). Participants have limited time and capacity, therefore they are only capable of allocating limited resources to a decision making process (Kørnøv, Christensen 2007). It is important to allocate resources to increase knowledge among participants in the early project phases. This will give a common understanding of the objectives for the project and perhaps generate more qualified choice alternatives by having a multidisciplinary collaboration. Not all participants in a project can have a detailed understanding of an environmental indicator tool such as Klimagassregnskap.no. But if the motive of the tool is conveyed to all participants, this will increase the environmental awareness in the project. Energy consultant Skogheim is familiar with the concepts of Framtidens Bygg, but he does not feel that the program has made an impact on his role for the project (Skogheim 2014). Observing Stjernehus Borettslag, Klimagassregnskap.no is used more as tool for documentation. Several of the participants is not involved in the process of klimagassregnskap.no. The calculation is mainly performed as a part of this thesis, and therefore is partly done after the materials were chosen. Due to the project strict budget, there has been a limited room for choices. Organizational structure is an important factor that impacts both the decision-making process and its ability to include environmental aspects (Kørnøv, Christensen 2007). Not all of the participants have access to contribute in the decision-making process; the organizational decision structure can be recognized as segmented. Having a structure that supports a nature of open communication is essential. A structure that supports confrontation between rationalities can contribute to increase the environmental aspects of a project from an early planning phase, but only if the participants are concerned and well informed about the environmental challenges. Hansen from Framtidens Bygg has encouraged to multidisciplinary cooperation from the beginning in order to achieve good quality. Additionally, Hansen believe it is crucial to have a positive contractor that is willing to transfer knowledge further on to their sub contractors (Hansen 2014). This indicates that Framtidens Bygg is interested in an unsegmented organizational decision structure, where several participants from different organizations can contribute in the decision-making process. A segmented decision structure will according to the garbage can model increase the amount of problem activity, even though the latency of problems decreases. Overall this can affect that efficiency of the decisions process and it is suggested that the number of solved problems would increase with an unsegment decision structure.

David Collingridge (1980) is often quoted when the time is essential for the decision consequences. He wrote “When change is easy, the need for it cannot be foreseen; when the need is apparent, change has become expensive, difficult and time consuming” (Collingridge 1980). Under what circumstances the decision is done can be crucial for the evaluated alternatives and their consequences. There are different processes for how a decision is performed in various project phases, such as during the planning and construction. Decisions done in an early stage of the project are often considered to be more constructive according to Skogheim. Since there is more time available and there is room to involve different actors, which leads to more choice alternatives can be explored. In a later project phase times is often crucial and the situation is fixed, which means less alternatives can be evaluated than in the planning phase when the setting is more open. Overall, Skogheim’s experience from other projects indicates that the sooner a decision is done, the more resources can be allocated to perform the decision process (Skogheim 2014). This indicates that environmental aspects should be taken into consideration in an early project phase in order to avoid expenses and difficulties. It is suggested to act discreetly in order to accomplish a change, if klimagassregnskap.no was to be included as a tool for evaluation of materials. It perhaps should have been introduced by a participant using an unobtrusively approach, to avoid fear from other participants. Instead of giving all participants a report showing the projects GHG emissions, in the end of the project, which include GHG emission from all three field included in klimagassregnskap.no; energy, materials and transportation. Giving them an example of reduction of GHG for just their field of expertise, could perhaps add knowledge and change in their decision-making pattern. Lets say the project manager would get an overview of window products GHG emission before he ordered windows.

Since the decision process is a result of random streams active at the given time, persistence is an important factor. Even though the GHG footprint of materials was not evaluated before they were ordered for this project, there is a chance to include this in the nest project. Since the second decision will be at a different time, perhaps including some different participants, problems and solutions. Cohen, March et al. (1972) warns that organizations should not be overloaded with projects. This will result in that some projects will achieve little attention, and instead of having a few good projects, an organization will have many less good projects. In the case of Stjernehus Borettslag the retrofit project received much attention by the contractor and the developer, and does not seem to be an “overloaded” project.

Hence, there are procedures and manuals for how a decision-making process is to be performed in Kruse Smith AS. But the garbage can model stresses that the reality does not exist in a stable environment and therefore these procedures are not to be dependable at all time. Employees should be aware of the non-consequential logic of decision-making, in order to act in the organizations best interest, the essential of this logic is listed in Chapter 9.

So, why did the GHG calculation in klimagassregnskap.no not achieve a 50% reduction from the designed to the reference building? Interpreting and writing history is provided as one of the major potentials for improvement of a decision-making process. It is stressed that history should not be interpreted before a time after the project, since opposition can arise if it is done to early. Meanwhile time will often accept the real history (Cohen, March et al. 1972). This makes perfect sense for the case of Stjernehus Borettslag, and might generate decisions, which can reduce the GHG emission even more for future projects.

10.4 KLIMAGASSREGNSKAP.NO AS AN INPUT IN DECISION MAKING

There are several environmental indicators developed to calculate the GHG from projects and contribute to organizational decision-making processes. These are often used as a tool for comparison, identification of potential, verification, and communication (Jasch 2000). Tools such as klimagassregnskap.no can have different purposes depending on the intention of applying the tool.

10.4.1 PROBLEMS AND SOLUTIONS

Framtidens Bygg requires their pilot projects to use a tool, which gives them the consequences of their actions. It identifies hot spots and makes the construction sector aware of the environmental impacts caused by their actions.
Meanwhile the City of Chicago, provides developers with a excel spreadsheet, called Chicago Green Home Checklist. Which is an example of a tool that provides a set of solutions and invites the construction sector to act sustainable. This checklist determines if the project is qualified to be a part of the Chicago Green Homes Program. Moreover, they have published a Chicago Green Homes Guide, which intent to provide a framework for how to reduce negative environmental impacts from buildings (Chicago Green Homes 2009).

Framtidens Bygg has visions to reduce the GHG emissions in 13 Norwegian cities and to develop strategies that can face future climate changes. Furthermore Framtidens Bygg wants to improve the cities, in regards to ecology, safety, health, experiences and business activities (Moe 2012). The question is if klimagassregnskap.no reflects the interest of Framtidens Bygg, or if it is just a partial tool that has to be supplemented with other tools and guidelines.

10.4.2 THREE PILLARS IN SUSTAINABILITY

Project manager Ulstein and accountant Skarpeid from Kruse Smith AS explained that a tool such as kimagassregnskap.no could be an integrated part of a decision making process. But to do so, it needs to be a preference from the developer. It is expected that using a tool such as this in the decision-making process would increase the project cost both by the resources allocated to perform the calculation and to modify the solutions. Today, the project manager and the accountant explains that there is not a market where the contractor can demand the developer to add a 2% extra cost, in order to accomplish a more sustainable building (Ulstein, Skarpeid 2014). If klimagassregnskap.no is to be integrated in the planning phase, as a base for decisions making, it could be argued that it does not take economic aspects of sustainability into account. Hansen recognize the importance of a pilot projects being financial realistic, even though klimagassregnskap.no do not take any economic measures into account (Hansen 2014).

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CONCLUSION

ENVIRONMENTAL IMPACT OF STJERNEHUS BORETTSLAG SHOWN BY KLIMAGASSREGNSKAP.NO

Klimagassregnskap.no shows an impact of 25,2 kg CO^2-eq/m2/year for the retrofit project. This accounts for the added materials and transportation and energy use when the building is operated. The result is based on both specified collected data and the database in egassregnskap.no. Moreover the result holds uncertainties, and is therefore tested for sensitivity in chapter 8.5, by using a recommended percentage change. The sensitivity test shows very different values and it is therefore difficult to determine the significance of the actual result. It is recommended to evaluate these percentage changes to determine if they have any affect on how the result is evaluated.

Moreover, gassregnskap.no gives a limited environmental impact of the projects. There are aspects of the module's life cycles that are not taken into account, such as the transportation of material to construction site. Additionally there are modules not considered at all such as the construction phase.

HOW TO USE KLIMAGASSREGNSKAP.NO TO CONSTRUCT DECISIONS

There are complications relaying on the results from the tool as guide for action. A mix of generic and specific data is used in the calculation of the energy and transportation modules. For the material module, exact data measures for material used in Stjernehus Borettslag is calculated, together with specific product data integrated in klimagassregnskap.no. There are several different data sources that indicate that there are differences in the used method for data collection. It can be complicated to use a result from such a nonspecific calculation as a guideline for a specific project. Aspects such as local production and used technology for production are not taken into account in klimagassregnskap.no. These aspects can be significant for the GHG emission of materials. Hence, it can be recommended to use klimagassregnskap.no, as a base for discussion in the early project phase. While calculating the GHG in a later project phase, when the evaluations and the choice of alternatives are done, hardly make any sense, Klimagassregnskap.no demands little data specifics, and can be used as weighting tool for alternatives in the early project phase. If a solution achieves a significant GHG reduction in klimagassregnskap.no, the reason should be investigated and evaluated. A suggestion would be to arrange a collaborative workshop where materials were decided and klimagassregnskap.no were used as an input for decision, but not as an overriding factor. This workshop could include project manager (ordering materials), accountant (considering economic aspects) and a "klimagassregnskap.no" expert such as an environmental manager. It is necessary to have at least one participant with a complete understanding of klimagassregnskap.no, in order to use it as an efficient input for decision-making.

POTENTIAL FOR KLIMAGASSREGNSKAP.NO

The fact that the calculator is a free web based tool and being constantly developed, makes it very attractive. But the construction sector needs to use the calculator and resources should be allocated to improve the calculator. Klimagassregnskap.no could be the future platform for reduction of GHG emission within the Norwegian construction sector. The calculator is already using specific data from actual supplier in the material module; an idea would be to have more specific products added to the tool. Particularly should the tool include products used by the Norwegian construction sector. These could be presented with the product name and supplier, and would perhaps generate a "green" competition amongst suppliers. Another possibility for the tool is to recommend solutions for sustainable construction instead of only showing the consequences. Pilot projects in Framtidens Bygg are supposed to accomplish new solutions that are energy and resource efficient. Solutions that already exist for this could be promoted through klimagassregnskap.no. In order to create a perfect tool to support sustainable construction, Framtidens Bygg should study what would engage the participants, and how their decision making processes can be influenced.

POTENTIAL IN RETROFIT PROJECTS

Kruse Smith AS has obtained a niche competence in retrofitting. They are a leading contractor in the filed, and are fulfilling the customers' demands. Yet, it is difficult to plan for results of decision-making processes, according to the garage can model. Procedures and motivations are essential for the result of decision-making process. But the underlying randomness that influences a process should most likely be stressed equally, to explain a result.

IMPROVE THE DECISION-MAKING PROCESS AND RECOGNIZE CHALLENGES

To optimize a result of a decision, one should include the "right" participants in the decision-making processes. This could be done by having a unsegment decision structure, where more participant could be informed of the choice opportunities, and perhaps more qualified solutions would appear. Problems latency is another aspect that should be recognized in an organization, since important problems should be resolved sooner than later. And it is important to strive for a decision style that resolves organizational problems. If not problems have a tendency to accrue later on, when they have become more expensive and difficult to resolve.

In retrofit project there are already a starting point, which can be problematic in regards to construct energy effect design sustainable. Since the bearing structure is often kept and the designers need to fit the solutions to the structure. Efficient solutions are essential and for a contractor it is therefore important to obtain good relationships with suppliers and designers in order to deliver the best retrofit. Residents of Stjernehus Borettslag invested a significant amount of money in the project. This was necessary to achieve the wanted results and Kruse Smith AS also allocated much time to lower the project cost and find cost efficient solutions. But, the challenge with retrofitting is initially the high cost, considering that the cost is between 20-40% of the apartments market value. It is hard to balance the three pillars in sustainable for retrofit projects.

There is a need for a paradigm shift in the construction sector, Sustainia (2012) claims it is already happening. Others such as Randers (2012) express concerns over the changes are happening to slow. The garbage can model explains that change is difficult and hard to achieve within organizations. So, who should make sure the change is pursued? Kruse Smith AS does recognize their responsibility to contribute lower the negative environmental impact (Kruse Smith AS 2014) Subsequently the municipality counts on the market and the private sector to act more sustainable. Summed up the government has set the goal to achieve a reduction of GHG. And this should be reflected in relevant regulations and be an implemented part of the bureaucratic process. Some already is, but again the process of change is most likley going to slow. In order to create a perfect tool to support sustainable construction, Framtidens Bygg should study what would engage the participants, and how their decision making processes can be influenced.
Lastly, interpretation of history can contribute to increased knowledge and competence within an organization. By interpreting decisions taken in the process for Stjernehus Borettslag retrofitting, future projects process can be improved.

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REFLECTIONS

The goal for this thesis was to gain insight in a construction project, and investigate current considerations taken regarding environmental impact and evaluate opportunities for improvements. In the case study of Stjernehus Borettslag, this was possible and the collaboration with Kruse Smith AS, was a positive experience.

Since the calculation of the GHG emission from Stjernehus Borettslag is a required component for all pilot projects, this thesis could contribute to the project process. The calculation did not achieve a 50% reduction from the deigned building model to the reference-building model for this report. But since other retrofit projects have achieved a 50% reduction, it is most likely possible. If more detailed data is collected to make the calculation more realistic the reduction could be increased. One action to improve the GHG calculation could be to document the resident's transportation habits by doing the survey (Appendix 1). This would give specified data, which perhaps could improve the transportation module. However, the result makes a base for discussion and an understanding of the tool and its application area was attained. Including the calculation in the thesis project also allowed an insight in the Norwegian governmental initiatives to reduce the negative environmental impact in the construction sector.

If the study were to continue, aspect that could have been interesting to study in regards to klimagassregnskap.no:

(1) Do a comparison of a pervious done calculation for a retrofit project in klimagassregnskap.no

(2) Compare the material module result, with values from Environmental Product Declarations (EPD) of the actually used products; to investigate the accuracy of the tool's material module.

The second part of the report concerning decision-making processes in organizations, have been a hermeneutic experience. To use a theory such as the garbage can model to understand the real life decision processes, have been both difficult and helpful. The latter, was more understood in final part of the project, because the knowledge base improved with the project time. The hermeneutic spiral was also recognized when qualitative data was collected. After interviews or meetings it was often needed to send a follow up email. Sometimes it was too late to get answers to wanted information. In general the investigation of the decision-making process shows that there are complications for changes to be accepted in an organization. Klimagassregnskap.no was not used to evaluate the materials used for the retrofitting of Stjernehus Borettslag. Aspects that could have been interesting to studied further more in relation to decision-making processes:

(3) Investigate what actions should be used to implement the environmental impact of a project, into the decision-making process in Kruse Smith AS's.

(4) Considered what are the conflicts and opportunities between economy and environment in the construction sector.

Finally, I would like to mention that I appreciated all knowledge I have attained while undertaking this project. And I am grateful for all the interesting actors I got a chance to meet.

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APPENDIX

APPENDIX 1: SURVEY: for data collection to the transportation module in klimagassregnskap.no

APPENDIX 2: LIST OF PARTICIPANTS & EVENTS

APPENDIX 3: WORKSHOP PARTICIPANT LIST

APPENDIX 4: WORK SHOP DRAWINGS

APPENDIX 5: AUDIO RECORDS:
- a) Meeting in Oslo Selvig and Rønningen
- b) Interview Ulstein and Skarpeid
- c) Interview Sandsmark

APPENDIX 6: INTERVIEW GUIDES:
- a) Ulstein and Skarpeid
- b) Skogheim
- c) Sandsmark
- d) To construct Figure 10-b "Motivation wheel"
- e) Framtidens Bygg

APPENDIX 7: MEASUREMENTS: for the material module in klimagassregnskap.no

APPENDIX 8: DATA BASE: for the material module in klimagassregnskap.no

APPENDIX 9: SIMIEN: calculations done by energy consultant

APPENDIX 10: KLIMAGASSREGNSKAP.NO CALCULATIONS
- a) Existing Building
- b) Reference Building
- c) Retrofit Building

SPØRREUNDERSØKELSE FOR KOBBERVEIEN 20

1. Hva er din alder?

☐ 0-12 ☐ 13-18 ☐ 19-25 ☐ 26-35 ☐ 36-45 ☐ 46-65 ☐ 66-85 ☐ 86-1

2.Hva stemte du under general forsamlingen for renoverings prosjektet og hva var årsaken?

☐ Stemte ikke
☐ NEI, det er en dyr investering
☐ NEI, ser ikke behovet for oppgradering
☐ NEI, grunnet annet (spesifiser under)
____

☐ JA, ser et behov for økt komfort
☐ JA, det er en økonomisk investering
☐ JA, grunnet annnet (spesifiser unde
____

3.Har du daglige gjøremål som krever at du bruker et transportmiddel?
(Eksempelvis studier, jobb andre avtaler etc.)

☐ JA ☐ NEI

4 Dersom ja, hvilke transport middel bruker du mest?
Prioriter fra mest brukt (1) til minst brukt (5)

__ Bil
__ Sykkel
__ Kollektivtransport
__ Gange
__ Annet (spesifiser under)
____

5.Hva er årsaken til at du hadde den fordelingen (fra spørsmål nr.3) på hvilket transportmiddel du bruker? (Eksempelvis bus/bil etc. er lettes tilegnelig for meg og jeg har ikke sykkel)

6. Hvor mange personer bor i din husstand?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7

7. Hvor mange biler har din husstand totalt?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

8.Hvor ofte bruker du bil?

☐ Aldri
☐ Mindre enn 1 ganger/uke
☐ 1-2 ganger/uke
☐ 3-5 ganger/uke
☐ 6-7 ganger/uke
☐ Mer enn 7 ganger/uke

9. Dersom du bruker bil, hva er den viktigste årsak til at du bruker bilen?

10. Hvordan vil du beskrive den eksisterende gang- og sykkelveien som er tilgjengelig fra din bolig?

☐ Svært Bra ☐ Bra ☐ Helt Grei ☐ Mindre Bra ☐ Dårlig

☐ Svært Dårlig ☐ Ubrukelig

11.Hva skal til for at du bruker sykkel eller gange som et mer hyppig transportmiddel?

NAME	POSITION	DATA COLLECTED
Svein Erik Bjorvand	Architect: Spiss Arkitektur & Plan AS	Mail for Figure 10-b "motivation wheel" Workshop 25.03.2014
Frank Eikeland	Kruse Smith	Meeting 30.04.2014
Øyvind Jensen	Project Manager: Kruse Smith AS	Skype Meeting Meeting 31.04.2014 Other Meetings Workshop 25.03.2014 Mail Correspondences
Lisbeth Lunden	HOA: Resident	Mail Correspondences Workshop 25.03.2014
Odd Helge Moen	Representing: SBBL on behalf of Stjernehus Borettslag	Mail Correspondences "Meeting 08.04.2014 Mail for Figure 10- b "motivation wheel" Workshop 22. 03.2014
Olav Rønningen	Environmental Manager: Kruse Smith AS	Mail Correspondences Skype Meetings Other Meetings Meeting 06.01.2014 Workshop 25.03.2014 Mail for Figure 10- b "motivation wheel"
Torstein Sarpeid	Accounted: Kruse Smith AS	Interview 06.04.2014
Erik Sandsmark	Kristiansand Kommune	Interview 21.05.2014 Workshop 25.03.2014
Eivind Torsvik	Trainee: Kruse Smith AS	Meeting 25.04.2014 Meeting 29.04.2014
Håkon Skogheim	Energy Consultant: Sweco	Interview 02.04.2014
Vibeke Ulstein	Project Manager: Kruse Smith AS	Interview 06.04.2014 Meeting 04.25.2014
Øystein Bull	Architect: Fremtidens Bygg	Mail interview 05.07.2014 Workshop 03.25.2014

FRAMTIDENS BYGG

Framtidens Bygg, Oppstartseminar i Kristiansand

Tid: **Tirsdag 25. Mars 2014**
Sted: Kristiansand, Grønt senter, Sjølystveien 5

08.30: Frokost

09.15 - 10.00:
Velkommen av Erik Sandsmark, Kristiansand kommune.
Kort introduksjon: Framtidens byer, Øystein Bull-Hansen, Barbara Hasenmüller
Kort intro og status (10-15min) Stjernehuset, Odd Helge Moen
Kort intro og status (10-15min) Bjørndalen, Ole Morten Helland

10.00 - 10.15: Drøfting, spørsmål

10.15 - 11.00:
Pål Sørensen, Vista Utredning. Tema: Transport og parkeringsbehov.
Klarer vi å halvere utslipp fra transport?

11.00 - 11.15: Pause

11.15 - 12.15: Workshop med Pål Sørensen og Øystein Bull-Hansen (NAL)

12.15 - 12.45: Lunsj

12.45 – 14.15: Elin Enlid, Civitas: Klimagassregnskap. Foredrag og workshop.

14.15 – 14.30: Pause

14.30 – 15.15:
Nina Astrid Rieck, Asplan Viak Trondheim og Espen Evensen Reinfjord, Asplan Viak Arendal.
Tema: Lokalklima Kristiansand.
Vind
Det sosiale uterom
Utnyttelse av bekken gjennom området. Fordeler og ulemper
Kuldedrenering av daldraget i forhold til støyskjerming mot E18.

15.15 – 16.30: Workshop med Nina Astrid Rieck og Espen Evensen Reinfjord.

16.30: Avslutning

Workshop: Hvert prosjekt jobber individuelt med én rådgiver. Workshopen er delt i to og gruppene bytter halvveis.

Alle prosjekter deltar (prosjekterende og interesserte) og oppfordres til å ta med arbeidsunderlag (planer, beskrivelser, data etc. av prosjektet)

Norske arkitekters landsforbund FRAMTIDENS BYER lavenergi programmet

FRAMTIDENS BYGG

Deltagerliste:

Fra Bjørndalen:
Ole Morten Helland, Skanska Bolig, ole-morten.helland@skanska.no
Karina Martin, Skanska Bolig
Andrea Buijs, Skanska Bolig

Fra Stjernehuset:
Odd Helge Moen, Sørlandet Boligbyggelag, ohm@sorbbl.no
Øyvind Jensen, Olav Rønningen, Kruse Smith Entreprenør, oyvind.jensen@kruse-smith.no,
Jenny Josefine Holen, Masterstudent, jholen12@student.aau.dk
Svein Erik Bjorvand, arkitekt, Spiss Arkitektur&Plan AS, seb@spissark.no
Sven Arild Bransdal, Styreleder
Lisbeth Lunden, Styremedlem
Frøydis Lind, Styremedlem

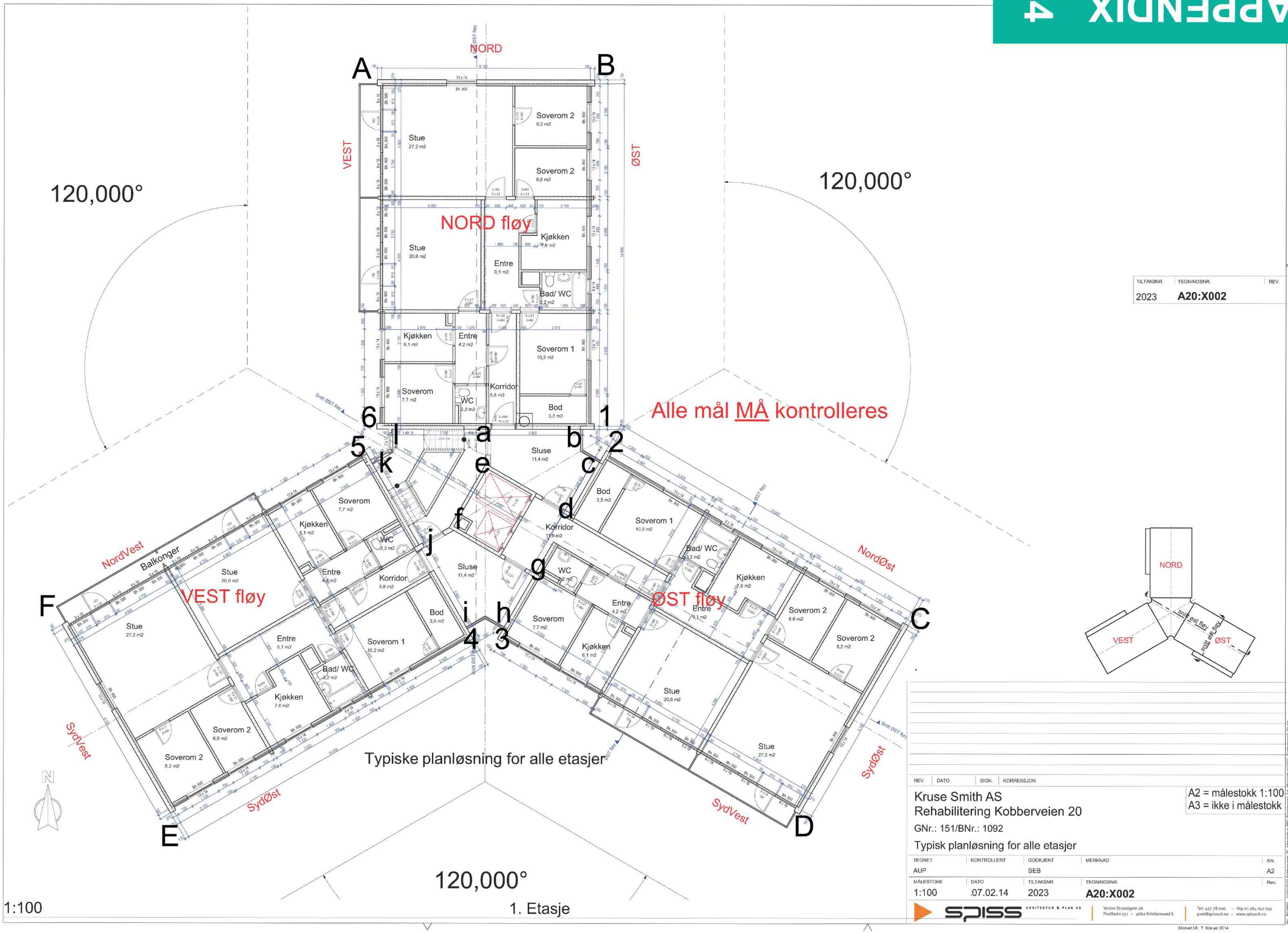
Fra Kristiansand kommune:
Ålaug Rosseland, Plan-, bygg- og oppmålingsetaten
Raimond Oseland, By- og samfunnsenheten
Christen Egeland, By- og samfunnsenheten (bare første del)
Marit Eik, By- og samfunnsenheten
Jon Holt, Kristiansand Eiendom
Gro Solaas, Ingeniørvesenet (bare første del)

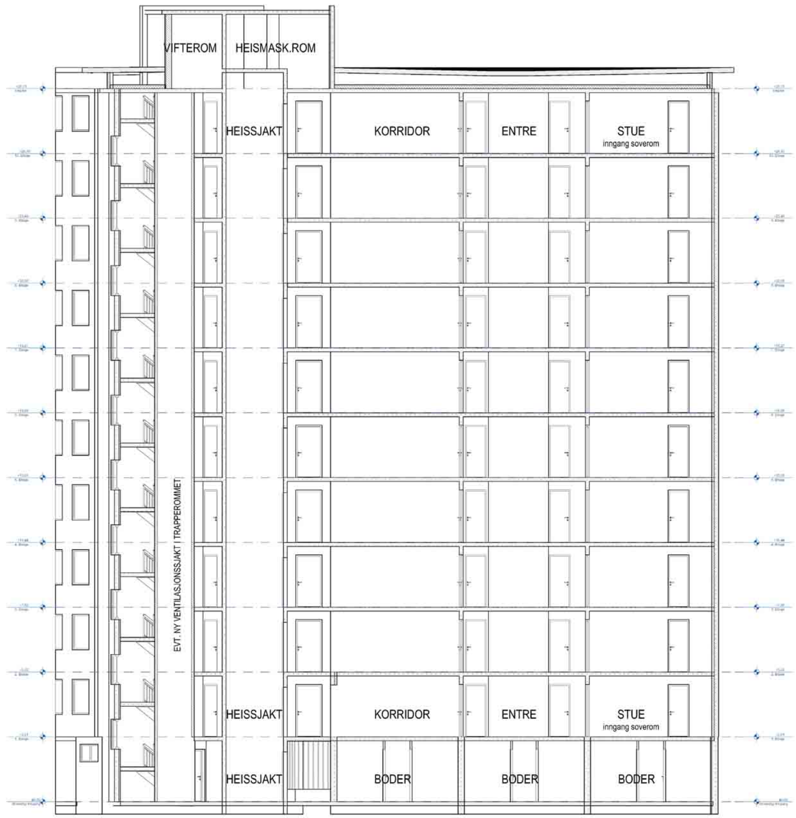
Gjest:
Johanna F. Guldager, Arkitekt/ byplanlegger, Haugesund kommune, Enhet for byutvikling, johanna.ferrer.guldager@haugesund.kommune.no

Tilknyttet Framtidens Bygg:
Erik Sandsmark, Kr. K. erik.sandsmark@kristiansand.kommune.no
Øystein Bull-Hansen, NAL - Framtidens Bygg, Prosjektleder, obh@arkitektur.no
Barbara Hasenmüller, NAL - Framtidens Bygg, Hovedkontakt Kristiansand, bch@arkitektur.no
Elin Enlid, Civitas, Klimagassregnskap.no, elin.enlid@civitas.no
Nina Astrid Riek, Asplan Viak Trondheim, nina.rieck@asplanviak.no
Espen Evensen Reinfjord, Asplan Viak Arendal, espenevensen.reinfjord@asplanviak.no
Paal Sørensen, Vista Utredning Oslo, paal.sorensen@vistautredning.no

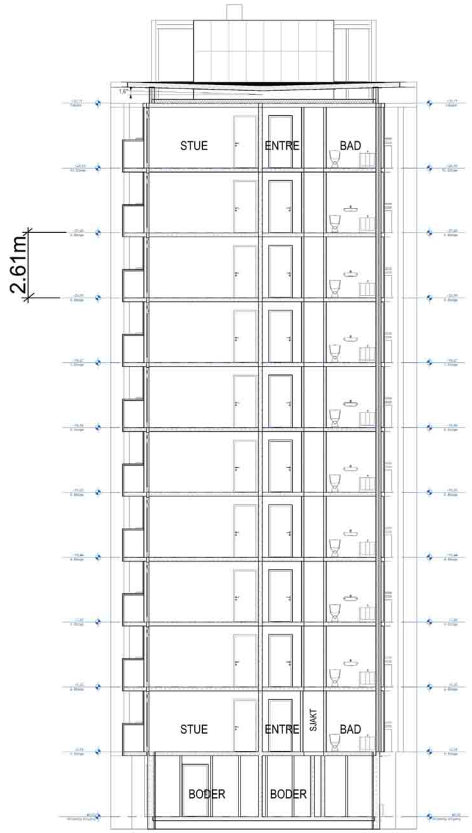
Norske arkitekters landsforbund FRAMTIDENS BYER

APPENDIX 3


NORD
VEST
ØST
NORD fløy
VEST fløy
ØST fløy
Alle mål MÅ kontrolleres
Typiske planløsning for alle etasjer
120,000°
120,000°
120,000°
NordVest
Balkonger
SydVest
SydØst
NordØst
SydVest
SydØst
Stue 27,2 m2
Stue 20,6 m2
Soverom 2 8,2 m2
Soverom 2 6,6 m2
Kjøkken 7,6 m2
Entre 9,1 m2
Bad/ WC 3,2 m2
Kjøkken 6,1 m2
Entre 4,2 m2
Soverom 1 10,2 m2
Soverom 7,7 m2
WC 2,2 m2
Korridor 5,8 m2
Bod 3,2 m2
Bod 3,5 m2
Sluse 11,4 m2
Korridor 11,0 m2
A B C D E F
1 2 3 4 5 6
a b c d e f g h i j k l
1:100
1. Etasje
TILTAKSNR. 2023
TEGNINGSNR. A20:X002
REV.
Kruse Smith AS
Rehabilitering Kobberveien 20
GNr.: 151/BNr.: 1092
Typisk planløsning for alle etasjer
A2 = målestokk 1:100
A3 = ikke i målestokk
TEGNET AUP
KONTROLLERT
GODKJENT SEB
MERKNAD
Ark. A2
MÅLESTOKK 1:100
DATO 07.02.14
TILTAKSNR. 2023
TEGNINGSNR. A20:X002
Rev.
SPISS ARKITEKTUR & PLAN AS
Vestre Strandgate 26
Postboks 151 – 4662 Kristiansand S
Skrevet Ut: 7. februar 2014



1:100 Snitt ØST fløy



1:100 ØST fløy

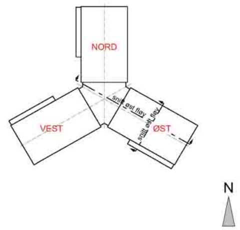
Øst fløy, langsnitt og tverrsnitt

TILTAKSNR. 2023

TEGNINGSNR. A40:Ø001

REV.

ARK



A2L = målestokk 1:100
A3 = 1:200

REV.	DATO	SIGN.	KORREKSJON

Kruse Smith AS
Rehabilitering Kobberveien 20
GNr.: 151/BNr.: 1092
Øst fløy, langsnitt og tverrsnitt

TEGNET	KONTROLLERT	GODKJENT	MERKNAD	Ark.
AUP		SEB		A2
MÅLESTOKK	DATO	TILTAKSNR.	TEGNINGSNR.	Rev.
1:100	07.02.14	2023	A40:Ø001	

SPISS

APPENDIX 4

Interview with employees in Kruse Smith AS:

Vibeke Ulstein (Project Manager)
Torgeir Skarpeid (Accountant)

Introduction

What is your title as an employee in Kruse Smith AS?

What is your main reaponisbility/tasks as an empolyee in Kruse Smith AS?

What are the main types of projects you are involved in?

How many projects are you normally involved in at the same time?

Have you been involved in energy retrofit projects before?

Stjernehus Borettslag // Kobberveien 20

1. What was the first step for the retrofit project of Stjernehus Borettslag?

ECONOMY

2. How was the economical profit from the project calculated?
3. Who were the involved participants in calculating the project?

RETROFIT PROJECTS

4. What are the main reasons that Kruse Smith AS offers the services of energy retrofit?
5. Who made the decision to apply for being a part of the program Fremtidens Bygg (FB) for Stjernehus Borettslag?
6. What was the motivation for Kruse Smith AS for being a part of the program FB?
7. Who are the involved stakeholders in energy retrofit projects such Stjernehus Borettslag?
8. What is the role of the municipality in Kristiansand in regards to this project?
9. Can you list all the stakeholders/participants
10. Are there any significant differences when energy efficiency is stressed in retrofit projects versus a normal retrofit?
11. Can you recall any specific lessons learned form past energy retrofit projects, especially concerning decisions made?

Decision Making Process for Kobberveien 20

12. Does Kruse Smith AS have a policy of how a decision making process should be preformed (Both for major and minor decisions)?
13. What would you consider to be important decisions to be made for this project?

- Who would be the participant(s) involved in a major decision process for this project?

14. What would you considered less important decisions to be made for this project?

- Who would be the participant(s) involved in a less important decision process or this project?

15. Do you notice a difference from decisions done in advance of a project versus the once done when the project is on going?
16. How is the key person of a retrofit project to make contracts with suppliers?
17. How does Kruse Smith AS make the decision of which supplier to use for a project?
18. Is the process of ordering materials for energy retrofit projects any different from a normal retrofit (or any other construction) projects?
19. Regarding the decision process for energy retrofit within the firm are there any decisions/processes that are more complicated to handle than in other projects?

Tools such as klimgassregnskap.no, calculate the total GHG footprint of a project. Which means that resource efficiency is stressed, and one can compare materials and see which has less impact on the environment.

20. Do you see any potential for tools such as this for being implemented in the decision-making process for a project such as this?

FINALLY

21. What do you see as the benefits and drawbacks with buildings being energy retrofitted?

Spørsmål til Energikonsulent Håkon Skogheim

Svarene skal brukes som input i en Masteroppgave 2014, hvor Stjernehus Blokken i Kristiansand er et 'case study'. Spørsmålene er laget av masterstudent innenfor Miljøledelse og Bæredyktighet Jenny Josefine Holen fra Aalborg Universitet, kontaktes på email: jholen12@student.aau.dk eller tlf: 938 29 848.

Introduksjon

I. Hva er din stilling i Sweco?

II. Når ble du involvert i rehabiliteringen av Stjernehusblokka?

III. Hva er dine hovedoppgaver i forhold til rehabiliteringen av Stjernehusblokka?

IV. Hva er som oftest grunnen til at du blir valgt som energikonsulent for prosjekter, slik som Stjernehus?

V. Hvilken aktører har du kontakt med i Stjernehus prosjektet? Eksempelvis byggherre, entreprenør, arkitekt, kommune, bank, underleverandører etc.

Avgjørelses prosesser

1. Når en SIMIEN beregning blir gjort for et rehabiliterings prosjekt er det noen vesentlig forskjeller fra når det blir gjort for et nybygg?

2. Beregningen i SIMIEN blir brukt til å bestemme energi kvaliteter til materialer for Stjernehusbokken, har du noen innvirkning på hvilken materialer som blir valgt uten om deres energi kvaliteter?

3. Fremtidens Byer er et statlig program som fokuserer blant annet på klimautslipp, kjenner du til dette programmet?

   - Dersom ja, føler du at Stjernehus prosjektets deltakelse i Fremtidens Byer, har hatt noen innvirkning på din rolle eller dine oppgaver som energikonsulent for Stjernehus prosjektet?

4. Materialers miljøbelastning er fokusert mye på i programmer slik som BREAM og Femtidens Byer. Hvordan ser du for deg klimagassutslipp fra materialer kan reduseres i et prosjekt slik som Stjernehus?

5. Sett bort fra avgjørelser som har med resultat fra SIMIENE beregningen å gjøre, er det andre avgjørelses prosesser du er med på å påvirke i Stjernehus prosjektet?
   - Dersom ja, hvilken påvirkning forventer du dine avgjørelser har på andre aktørers videre avgjørelser eller alternativer i prosjektet?

6. Ser du noen forskjeller på (1) tid brukt, (2) antall eller hvilke personer involvert, (3) antall alternativer vurdert for en avgjørelse som blir tatt i planleggingsfasen versus en som blir tatt etter igangsetting av prosjektet?

7. Har du noen eksempler på avgjørelser som har måttet endres underveis i Stjernehus?
   - Dersom ja, var prosessen for hvordan avgjørelsen ble tatt, annerledes andre gang enn førstegang den ble tatt? (igjen med hensyn til tid brukt, antalla/hvilke personer involvert, antall alternativer vurdert)

Spørsmål til Representant fra Kristiansand Kommune

Hva er din stilling i Kommunen?
Prosjektleder framtidens byer

Stjernehus

Når ble kommunen engasjert i renoverings prosjektet ?

Hva er kommunens rolle i forhold til rehabiliteringen av Stjernehus Borettslag (både i forhold til framtidens Bygg og som saksbehandler)?

Hvilken deltakere av prosjektet har kommunen kommunikasjonen med (ex: Kruse Smith, beboere, SBBL) ?

Framtidens bygg

Hva har kommunen å si forhold til hvilken prosjekter som blir valgt til å være en del av Framtidens Bygg?

Hva er kommunens ansvarsområdet i forhold til Framtidens Bygg?

Hva forventer kommunen av prosjekter som er med i Fremtidens Byer i forhold til hvordan avgjørelser skal tas i prosjekterer (er det noen spesielle hensyn som skal tas)?

Genereltmiljø

Har Kristiansand Kommune noen spesifikk mål for å oppnå klimagass reduksjon innen for eksistrenede byggmasse og ny bygg?

Oppfølging
Dersom ja: Hvordan skal dere nå målet/målene?

Dersom nei: Har Kristiansand Kommune andre initiativer (tillegg til Framtidens Bygg) som promotere mer miljøvennlig bygg?

Eksempler: Har dere sett noen virkninger av initiativ dere har gjort her i kommune eller andre kommuner har gjort i forhold til klimagassutslipp?

Til info: Framtidens Bygg tilbyr verktøyet klimagassregnkap.no, dette verktøyet viser brukeren/ entreprenøren konsekvensene av sine handlinger i form av CO2 utslipp.

Har kommunen tenkt på andre metoder for å bevisstgjøre bygge bransjen på miljø påvirkningene deres? (mulighet/løsnings verktøy en annen tilnærming)

Oppfølgingsspørsmål: hva kan du se for deg hadde vært et bra verktøy for å gjøre bygge bransjen mer bevist på deres miljøpåvirkninger?

Hvem tror du er den viktigste aktøren for å kunne reduser miljøbelastninger fra bygge bransjen? (kommunen, staten, entreprenøren, underleverandører, kunder)

Oppfølgingsspørsmål: Hvordan skal man få til å redusere klimagasser fra bygge bransjen hvilken aktører må aktiviseres (både nybygg og eksisterende)?

Hvordan ser du for deg at byggesektoren skal kunne [illegible] reglement, kunder krever det…etc.)

Avgjørelser i byggeprosessen

Merker du noen forskjeller fra avgjørelser som er gjort i planleggingsfasen enn avgjørelser som er gjort under eller etter et prosjekt ?

Har du erfart at prosjekter som er en del av Fremtidens Byer har enn vanskeligere, lettere eller annerledes prosess i forhold til andre prosjekter, med å ta prosjektavgjørelser?

Hvilken rolle har framtidens Bygg når det gjelder å være med på avgjørelser i pilotprosjekter?

Klimagassregnskap.no

Hvordan forventer du at prosjektteamet bruker klimgassregnskap.no?

Erfarer du at klimagassregnskap.no brukes som forventet?

Hva ser du som fordeler og ulemper med at et bygg blir energirenovert?

To make Figure 10-b

Question guide:

1) What is the organizations goal for this project?
2) Why is this the aim?
3) How is the organization going to achieve the goal?

Data collected from:

- CITY OF KRISTIANSAND: During Interview with Erik Sandsmark
- ENOVA/ FRAMTIDENS BYGG/ MILJØDEPARTEMENTE: Home pages listed in the report reference list Chapter 13.
- SBBL/KRUSE SMITH AS/ SPISS ARKITEKTUR & PLAN AS: Mail

Interview to employee in Fremtidens Bygg: Øyvind Bull Hansen

Introduction
What is your title in the program Framtidens Bygg?

What is your main reaponisbility/tasks in the program?

Pilot projects

What is the first step for projects involved in Framtidens Bygg (FB)?

What are the benefits for the projects that are part of the program?

What are the main reasons that retrofit projects is part of the program Framtidens Bygg?

How are decisions made for what projects are accepted to the program?
- And who makes the decisions?

Who are the involved stakeholders/participants in a project that are part of Framtidens Bygg?

What is the role of the municipality and the government in regards to program Framtidens Bygg?

What are expected from the FB projects, in regards to the decision-making processes done in these projects?

What would you consider to be important decisions to be made for FB projects?

- Who would be the participant(s) involved in an important decision process for a FB project?

What would you considered less important decisions to be made for FB projects?

- Who would be the participant(s) involved in a less important decision process for a FB project?

Do you notice a difference from decisions done in advance of a FB project versus the once done when the project is on going?

Have you experienced that FB projects decisions are harder to make than in normal construction projects?

How do you expect the project team to use klimgassregnskap.no?

FINALLY
What do you see as the benefits and drawbacks with buildings being energy retrofitted?

REGNEARK FOR SPEK AV MATERIALER

SPEK= (l x h)/ (YUM eller YOM)

Avledede størrelser			
		TEK10	Passivhus
BRA	m2	3750	3655
YUM	m2	300	85
YOM	m2	2374	801
INV	m2	2640	2475
BTA_OM	m2	3531	3375
høyde mellom etajsene	m	2,6	2,6

ISOLASJON OPPGANG	
a-b [mm]	3320
c-d [mm]	3140
d-e [mm]	2900
e-a [mm]	500
f-g [mm]	2900
g-h [mm]	3140
i-j [mm]	3320
j-f [mm]	500
k-l [mm]	1800
sum omkrets [m]	21,52
prosent av yttervegg	12 %
10 etasjer [m2]	559,52

ISJOLASJON STENDER	
2-C [mm]	15220
3-D [mm]	15220
4-E [mm]	15220
5-F [mm]	15220
6-A [mm]	15220
Vinduer [mm]	36720
Dører [mm]	6060
sum omkrets uten vinduer [m]	91,32
sum omkrets ink vinduer og dører	134,1
sumomkrets kun vinduer [m]	36,72
sum omkrets dører [m]	6,06
prosent av yttervegg uten vind	49 %
prosent av yttervegg ink vind	72 %
10 etajser kun vinduer [m2]	954,72

ISOLAJSON ROCKWOOL KASETTER	
A-B	9480
C-D	9480
E-F	9480
vidnduer	2700
sum omkrets uten vinduer [m]	28,44
sum omkrets ink vinduer [m]	31,14
sum omkrets kun vinduer [m]	2,7
prosent av yttervegg uten vind	15 %
prosent av yttervegg ink vind	17 %
10 etasjer kun vinduer [m2]	739,44

KLIMAVEGG	100,00 %
vinduer	21 %
isolajson oppgang	12 %
rockwool	15 %
dører	3 %
fasade ink vinduer	85 %

ISOLAJSON PÅ GURNN XPS	
1 til 2	1800
3 til 4	1800
5 til 6	1800
hele omkrets uten vinduer [m]	125,16
1 Etasje [m2]	325,42
SPEK	108 %

DØR INVENDING	
antall dører	60
bredde [m]	1
høyde [m]	2,3
sum alle dører [m2]	138
SPEK DØRER	1 %

YTTERVEGG	total OM i meter	186,76	
SPEK	YOM	YUM	SUM OM.
Klimavegg	155 %		141,28
Blokkvegg	108 %	108 %	125,16
Betongvegg	0		
Fasade	131 %		119,76
Dør	7 %		60,6
Vindu	43 %		394,2

TAK	
Tak plan [m2]	469
SPEK tretak/tekking	19,76 %

BALKONGER	
Stål [m2]	12
antall	30
høyde balkong	1,2
SPEK stål balkonger	18,20 %

kode	navn	bekrivelse	[kg CO2eq./kg materiale]	utslipp_pr	Kilde	tetthet - kg/m3	tetthet_grunnlag
B7	Titanzinkplate	Titanzinkplate	4,28	kg	Referanse Økobilanzdaten im Baubereich (juli 2012)	7200	m3
B91	Hullteglsfasade	Inkludert mørtel	0,24	kg	KGR4?	1480	m3
C1	Glass	Glass til bruk i vinduer og fasader. Datasettet gjelder for primærglass. For resirkulert glass må et annet datasett benyttes. Datasettet representerer gjennomsnittlig teknologi fra britiske glassprodusenter.	0,91	kg	Inventory of carbon and energy v.2 (ICE)	2500	m3
C2	2-lags vindu	Moderne 2-lagsvindu til bruk i bygninger. Data innhentet fra økobyggdatabasen KBOB, utgitt av det føderale sveitsiske konstruksjon- og eiendomskontoret. Antar 20 kg/m2 (tall fra bransjen).	31,2	m2	Sveitsiske føderale kontor for konstruksjon og fast eiendom (KBOB)	20	m2
C3	3-lags vindu	Moderne 3-lagsvindu til bruk i bygninger. Data innhentet fra økobyggdatabasen KBOB, utgitt av det føderale sveitsiske bygg og eiendomskontoret. Antar 30 kg/m2 (tall fra bransjen).	56,9	m2	Sveitsiske føderale kontor for konstruksjon og fast eiendom (KBOB)	30	m2
C4	Glassfasade	Glassfasade (Phosten-Riegel) med aluminiumsramme. Data innhentet fra økobyggdatabasen KBOB, utgitt av det føderale sveitsiske bygg og eiendomskontoret.	153	m2	Sveitsiske føderale kontor for konstruksjon og fast eiendom (KBOB)	37,5	m2
D1	Polystyren (EPS)	Polystyren (EPS) som kan brukes som isolasjon i vegger/dekker. Datasettet representerer gjennomsnittlig Europeisk teknologi for generell produksjon av polystyren.	3,415	kg	European Reference Life-Cycle Database (ELCD)	25	m3
D2	Glassull	Standard isolasjonsprodukt til bruk i bygninger. Datasettet er modellert med 50/50 fordeling mellom varmetilskudd i produksjonen fra elektrisitet og gass. Datasettet representerer gjennomsnittlig Europeisk teknologi.	2,772	kg	European Reference Life-Cycle Database (ELCD)	20	m3
D3	Steinull / Rock wool	Standard isolasjonsprodukt til bruk i bygninger. Datasettet representerer gjennomsnittlig Europeisk teknologi.	1,136	kg	European Reference Life-Cycle Database (ELCD)	30	m3
D4	Cellulosefiber	Cellulosefiberisolasjon til bruk i bygninger. Data innhentet fra økobyggdatabasen KBOB, utgitt av det føderale sveitsiske bygg og eiendomskontoret.	0,368	kg	Sveitsiske føderale kontor for konstruksjon og fast eiendom (KBOB)	50	m3
D5	Polyuretan	Polyuretanskum til bruk som isolering i bygg. Datasettet representerer gjennomsnittlig Europeisk teknologi og er innsamlet av den europeiske plastforeningen.	4,249	kg	Plastics Europe 2012	40	m3
D7	Korkplate	Kork til isolering i bygg. Data innhentet fra økobyggdatabasen KBOB, utgitt av det føderale sveitsiske bygg og eiendomskontoret.	1,16	kg	Sveitsiske føderale kontor for konstruksjon og fast eiendom (KBOB)	110	m3
D8	Ekstrudert polystyren (XPS)	XPS isolasjon til bygg. Data innhentet fra økobyggdatabasen KBOB, utgitt av det føderale sveitsiske bygg og eiendomskontoret	11,1	kg	Sveitsiske føderale kontor for konstruksjon og fast eiendom (KBOB)	35	m3
D9	Skumglass (glasopor)	Skumglassisolasjon til bygg. Data innhentet fra økobyggdatabasen KBOB, utgitt av det føderale sveitsiske bygg og eiendomskontoret	1,16	kg	Sveitsiske føderale kontor for konstruksjon og fast eiendom (KBOB)	130	m3
E1	Gips	Gips som råmateriale.	0,243	kg	European Reference Life-Cycle Database (ELCD)	650	m3
E10	OSB-plate	OSB-plate (oriented strand board). Trefiberplate laget av trefiber og lim, presset under høyt trykk og høy temperatur. Tetthet: 620 kg/m3, vanninnhold 4,8%. Datasettet representerer gjennomsnittlig Europeisk teknologi.	0,736	kg	European Reference Life-Cycle Database (ELCD)	620	m3
E11	Fibersement-plate	Fibersementplate til bruk i bygninger	0,451	kg	Sveitsiske føderale kontor for konstruksjon og fast eiendom (KBOB)	1580	m3
E2	Gipsplater	Gipsplater til bruk i bygninger. Datasettet er bygget på gjennomsnittlig Europeisk teknologi og inkluderer bruk av gjenvunnet gips og biprodukt fra kullkraft i produksjonen etter statistikk fra de respektive landene.	0,214	kg	European Reference Life-Cycle Database (ELCD)	900	m3
E3	Kryssfiner (plywood)	Kryssfinerplater til bruk i bygninger.	0,45	kg	Inventory of carbon and energy v.2 (ICE)	650	m3
E4	sponplater	Sponplater (particle board) til bruk i bygninger. Tetthet: 691 kg/m3, vanninnhold: 7,8%. Datasettet representerer gjennomsnittlig Europeisk teknologi.	0,875	kg	European Reference Life-Cycle Database (ELCD)	12,5	m3
E5	porøse trefiber/asfaltplater	Asfaltimpregnerte porøse trefiberplater beregnet til bruk som vindsperre. Data basert på EPD fra én enkelt produsent i Norge.	0,823	kg	EPD-Norge (Follvik, 2011)	160	m3
E6	Presset trefiberpalte	Bygningsplate med tetthet 800 kg/m3.	0,58	kg	Inventory of carbon and energy v.2 (ICE)	800	m3
E7	Fiberbord Medium Tetthet	Bygningsplate med tetthet mellom 350 og 800 kg/m3.	0,39	kg	Inventory of carbon and energy v.2 (ICE)	700	m3
E8	Glulam (laminat) (kg/m3)	Bygningsplate (laminat) med tetthet 517 kg/m3.	0,341	kg	Puettman & Wilson 2005	517	m3
E9	PVC-takbelegg/plater	Homogen PVC-plate på 2 mm	4,48	kg	KBOB. Ökobilanzdaten im Baubereich, Stand Juli 2012.	1550	m3
F7	Propylen-membran	Polypropylen (PP) membran til bruk i bygninger. Datasettet representerer gjennomsnittlig Europeisk teknologi og er innsamlet av den europeiske plastforeningen.	3,219	kg	Plastics Europe 2012	900	m3

kode	navn	bekrivelse					
F8	PVC-membran/tettesjikt	Polyvinylklorid (PVC) membran til bruk i bygninger. Datasettet representerer gjennomsnittlig Europeisk teknologi og er innsamlet av den europeiske plastforeningen.	3,201	kg	Plastics Europe 2012	1360	m3
F9	Asfaltpapp	Asfaltpapp til tak og vegger	0,826	kg	Sveitsiske føderale kontor for konstruksjon og fast eiendom (KBOB)	1178	m3
G1	Polyetylen	Polyetylen til bruk i bygninger som bunnfyllingslister og fugemasse. Datasettet representerer gjennomsnittlig Europeisk teknologi og er innsamlet av den europeiske plastforeningen.	1,84	kg	Plastics Europe 2012	950	m3
H1	Linoleum	Linoleumsbelegg til bruk i bygninger. 2.88 kg/m2. Datasettet representerer gjennomsnittlig Europeisk teknologi og er innsamlet av den europeiske foreningen for produsenter av slitesterke gulv (ERFMI).	2,005	kg	Europeisk forening for produsenter av slitesterke gulv (ERFMI)	1200	m3
H10	Keramisk flis	Keramiske fliser til gulv og vegger.	0,48	kg	Inventory of carbon and energy v.2 (ICE)	1900	m3
H2	Vinyl	Vinylbelegg til bruk i bygninger.	3,19	kg	Inventory of carbon and energy v.2 (ICE)	1200	m3
H3	Polyamid	Nylonbelegg til bruk i bygninger.	7,92	kg	Inventory of carbon and energy v.2 (ICE)	1380	m3
H4	Teppe	Teppegulv til bruk i bygninger. 2,427 kg/m2, garnvekt 900g/m2.	6,43	kg	Inventory of carbon and energy v.2 (ICE)	2,427	m2
H5	Maling	Gjennomsnittlig verdi av maling til ute- og innendørs bruk. (oljemaling)	2,91	kg	Inventory of carbon and energy v.2 (ICE)	1500	m3
H6	Porselen	Porselen til bruk i sanitæranlegg.	1,61	kg	Inventory of carbon and energy v.2 (ICE)	35	m3
H7	Vannbasert maling	Vannbasert maling til bruk inne- og utendørs.	2,54	kg	Inventory of carbon and energy v.2 (ICE)	1100	m3
H8	Oljemaling	Oljemaling til bruk inne- og utendørs	3,76	kg	Inventory of carbon and energy v.2 (ICE)	1500	m3
H9	Innvendig kledning	Ubehandlede innvendige trepaneler av høvlede byggevarer i heltre som brukes til innvendig kledning av vegg og tak. Data representerer norske forhold og er utarbeidet av Treindustrien.	0,039	kg	EPD-Norge (Grini, 2010)	483	m3
H91	Parkett	Parkett	0,2427	kg	KGR4?	517	m3
I1	Papir	Datasettet er modellert med basis i svensk papirindustri med gjennomsnittlig europeiske data for innsatsfaktorer.	0,937	kg	Chalmers - Spine@CPM	160	m3
I10	Murpuss	Murpuss til bruk på inner/yttervegger. Data innhentet fra økobyggdatabasen KBOB, utgitt av det føderale sveitsiske bygg og eiendomskontoret	0,213	kg	Sveitsiske føderale kontor for konstruksjon og fast eiendom (KBOB)	1500	m3
I2	Papp	Papp til bruk i bygninger og emballasje. Datasettet representerer gjennomsnittlig Europeisk teknologi.	1,152	kg	European Reference Life-Cycle Database (ELCD)	350	m3
I3	Asfaltpapp	Asfaltpapp til bruk i bygninger.	0,826	kg	Sveitsiske føderale kontor for konstruksjon og fast eiendom (KBOB)	1178	m3
I4	spiker, rustfrie	Varmforsinket stål.	2,574	kg	Worldsteel	7700	m3
I5	Sparkelmasse	Beholder data fra Byggforsk raopport 173 (1995) i mangel på nyere data.	0,599	kg	Byggforsk, 1995	570	m3
I6	Kobber	Generell primær kobber. Datasettet representerer gjennomsnittlig Europeisk teknologi.	0,977	kg	European Reference Life-Cycle Database (ELCD)	8900	m3
I7	Fugemasse	Silikonbasert fugemasse. Data innhentet fra økobyggdatabasen KBOB, utgitt av det føderale sveitsiske bygg og eiendomskontoret	2,71	kg	Sveitsiske føderale kontor for konstruksjon og fast eiendom (KBOB)	1300	m3
I8	Kalkpuss	Kalkpuss / hvitpuss til bruk på inner/yttervegger. Data innhentet fra økobyggdatabasen KBOB, utgitt av det føderale sveitsiske bygg og eiendomskontoret	0,085	kg	Sveitsiske føderale kontor for konstruksjon og fast eiendom (KBOB)	1600	m3
I9	Avrettingsmasse	Syntetisk avrettingsmasse til bruk på inner/yttervegger. Data innhentet fra økobyggdatabasen KBOB, utgitt av det føderale sveitsiske bygg og eiendomskontoret	0,191	kg	Sveitsiske føderale kontor for konstruksjon og fast eiendom (KBOB)	1500	m3
J2	Kobberledning	Kobberledninger til bruk i bygninger. Datasettet representerer gjennomsnittlig Europeisk teknologi.	0,789	kg	European Reference Life-Cycle Database (ELCD)	8900	m3
J3	Rustfritt stål	Rustfritt stål til bruk i bygninger. Datasettet representerer gjennomsnittlig Europeisk teknologi. Datasettet er modellert med antakelse om 80% resirkulering og representerer gjennomsnittlig Europeisk teknologi.	3,379	kg	European Reference Life-Cycle Database (ELCD)	8000	m3

kode	navn	bekrivelse	[kg CO2eq./kg materiale]	utslipp_pr	Kilde	tetthet - kg/m3	tetthet_grunnlag
A1_1	Kalksementpeler	-	0,83	kg	(Oppgitt fra Norcem Heidelberg)	2400	m3
A1_2	Multicempeler	-	0,415	kg	(Oppgitt fra Norcem Heidelberg)	2400	m3
A10	Aluminium, primær (ingot)	Dette datasettet omfatter produksjon av primær aluminium fra utvinning av bauxitt gjennom omdanning til alumina og støpning av ingot. Dette er ubehandlet aluminium og representerer gjennomsnittlig Europeisk teknologi.	9,908	kg	European Aluminium Association (EAA)	2700	m3
A10_1	Aluminium, primær - 20% resirk	Dette datasettet omfatter de innsatsfaktorer i behandlingen av aluminiumskrap til sekundær ingot av resirkulert aluminium. Datasettet representerer gjennomsnittlig Europeisk teknologi.	8,03	kg	European Aluminium Association (EAA)	2700	m3
A10_2	Aluminium, primær - 40% resirk	Dette datasettet omfatter de innsatsfaktorer i behandlingen av aluminiumskrap til sekundær ingot av resirkulert aluminium. Datasettet representerer gjennomsnittlig Europeisk teknologi.	6,15	kg	European Aluminium Association (EAA)	2700	m3
A10_3	Aluminium, primær - 60% resirk	Dette datasettet omfatter de innsatsfaktorer i behandlingen av aluminiumskrap til sekundær ingot av resirkulert aluminium. Datasettet representerer gjennomsnittlig Europeisk teknologi.	4,28	kg	European Aluminium Association (EAA)	2700	m3
A10_4	Aluminium, primær - 80% resirk	Dette datasettet omfatter de innsatsfaktorer i behandlingen av aluminiumskrap til sekundær ingot av resirkulert aluminium. Datasettet representerer gjennomsnittlig Europeisk teknologi.	2,4	kg	European Aluminium Association (EAA)	2700	m3
A11	Aluminium, resirkulert (ingot)	Dette datasettet omfatter de innsatsfaktorer i behandlingen av aluminiumskrap til sekundær ingot av resirkulert aluminium. Datasettet representerer gjennomsnittlig Europeisk teknologi.	0,521	kg	European Aluminium Association (EAA)	2700	m3
A12	Porebetongblokk	Porebetongblokk til bruk i bygninger. Tetthet: 433 kg/m3. Datasettet representerer gjennomsnittlig Europeisk teknologi.	0,46674	kg	European Reference Life-Cycle Database (ELCD)	433	m3
A13	Forsterket pore-betongblokk	Porebetongblokk til bruk i bygninger. Tetthet: 485 kg/m3. Datasettet representerer gjennomsnittlig Europeisk teknologi.	0,51879	kg	European Reference Life-Cycle Database (ELCD)	485	m3
A14	Lettbetongblokk	Ekspandert leire som basismateriale. Kan brukes i inner/yttervegger. Tetthet: 500-1600 kg/m3. Kan formstøpes. Datasettet representerer gjennomsnittlig Europeisk teknologi.	0,2594	kg	European Reference Life-Cycle Database (ELCD)	1000	m3
A15	Prefabrikert betong	Prefabrikert betong av typen C20/25 med armering til bruk I bygninger. Tettet: 2400 kg/m3. Datasettet representerer gjennomsnittlig Europeisk teknologi.	0,12089	kg	European Reference Life-Cycle Database (ELCD)	2400	m3
A16	Aluminiumsprofil, ekstrudert	Aluminiumprofiler til bruk i bygninger (vindusrammer, rekkverk, etc.) Resirkuleringsgrad på 88%. Primærproduksjonsdata fra EAA er benyttet og representerer gjennomsnittlig Europeisk teknologi.	2,452	kg	European Reference Life-Cycle Database (ELCD)	2700	m3
A17	Stålseksjon av varmrullet stål	Stålseksjoner (I-bjelker H-bjelker, etc.) til bruk i bygninger. Resirkuleringsgrad på 80%. Datasettet representerer gjennomsnittlig Europeisk teknologi.	1,132	kg	European Reference Life-Cycle Database (ELCD)	7800	m3
A18	Armeringsjern	Armeringsjern til bruk innen konstruksjon. Resirkuleringsgrad på 80%. Datasettet representerer gjennomsnittlig Europeisk teknologi.	1,0285	kg	European Reference Life-Cycle Database (ELCD)	7800	m3
A19	Limtrebjelke	Limtrebjelke til bruk i bærende konstruksjoner. Tetthet: 567,5 kg/ m3. Data fra amerikansk studie.	0,2427	kg	Puettman & Wilson 2005	517	m3
A2	Tre	Dette datasettet omfatter kultivering og foredling av gran til ferdig, ubehandlet trevirke/skurlast til bruk innen konstruksjon som reisverk, fasader og andre relevante bruksområder. Datasettet representerer gjennomsnittlig Europeisk teknologi.	0,026	kg	European Reference Life-Cycle Database	500	m3
A20_1	Betong (25/30 MPa) med 0% iblandet flyve aske	Betong til bruk i forsterkede fundament. Datasettet er hentet fra en britisk database, men kan antas å være representativ for bruk her siden data er klassifisert etter trykkfasthet. GWP gitt etter innhold av flyve aske i prosent.	0,14	kg	Inventory of carbon and energy v.2 (ICE)	2400	m3
A20_2	Betong (25/30 MPa) med 15% iblandet flyve aske	Betong til bruk i forsterkede fundament. Datasettet er hentet fra en britisk database, men kan antas å være representativ for bruk her siden data er klassifisert etter trykkfasthet. GWP gitt etter innhold av flyve aske i prosent.	0,13	kg	Inventory of carbon and energy v.2 (ICE)	2400	m3
A20_3	Betong (25/30 MPa) med 30% iblandet flyve aske	Betong til bruk i forsterkede fundament. Datasettet er hentet fra en britisk database, men kan antas å være representativ for bruk her siden data er klassifisert etter trykkfasthet. GWP gitt etter innhold av flyve aske i prosent.	0,115	kg	Inventory of carbon and energy v.2 (ICE)	2400	m3
A21_1	Betong (32/40 MPa) med 0% iblandet flyve aske	Betong til bruk i hovedkonstruksjon etasjeskillere og vegger. Datasettet er hentet fra en britisk database, men kan antas å være representativ for bruk her siden data er klassifisert etter trykkfasthet. GWP gitt etter innhold av flyve aske i prosent.	0,163	kg	Inventory of carbon and energy v.2 (ICE)	2400	m3
A21_2	Betong (32/40 MPa) med 15% iblandet flyve aske	Betong til bruk i hovedkonstruksjon etasjeskillere og vegger. Datasettet er hentet fra en britisk database, men kan antas å være representativ for bruk her siden data er klassifisert etter trykkfasthet. GWP gitt etter innhold av flyve aske i prosent.	0,152	kg	Inventory of carbon and energy v.2 (ICE)	2400	m3
A21_3	Betong (32/40 MPa) med 30% iblandet flyve aske	Betong til bruk i hovedkonstruksjon etasjeskillere og vegger. Datasettet er hentet fra en britisk database, men kan antas å være representativ for bruk her siden data er klassifisert etter trykkfasthet. GWP gitt etter innhold av flyve aske i prosent.	0,136	kg	Inventory of carbon and energy v.2 (ICE)	2400	m3
A22_1	Betong (40/50 MPa) med 0% iblandet flyve aske	Betong til bruk hvor det kreves høy styrke. Datasettet er hentet fra en britisk database, men kan antas å være representativ for bruk her siden data er klassifisert etter trykkfasthet. GWP gitt etter innhold av flyve aske i prosent.	0,188	kg	Inventory of carbon and energy v.2 (ICE)	2400	m3
A22_2	Betong (40/50 MPa) med 15% iblandet flyve aske	Betong til bruk hvor det kreves høy styrke. Datasettet er hentet fra en britisk database, men kan antas å være representativ for bruk her siden data er klassifisert etter trykkfasthet. GWP gitt etter innhold av flyve aske i prosent.	0,174	kg	Inventory of carbon and energy v.2 (ICE)	2400	m3
A22_3	Betong (40/50 MPa) med 30% iblandet flyve aske	Betong til bruk hvor det kreves høy styrke. Datasettet er hentet fra en britisk database, men kan antas å være representativ for bruk her siden data er klassifisert etter trykkfasthet. GWP gitt etter innhold av flyve aske i prosent.	0,155	kg	Inventory of carbon and energy v.2 (ICE)	2400	m3

kode	navn	bekrivelse	[kg CO2eq./kg materiale]	utslipp_pr	Kilde	tetthet - kg/m3	tetthet_grunnlag
A23	Norsk skurlast	Skurlast er en råvare for trebaserte byggevarer. Hovedandel av produksjonen er skurlast av gran med fuktighetsgrad 14-18%. Data er representerer norske forhold og er utarbeidet av Treindustrien. Antar massetetthet på 483 kg/ m3.	0,0395	kg	EPD-Norge (Grini, 2009)	483	m3
A24	Norsk konstruksjonslast	Høvlede byggevarer i heltre som benyttes eksempelvis til takstoler eller i bindingsverk. Hovedandel av produksjonen er skurlast av gran med fuktighetsgrad 14-18%. Data er representerer norske forhold og er utarbeidet av Treindustrien. Antar massetetthet på 483 kg/ m3.	0,06	kg	EPD-Norge (Grini, 2009)	483	m3
A25	Kobberimpregnert trelast	Kobberimpregnert trelast som benyttes i hovedsak til konstruksjonslast, terrassebord, samt utvendig kledning i værutsatte strøk. Data er representerer norske forhold og er utarbeidet av Treindustrien. Antar massetetthet på 483 kg/ m3.	0,069	kg	EPD-Norge (Grini, 2010)	483	m3
A3	Tømmer	Data omfatter livsløpet til gran fra kultivering til sagbruk hvor det ferdige produktet er rundtømmer med bark. Datasettet representerer gjennomsnittlig Europeisk teknologi.	0,007	kg	European Reference Life-Cycle Database	500	m3
A4	Stålbjelke	Stålbjelker og stålseksjoner av varmrullet stål. Dette omfatter I-bjelker, H-bjelker og lignende produkter som benyttes innen konstruksjon. Datasettet representerer gjennomsnittlig Europeisk teknologi.	1,132	kg	European Reference Life-Cycle Database	7700	m3
A5	Stål fra skrap, generell	Stål som er produsert utelukkende av skrap, dvs. 100% resirkulert. Dette er sjelden tilfelle i praksis og det anbefales å bruke data med en gitt resirkuleringsgrad.	0,47	kg	Inventory of carbon and energy v.2 (ICE)	7700	m3
A6	Stål fra malm	Dette er stål som er fremstilt uten bruk av skrap i smelten. Dette er sjelden tilfelle i praksis og det anbefales å bruke data med en gitt resirkuleringsgrad. Datasettet representerer gjennomsnittlig Europeisk teknologi.	2,89	kg	Inventory of carbon and energy v.2 (ICE)	7700	m3
A6_1	Stål fra malm - 20% resirk	Til bruk for armeringsjern	2,41	kg	Inventory of carbon and energy v.2 (ICE)	7700	m3
A6_10	Stål fra malm - 0% resirk	Til bruk for H-bjelke	3,18	kg	avledet fra ICE	7700	m3
A6_11	Stål fra malm - 20% resirk	Til bruk for H-bjelke	2,64	kg	avledet fra ICE	7700	m3
A6_12	Stål fra malm - 40% resirk	Til bruk for H-bjelke	2,12	kg	avledet fra ICE	7700	m3
A6_13	Stål fra malm - 60% resirk	Til bruk for H-bjelke	1,58	kg	avledet fra ICE	7700	m3
A6_14	Stål fra malm - 80% resirk	Til bruk for H-bjelke	1,05	kg	avledet fra ICE	7700	m3
A6_15	Stål fra malm - 100% resirk	Til bruk for H-bjelke	0,52	kg	avledet fra ICE	7700	m3
A6_2	Stål fra malm - 40% resirk	Til bruk for armeringsjern	1,92	kg	Inventory of carbon and energy v.2 (ICE)	7700	m3
A6_3	Stål fra malm - 60% resirk	Til bruk for armeringsjern	1,44	kg	Inventory of carbon and energy v.2 (ICE)	7700	m3
A6_4	Stål fra malm - 80% resirk	Til bruk for armeringsjern	0,95	kg	Inventory of carbon and energy v.2 (ICE)	7700	m3
A7	Sement	Portland sement (CEM I) bestående i hovedsak av Portland sement klinker hvor klinkerprosessen er modellert med gjennomsnittsverdier av de ulike prosesseringsmetodene. Datasettet representerer gjennomsnittlig Europeisk teknologi.	0,9	kg	European Reference Life-Cycle Database	2100	m3
A8	lettklinker (leca)	Lettklinker levert som bulk. Data basert på EPD fra én enkelt produsent i Norge.	0,252	kg	EPD-Norge (Vold, 2008)	770	m3
A9	leca-vegg	Pusset vegg av lecastein. Data basert på EPD fra én enkelt produsent i Norge. (Beregnet ut i fra tall gitt per m2 vegg (165 kg / m2))	0,224	kg	EPD-Norge (Vold, 2009)	770	m3
B1	Tegl	Data omfatter produksjon av teglstein fremstilt fra brent leire til bruk i murverk i bygninger. Fuging er ikke inkludert i datasettet. Det antas en tetthet på 2.3 kg per teglstein	0,24	kg	Inventory of carbon and energy v.2 (ICE)	1850	m3
B2	mørtel	Materiale til fuging i murverk som binding mellom teglstein. Blandingsforhold 1:4 er antatt.	0,182	kg	Inventory of carbon and energy v.2 (ICE)	1700	m3
B3	Aluminiumsplate	Aluminiumsplater til bruk i fasader, tak og lignende. En resirkuleringsgrad på 78% er benyttet i modelleringen. Datasettet representerer gjennomsnittlig Europeisk teknologi.	3,229	kg	European Reference Life-Cycle Database (ELCD)	2700	m3
B4	Ekstrudert aluminiumsprofil	Ekstruderte aluminiumprofiler til bruk vindusrammer, rekkverk, osv. En resirkuleringsgrad på 88% er benyttet i modelleringen. Datasettet representerer gjennomsnittlig Europeisk teknologi.	2,452	kg	European Reference Life-Cycle Database (ELCD)	2700	m3
B5	Forsinkede og belagte stålpater	Forsinkede stålplater til tak, kledning og lignende med organisk fargebelegg. For eksempel bølgeblikk og fasader	2,82	kg	European Reference Life-Cycle Database (ELCD)	7800	m3
B6	Malt trekledning	Norsk malt (2 strøk), utvendig kledning av skåret byggevare i heltre. Spiker er ikke inkludert. Data representerer norske forhold og er utarbeidet av Treindustrien.	0,171	kg	EPD-Norge (Grini, 2010)	483	m3

SIMIEN
Evaluering lavenergihus

Simuleringsnavn: Passivhusevaluering
Tid/dato simulering: 11:50 9/4-2014
Programversjon: 5.021
Brukernavn: Flerbruker
Firma: Kruse Smith Entreprenør AS
Inndatafil: R:\Energieffektivitet\Master\Stjernehus brl ny..smi
Prosjekt: Kobbeveien 20, Stjernehus BRL
Sone: Alle soner

Resultater av evalueringen

Evaluering mot NS 3700:2013	Beskrivelse
Varmetapsramme	Bygningen tilfredstiller kravet for varmetapstall
Energiytelse	Bygningen tilfredsstiller krav til energiytelse
Minstekrav	Bygningen tilfredsstiller ikke minstekrav til enkeltkomponenter
Luftmengder ventilasjon	Luftmengdene tilfredsstiller minstekrav gitt i NS3700:2013
Samlet evaluering	Bygningen tilfredstiller ikke alle krav til lavenergihus

Varmetapsbudsjett

Beskrivelse	Verdi
Varmetapstall yttervegger	0,14
Varmetapstall tak	0,03
Varmetapstall gulv på grunn/mot det fri	0,05
Varmetapstall glass/vinduer/dører	0,19
Varmetapstall kuldebroer	0,11
Varmetapstall infiltrasjon	0,05
Totalt varmetapstall	0,55
Krav varmetapstall	0,55

Energiytelse

Beskrivelse	Verdi	Krav
Netto oppvarmingsbehov	24,1 kWh/m²	30,0 kWh/m²
Netto kjølebehov	0,0 kWh/m²	0,0 kWh/m²
Energibruk el./fossile energibærere	41,4 kWh/m²	76,4 kWh/m²
Andel av varmebehovet som dekkes av annet enn direkte el. og fossile brensler	93,1 %	60,0 %

SIMIEN

Evaluering lavenergihus

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Sone: Alle soner

Minstekrav enkeltkomponenter

Beskrivelse	Verdi	Krav
U-verdi yttervegger [W/m²K]	0,22	0,22
U-verdi tak [W/m²K]	0,11	0,18
U-verdi gulv mot grunn og mot det fri [W/m²K]	0,48	0,18
U-verdi glass/vinduer/dører [W/m²K]	0,86	1,20
Normalisert kuldebroverdi [W/m²K]	0,11	0,05
Oppgraderingsprosjekt hvor det er praktisk umulig å tilfredsstille kravet til norm. kuldebroverdi	-	-
Årsmidlere temperaturvirkningsgrad varmegjenvinner ventilasjon [%]	80	70
Spesifikk vifteeffekt (SFP) [kW/m³/s]:	2,00	2,00
Varmetapstall glass/vinduer/dører	0,19	0,24
Lekkasjetall (lufttetthet ved 50 Pa trykkforskjell) [luftvekslinger pr time]	1,00	1,00

Krav til solfaktor for solutsatte fasader

Kravet til total solfaktor for vinduer/solskjerming på solutsatte fasaderer er ikke en del av evalueringen i SIMIEN.
Der dette er aktuelt må det dokumenteres separat.

Energibudsjett (NS 3700)

Energipost	Energibehov	Spesifikt energibehov
1a Romoppvarming	92883 kWh	20,4 kWh/m²
1b Ventilasjonsvarme (varmebatterier)	16824 kWh	3,7 kWh/m²
2 Varmtvann (tappevann)	135349 kWh	29,8 kWh/m²
3a Vifter	37594 kWh	8,3 kWh/m²
3b Pumper	641 kWh	0,1 kWh/m²
4 Belysning	51728 kWh	11,4 kWh/m²
5 Teknisk utstyr	79570 kWh	17,5 kWh/m²
6a Romkjøling	0 kWh	0,0 kWh/m²
6b Ventilasjonskjøling (kjølebatterier)	0 kWh	0,0 kWh/m²
Totalt netto energibehov, sum 1-6	414589 kWh	91,3 kWh/m²

SIMIEN

Evaluering lavenergihus

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Levert energi til bygningen (NS 3700)

Energivare	Levert energi	Spesifikk levert energi
1a Direkte el.	188227 kWh	41,4 kWh/m²
1b El. Varmepumpe	0 kWh	0,0 kWh/m²
1c El. solenergi	0 kWh	0,0 kWh/m²
2 Olje	0 kWh	0,0 kWh/m²
3 Gass	0 kWh	0,0 kWh/m²
4 Fjernvarme	271705 kWh	59,8 kWh/m²
5 Biobrensel	0 kWh	0,0 kWh/m²
Annen energikilde	0 kWh	0,0 kWh/m²
Totalt levert energi, sum 1-6	459932 kWh	101,2 kWh/m²

Referanseinformasjon beregning

Evaluering mot NS 3700:2013	Beskrivelse
Beregning	Utført etter NS 3700:2013 med validert dynamisk timesberegning etter reglene i NS 3031:2007
Kommune, gårds- og bruksnummer	
Konstruksjon og plassering	
Tekniske installasjoner	
Soneinndeling	
Arealvurdering	

SIMIEN
Evaluering lavenergihus

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Prosjekt: Kobbeveien 20, Stjernehus BRL
Sone: Alle soner

Dokumentasjon av sentrale inndata (1)

Beskrivelse	Verdi	Dokumentasjon
Areal yttervegger [m²]:	2845	
Areal tak [m²]:	1181	
Areal gulv [m²]:	428	
Areal vinduer og ytterdører [m²]:	977	
Oppvarmet bruksareal (BRA) [m²]:	4543	
Oppvarmet luftvolum [m³]:	9300	
U-verdi yttervegger [W/m²K]	0,22	
U-verdi tak [W/m²K]	0,11	
U-verdi gulv [W/m²K]	0,48	
U-verdi vinduer og ytterdører [W/m²K]	0,86	
Areal vinduer og dører delt på bruksareal [%]	21,5	
Normalisert kuldebroverdi [W/m²K]:	0,11	
Normalisert varmekapasitet [Wh/m²K]	35	
Lekkasjetall (n50) [1/h]:	1,00	
Temperaturvirkningsgr. varmegjenvinner [%]:	80	

Dokumentasjon av sentrale inndata (2)

Beskrivelse	Verdi	Dokumentasjon
Estimert virkningsgrad gjenvinner justert for frostsikring [%]:	80,3	
Spesifikk vifteeffekt (SFP) [kW/m³/s]:	2,00	
Luftmengde i driftstiden [m³/hm²]	1,7	
Luftmengde utenfor driftstiden [m³/hm²]	1,7	
Systemvirkningsgrad oppvarmingsanlegg:	0,84	
Installert effekt romoppv. og varmebatt. [W/m²]:	80	
Settpunkttemperatur for romoppvarming [°C]	20,3	
Systemeffektfaktor kjøling:	2,50	
Settpunkttemperatur for romkjøling [°C]	22,0	
Installert effekt romkjøling og kjølebatt. [W/m²]:	0	
Spesifikk pumpeeffekt romoppvarming [kW/(l/s)]:	0,50	
Spesifikk pumpeeffekt romkjøling [kW/(l/s)]:	0,00	
Spesifikk pumpeeffekt varmebatteri [kW/(l/s)]:	0,50	
Spesifikk pumpeeffekt kjølebatteri [kW/(l/s)]:	0,00	
Driftstid oppvarming (timer)	16,0	

SIMIEN

Evaluering lavenergihus

Simuleringsnavn: Passivhusevaluering
Tid/dato simulering: 11:50 9/4-2014
Programversjon: 5.021
Brukernavn: Flerbruker
Firma: Kruse Smith Entreprenør AS
Inndatafil: R:\Energieffektivitet\Master\Stjernehus brl ny..smi
Prosjekt: Kobbeveien 20, Stjernehus BRL
Sone: Alle soner

Dokumentasjon av sentrale inndata (3)		
Beskrivelse	Verdi	Dokumentasjon
Driftstid kjøling (timer)	24,0	
Driftstid ventilasjon (timer)	24,0	
Driftstid belysning (timer)	16,0	
Driftstid utstyr (timer)	16,0	
Oppholdstid personer (timer)	24,0	
Effektbehov belysning i driftstiden [W/m²]	1,95	
Varmetilskudd belysning i driftstiden [W/m²]	1,95	
Effektbehov utstyr i driftstiden [W/m²]	3,00	
Varmetilskudd utstyr i driftstiden [W/m²]	1,80	
Effektbehov varmtvann på driftsdager [W/m²]	3,40	
Varmetilskudd varmtvann i driftstiden [W/m²]	0,00	
Varmetilskudd personer i oppholdstiden [W/m²]	1,50	
Total solfaktor for vindu og solskjerming:	0,67	
Gjennomsnittlig karmfaktor vinduer:	0,20	
Solskjermingsfaktor horisont/utspring (N/Ø/S/V):	0,91/0,96/0,96/0,95	

Inndata bygning	
Beskrivelse	Verdi
Bygningskategori	Boligblokker
Simuleringsansvarlig	Håkon Skogheim
Kommentar	

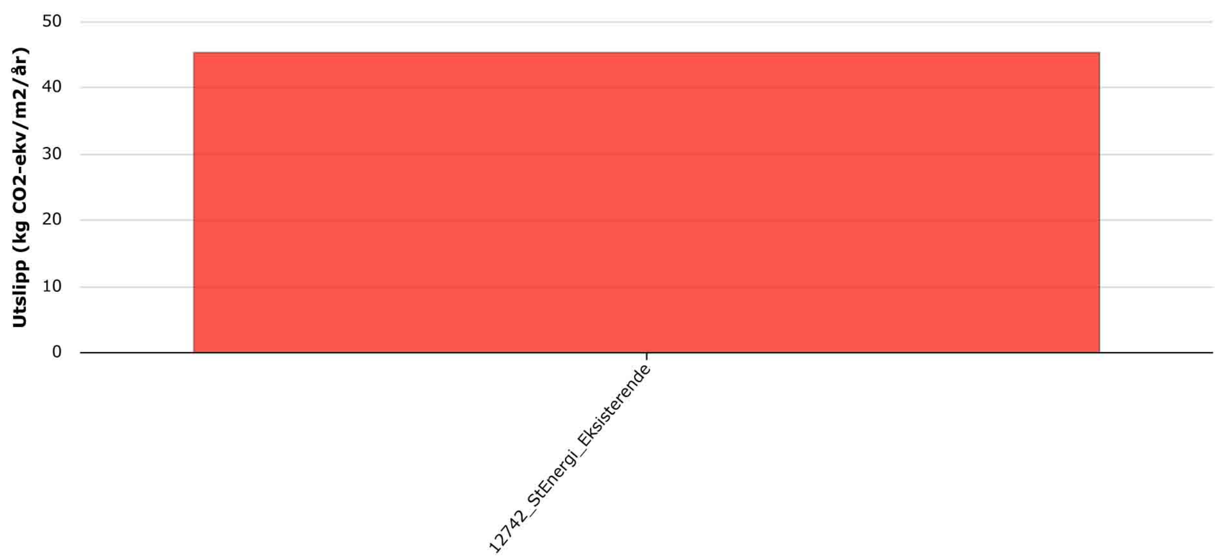
APPENDIX 10A

Sammendrag - STJERNEHUS ERFARINGSTALL

- Skjul grafikk
- Vis fritekstfelt
- Endre til vanlig visning
- Lagre til Excel (uten grafikk)

Utslippsberegninger

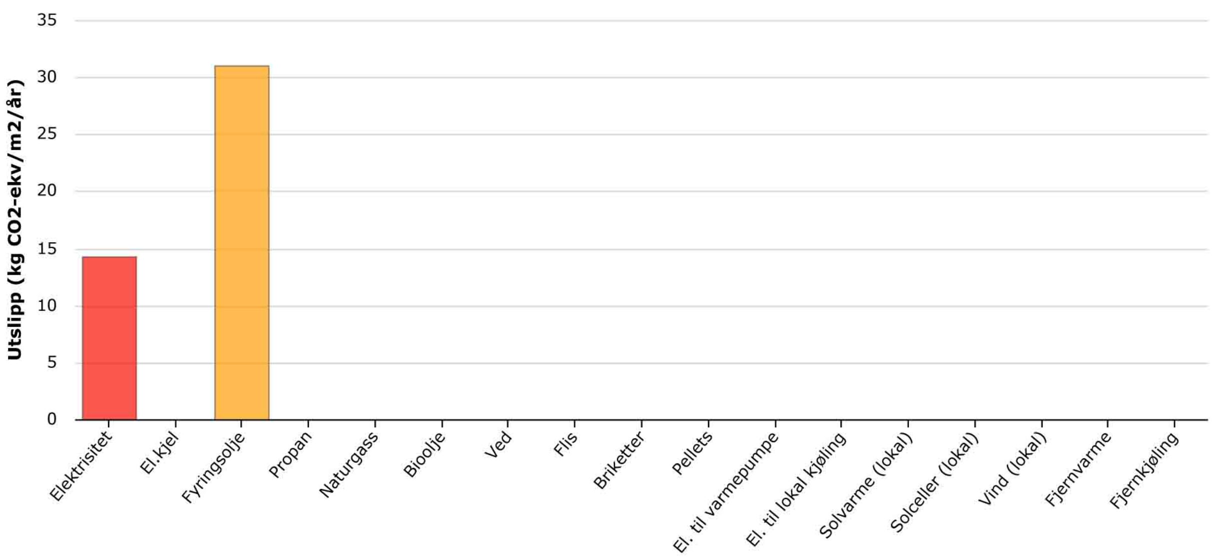
Modul	Tittel (åpne)	Tonn CO_2-ekv/livsløp	Kg CO_2-ekv/m^2/år	Kg CO_2-ekv/bruker/år
12742 - Stasjonær energi - Eksisterende bygg	Energi Erfaringstall	10215	45.4	1956.9



APPENDIX 10A

Detaljer for modul 12742 Stasjonær energi - Eksisterende bygg - Energi Erfaringstall

	Tonn CO_2-ekv/livsløp	Kg CO_2-ekv/m^2/år	Kg CO_2-ekv/bruker/år
Elektrisitet	3218	14.3	616.4
El.kjel	-	-	-
Fyringsolje	6998	31.1	1340.5
Propan	-	-	-
Naturgass	-	-	-
Bioolje	-	-	-
Ved	-	-	-
Flis	-	-	-
Briketter	-	-	-
Pellets	-	-	-
El. til varmepumpe	-	-	-
El. til lokal kjøling	-	-	-
Solvarme (lokal)	-	-	-
Solceller (lokal)	-	-	-
Vind (lokal)	-	-	-
Fjernvarme	-	-	-
Fjernkjøling	-	-	-
Sum	10215	45.4	1956.9



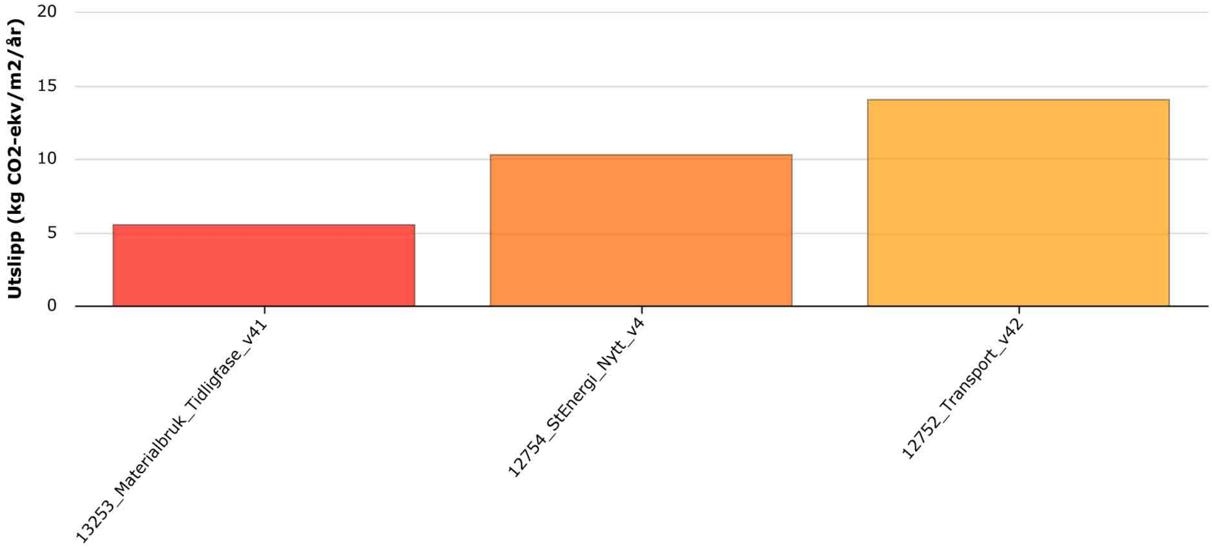
APPENDIX 10B

Sammendrag - STJERNEHUS REFERANSEBYGG

- Skjul grafikk
- Vis fritekstfelt
- Endre til vanlig visning
- Lagre til Excel (uten grafikk)

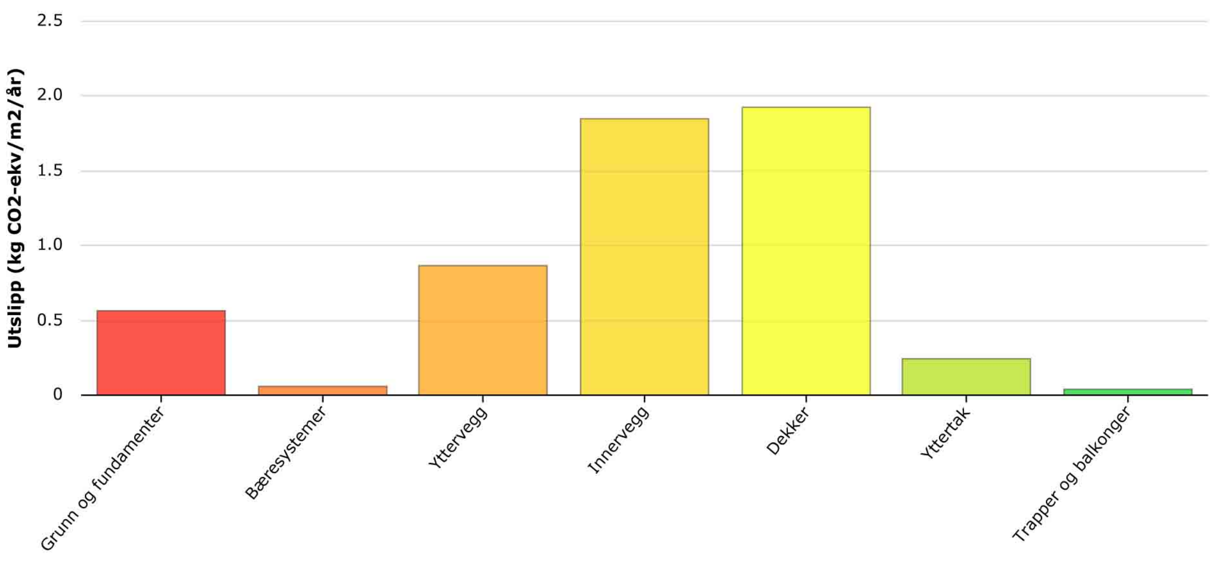
Utslippsberegninger

Modul	Tittel (åpne)	Tonn CO_2-ekv/livsløp	Kg CO_2-ekv/m^2/år	Kg CO_2-ekv/bruker/år
13253 - Materialbruk - Tidligfase (v4.1)	Materialer etter TEK10	1248	5.5	239.2
12754 - Stasjonær energi - Nytt bygg	TEK 10	2306	10.3	441.8
12752 - Transport	Transport Referansebygg	3167	14.1	606.7



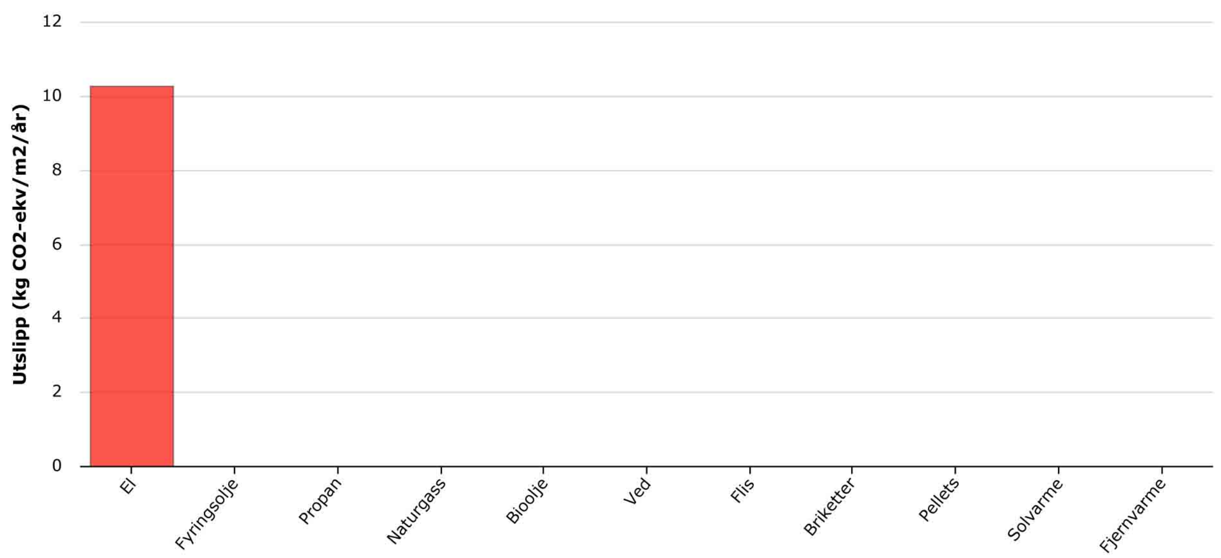
Detaljer for modul 13253 Materialbruk - Tidligfase (v4.1) - Materialer etter TEK10

Gruppe	Tonn CO_2-ekv/livsløp	Kg CO_2-ekv/m^2/år	Kg CO_2-ekv/bruker/år
1 Grunn og fundamenter	125	0.6	24.0
2 Bæresystemer	14	0.1	2.6
3 Yttervegg	196	0.9	37.6
4 Innervegg	416	1.8	79.7
5 Dekker	434	1.9	83.1
6 Yttertak	54	0.2	10.3
7 Trapper og balkonger	10	0.0	1.9
Sum	1248	5.5	239.2



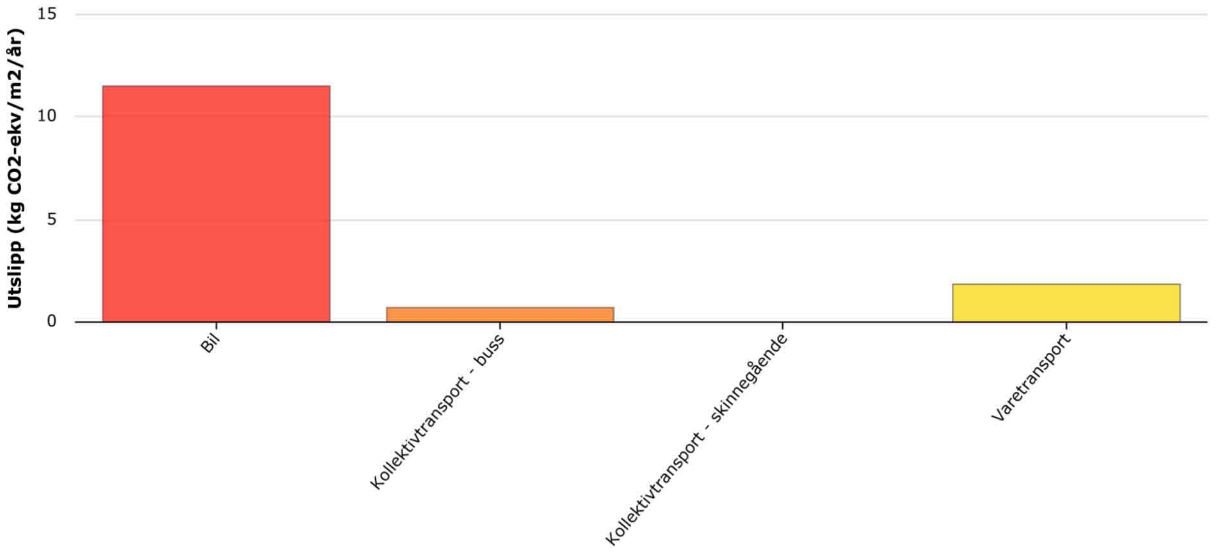
Detaljer for modul 12754 Stasjonær energi - Nytt bygg - TEK 10

	Tonn CO_2-ekv/livsløp	Kg CO_2-ekv/m^2/år	Kg CO_2-ekv/bruker/år
El	2306	10.3	441.8
Fyringsolje	-	-	-
Propan	-	-	-
Naturgass	-	-	-
Bioolje	-	-	-
Ved	-	-	-
Flis	-	-	-
Briketter	-	-	-
Pellets	-	-	-
Solvarme	-	-	-
Fjernvarme	-	-	-
Sum	2306	10.3	441.8



Detaljer for modul 12752 Transport - Transport Referansebygg

	Tonn CO_2-ekv/livsløp	Kg CO_2-ekv/m^2/år	Kg CO_2-ekv/bruker/år
Bil	2594	11.5	496.9
Kollektivtransport - buss	158	0.7	30.3
Kollektivtransport - skinnegående	-	-	-
Varetransport	415	1.8	79.5
Sum	3167	14.1	606.7



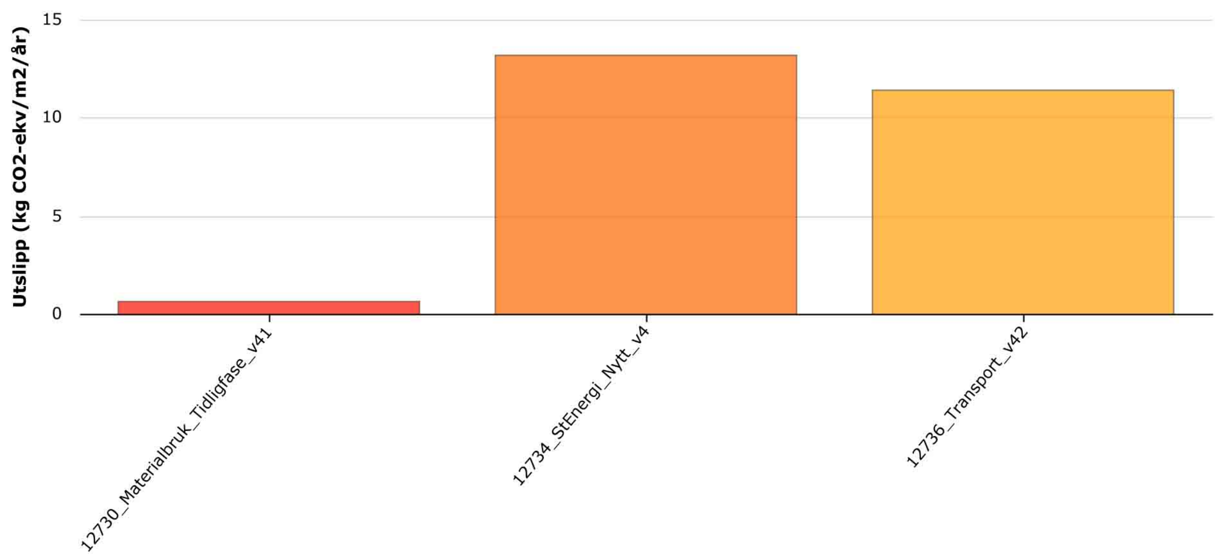
APPENDIX 10C

Sammendrag - STJERNEHUS REHABLITERING

- Skjul grafikk
- Vis fritekstfelt
- Endre til vanlig visning
- Lagre til Excel (uten grafikk)

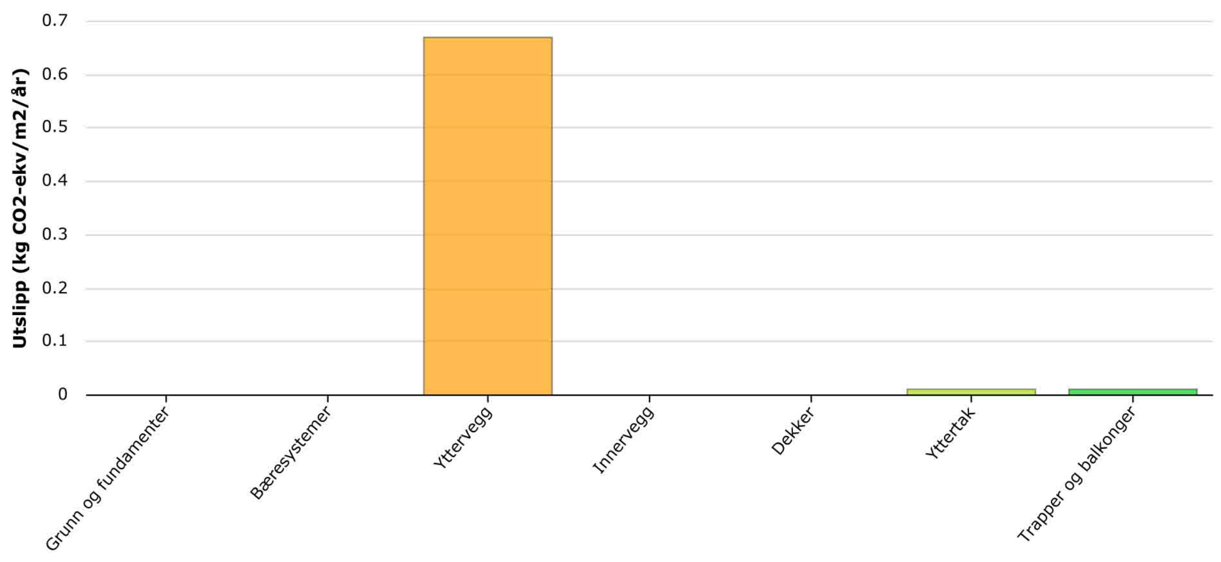
Utslippsberegninger

Modul	Tittel (åpne)	Tonn CO_2-ekv/livsløp	Kg CO_2-ekv/m^2/år	Kg CO_2-ekv/bruker/år
12730 - Materialbruk - Tidligfase (v4.1)	Prosjektert Rehablitering	156	0.7	29.9
12734 - Stasjonær energi - Nytt bygg	Fjernvarme og el.bruk	2961	13.2	567.2
12736 - Transport	Transport basert på tiltak 2000m til sentrum	2565	11.4	491.3



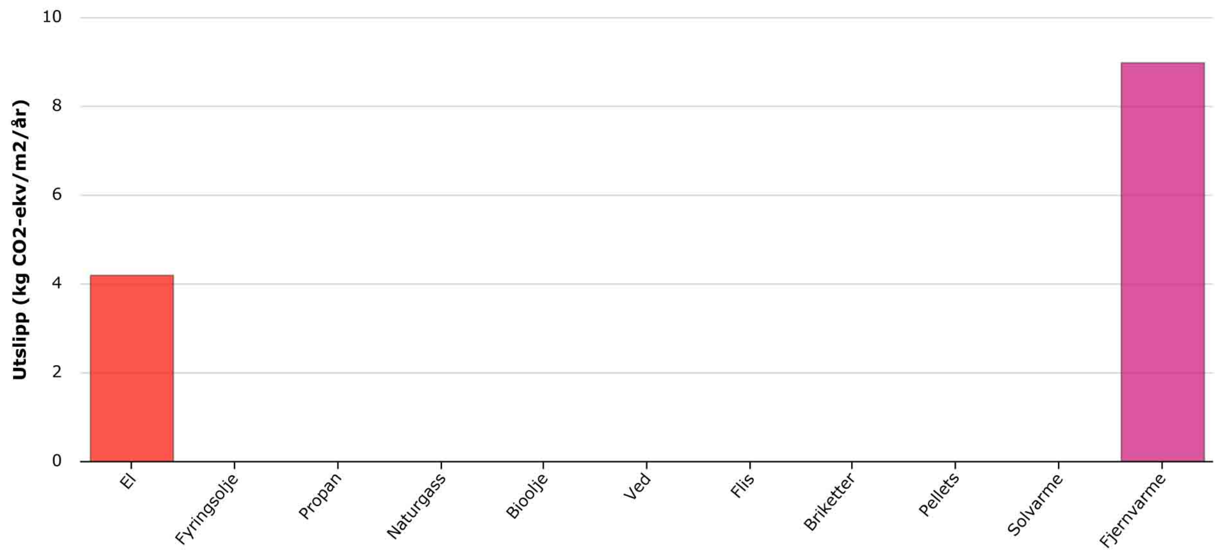
Detaljer for modul 12730 Materialbruk - Tidligfase (v4.1) - Prosjektert Rehablitering

Gruppe	Tonn CO_2-ekv/livsløp	Kg CO_2-ekv/m^2/år	Kg CO_2-ekv/bruker/år
1 Grunn og fundamenter	-	-	-
2 Bæresystemer	-	-	-
3 Yttervegg	152	0.7	29.0
4 Innervegg	-	-	-
5 Dekker	-	-	-
6 Yttertak	3	0.0	0.6
7 Trapper og balkonger	1	0.0	0.3
Sum	156	0.7	29.9



Detaljer for modul 12734 Stasjonær energi - Nytt bygg - Fjernvarme og el.bruk

	Tonn CO_2-ekv/livsløp	Kg CO_2-ekv/m^2/år	Kg CO_2-ekv/bruker/år
El	944	4.2	180.8
Fyringsolje	-	-	-
Propan	-	-	-
Naturgass	-	-	-
Bioolje	-	-	-
Ved	-	-	-
Flis	-	-	-
Briketter	-	-	-
Pellets	-	-	-
Solvarme	-	-	-
Fjernvarme	2017	9.0	386.5
Sum	2961	13.2	567.2



Detaljer for modul 12736 Transport - Transport basert på tiltak 2000m til sentrum

	Tonn CO_2-ekv/livsløp	Kg CO_2-ekv/m^2/år	Kg CO_2-ekv/bruker/år
Bil	1985	8.8	380.3
Kollektivtransport - buss	164	0.7	31.5
Kollektivtransport - skinnegående	-	-	-
Varetransport	415	1.8	79.5
Sum	2565	11.4	491.3