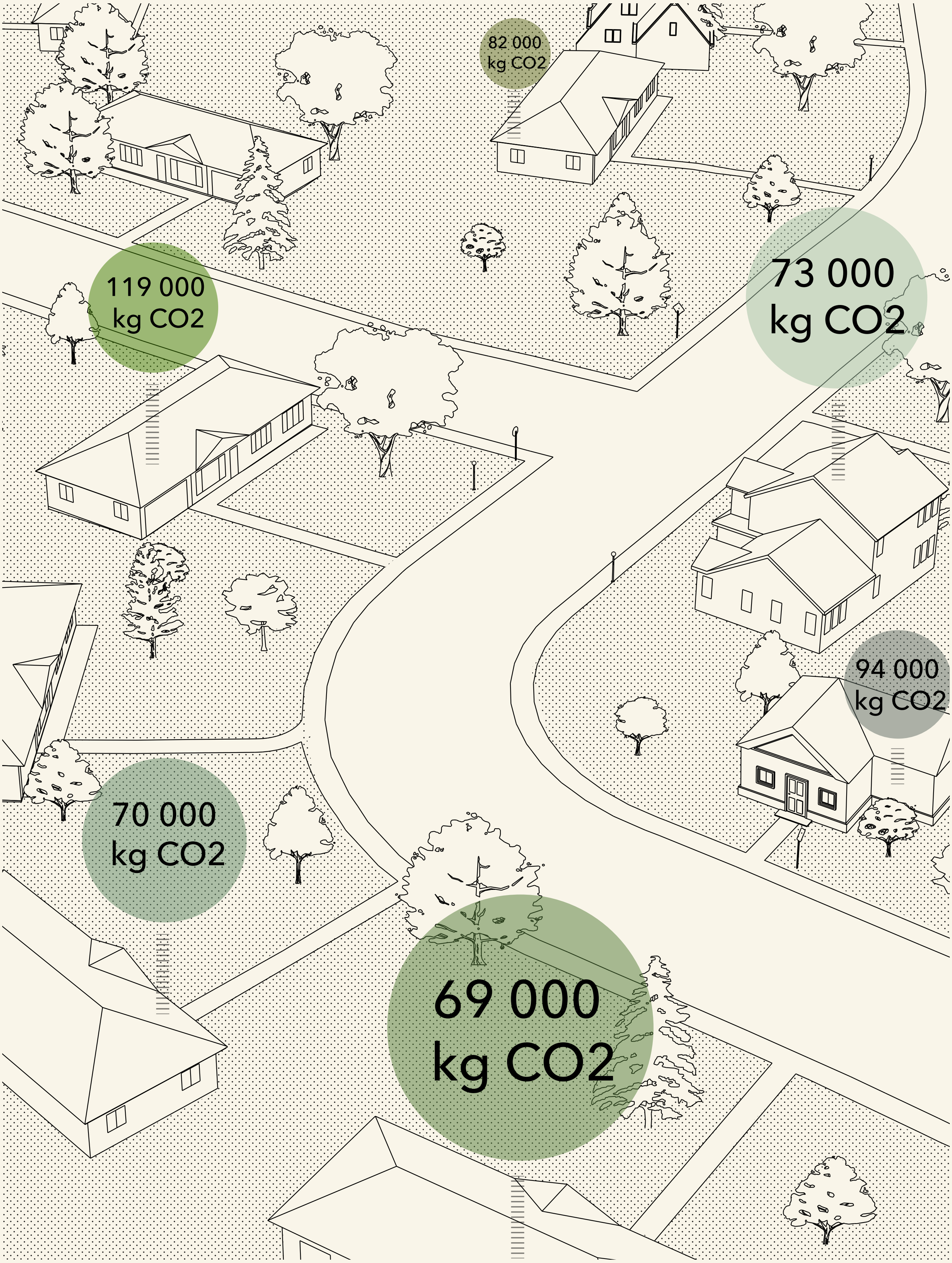
HOW GREEN IS YOUR HOUSE?

Labelling catalogue house's CO_2 emissions
with aid of LCA

PATRICIA LUNDBLAD & JULIA RIBECK



CHALMERS

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Content

Abstract

Of Sweden's 4.8 million households, almost two million consist of privately owned detached houses. The Swedish catalogue house market produces around 4000 new houses every year. This is an industry that contributes to the building sector's large share of Sweden's total greenhouse gas emissions. Despite this, the catalogue house manufacturers lack information about the environmental impact of their houses. With this year's new law from Boverket requiring new larger buildings to be climate declared, it will also become important for catalogue house manufacturers in the future to exhibit their house's CO2 emissions.

The purpose of this study is to examine and understand how to communicate the environmental impact of catalogue houses. The aim is to create environmental labelling of the house's CO2 emissions with aid of life cycle assessment. Together with the labelling, a design proposal for a CO2 optimised catalogue house is created. Both new materials, building components, latitudes and houses lifespans are investigated.

Main research question examines how customers of catalogue houses can be influenced to make more sustainable choices by communicating the house's CO2 footprint in an understandable way with the help of LCA. The thesis subject is explored by using the methods research for design and research on design. Interviews, literature studies, document analysis and study of existing certifications is being conducted. Case studies of catalogue houses, reference project and carbon footprint calculations are executed with the tool CAALA to help apply the information of CO2 footprint into a labelling system.

The result shows that CO2 footprint can be communicated with aid of labelling in an understandable way for a catalogue house customer. The houses can also be compared to each other with the aid of traffic light label bars. By changing the building materials and constructions to CLT-wood and foamglas a significant reduction of CO2 emissions can be done. The roof and foundation are the building parts that emit most CO2. The most green house calculated is a house with a small roof and foundation area, even though that house has the biggest living area.

Keywords: Life cycle assessment, catalogue houses, climate declaration, carbon labelling

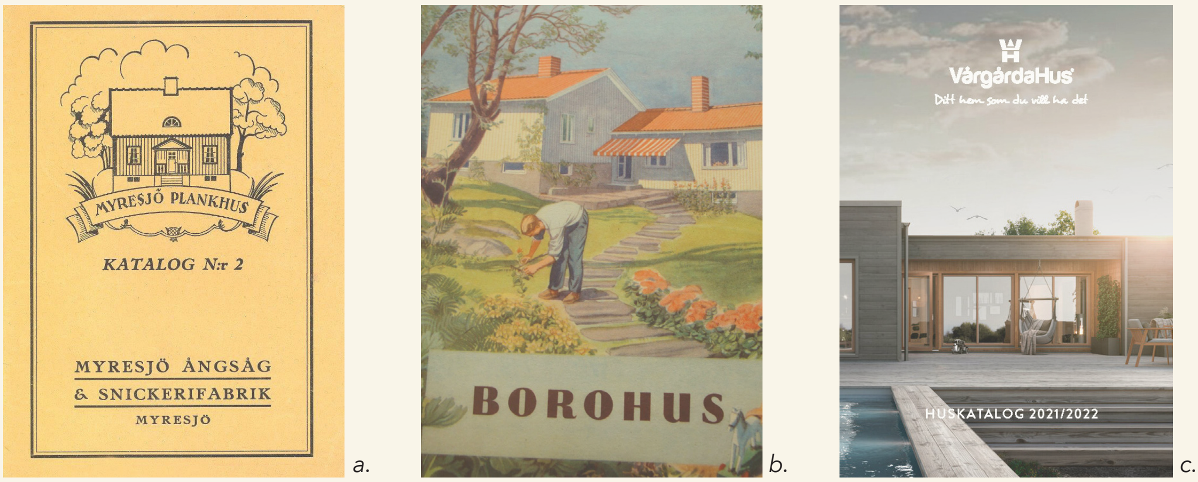

Figure 1: House catalogues: a. 1928, b. 1947, c. 2021/2022.
a. Byggnadsvård Jönköping, 2013, b. Miaw inredning och design, 2010 & c. Vårgårdahus, 2022.

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Research questions

Q1.
How can the CO_2 footprint of catalogue houses be communicated to house buyers in an understandable way with the aid of LCA?

Q2.
How much CO_2 emissions can be reduced by optimising catalogue house's materials and building components with aid of LCA tools?

Purpose and motivation

What is the problem?

When looking into catalogue house companies, it is clear that they lack information and visions for the companies' sustainability goals and the environmental impact of their houses. With the new governmental regulation about climate declaration of buildings in 2022 (Boverket, 2021), it will become important for housing companies to exhibit the environmental impact of their catalogue houses to customers. This type of information is currently not accessible to house buyers.

Why is this a problem?

The category of catalogue house buyers should be seen as a group who can contribute to a sustainable way of living. In general privately owned houses are seen as a less sustainable housing solution which makes it important to start developing better options. We believe that our generation and future generations are more aware of the climate and willing to make more sustainable decisions, including the house you live in.

Aim

How can this be done?

The purpose of this thesis is to clearly communicate a house's CO_2 footprint for people who decide to build a house. The aim is to help house buyers and catalogue house companies make conscious choices, which in turn leads to a positive environmental impact in general. The idea is to label the CO_2 footprint of these houses in a way that is easy to understand. We are using the CO_2 footprint as a measurement of sustainability since it is the most common way of measuring and communicating emissions. It is a dimension that easily can be translated and compared into various relatable contexts.

Background

Our climate is changing and we need to start taking larger steps towards a more sustainable future. According to the United Nations' climate goals we need to reduce greenhouse gas emissions to as close to net zero by 2050 to be able to preserve a livable climate. "*By making choices that have less harmful effects on the environment, we can be part of the solution and influence change*" (UN, 2021).

All steps towards a more sustainable way of living counts, and as the UN stated one way is to make conscious choices and change habits. In today's world there are several ways to communicate and clarify the climate impact of our actions. There are several scientific methods and tools on how to calculate different emissions and impact. Some of the methods are more complicated and some more simple, but all in all the idea is the same: to get people to understand the emissions and footprint of one's actions.

Conscious choices and change of habits does not only apply to individuals, but also to different industries. The building sector has a big impact on our climate. During 2019 21% of all the greenhouse gas emissions in Sweden came from the building industry (Boverket, 2021a). An explanation of why the building industry does have such a big impact on our climate is because it is connected to many different fields that affect climate change such as natural resources, energy and emissions.

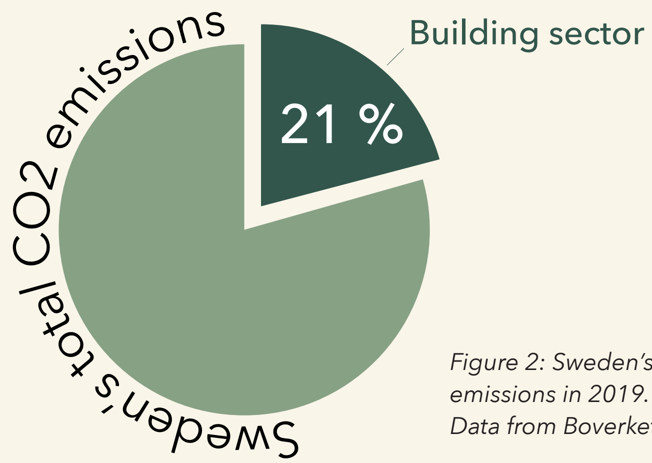


Figure 2: Sweden's total emissions in 2019.
Data from Boverket, 2021a

Sweden's defined goal is to reach net zero of greenhouse gas emissions in 2045 (Ministry of environment, 2020). To be able to reach this goal there are different actions taken by the government and new regulations have been created. Regarding the Swedish building industry the National Building Council Boverket, is responsible to address new regulations that will help achieve the climate goals (Boverket, 2021b).

CO2 emissions on an individual level

Today there are several ways of communicating the environmental impact of a building, such as different certifications and declarations. From january 2022 there is a new law that states the environmental impact of a new building must be declared. A life cycle assessment of the building's construction phase is required in order to get permission to build (Boverket, 2021c).

The growing interest in sustainability on an individual level contributes to greater self awareness of people's actions and what impact they have on climate. The biggest emissions on an individual level are connected to how we live, how we travel, how we eat and how we consume (Spark sustainability, 2021). The climate impact for each Swedish person per year is on average nine ton CO_2. This is significantly higher than the global average according to Naturvårdsverket (2022). To cope with the Paris agreements' climate goal and keep the average global temperature increase below 1.5 degrees, each person's emission levels should be one ton CO_2 per year by 2050. One ton of carbon dioxide is what a person emits only on their household today every year. It can also be equated with a return flight between Stockholm - Rome or 30 pairs of jeans (Zeromission, 2018). Thus, it is easy to conclude that we have to make large reductions on our personal environmental footprint when it comes to household and our choice of home.

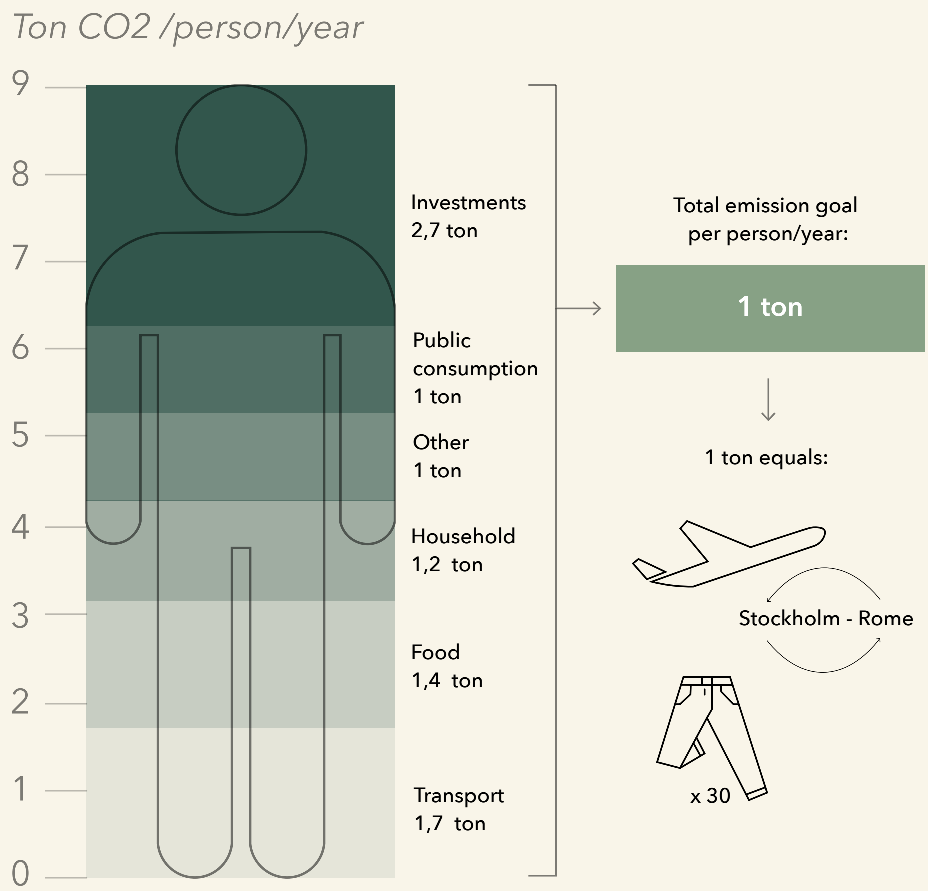


Figure 3: Individual CO2 emissions in 2019. Data from Naturvårds-verket, 2022.

Households

In Sweden there are nearly 4,8 million households. Almost half of the households live in a detached house, most commonly privately owned, and the other partly larger half in an apartment in an apartment building (SCB, 2021). Most villas built in Sweden today are catalogue houses with a national production of about 4 000 new houses each year. A minor percentage of the villa stock is designed by an architect (Hustillverkare.nu, 2021). There are about one hundred different catalogue house companies in Sweden (hus.se, 2022). The company who topped the list of applied building permits by house buyers in 2019 was Älvsbyhus who delivered 440 houses that year. Followed by Fiskarhedenvillan with 390 completed houses and Myresjöhus with 375 delivered houses (Byggvärlden, 2020).

Since the privately owned detached houses are popular it is justifiable to presume that many people still dream of living in a villa. Preferences about how we would like to live in the future can still be changed but if we look at how the Swedish people live today, with nearly half of all households living in detached houses, it is predictable to say that many people will continue to live in their own house in the near future. According to TMF (2021) several surveys show that over 70% of Swedes would prefer to live in their own detached house. And about every third person living in apartments would like to move to a detached house. So if the majority of Swedes would prefer to live in their own house it is highly relevant to take a look at the CO2 footprint, not only on bigger buildings, but also on privately owned houses where the sustainability aspects often are forgotten.

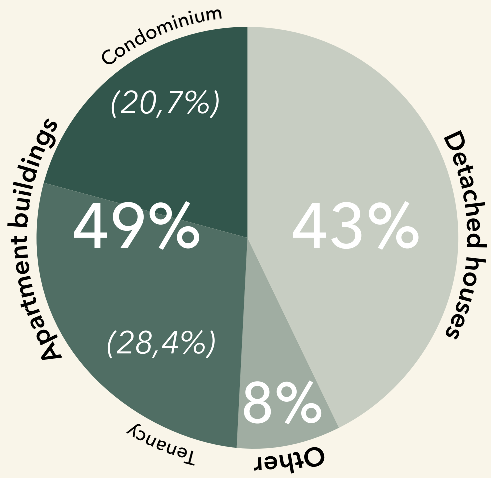


Figure 4: Households in Sweden. Data from SCB, 2021.

Method

Different methods are used when studying and analysing the topic. The methodology is divided into two parts with submethods. In the first part is Research for Design (Theory) used followed by Research on Design (Case study experiments).

Research for Design

Literature studies
Scientific references are conducted early in the process in order to create a theoretical framework. Scientific references about LCA for buildings, sustainable future scenarios and actions for sustainable ways of living are the researched topics.

Document analysis
A desktop research of articles, news, websites and previous master theses is also relevant to support our thesis.

Interviews
Interviews with different house companies and reference project team are being held. It is an important qualitative research technique for this thesis with the purpose to collect information about today's housing market, its vision and existing sustainable houses.

Research on Design

Case study
Six catalogue houses from a chosen housing manufacturer company are being used as case study. These houses vary in square metres and number of floors. Exploratory research on the houses is useful when trying to understand the existing solutions and make a comparison of CO2 emissions. Interviews of the manufacturer and data collection, such as architectural drawings and material calculations, are helpful in the case study.

Carbon calculations
Existing climate calculation tools are used to support the design process of the labelling. Existing climate labelling of branches other than the building sector are explored.

Delimitations

This thesis focuses on catalogue houses intended for private residential use in a Swedish/Nordic context. The environmental impact is being analysed with aid of life cycle analysis. Costs and prices are excluded in these calculations.

As Co2 footprint has been identified as the most comprehensive unit of measurement when emissions are measured, it is used as a unit in this thesis where emissions are compared and clarified.

Reading instructions

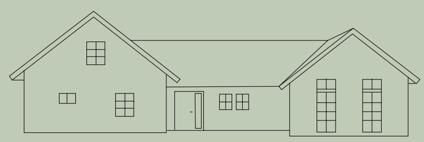
This thesis is divided into two main parts which consist of different chapters. Part one, chapter 1 - 4, is about LCA and the catalogue house market. Part two, chapter 5 - 10, is about labelling and optimisation. The thesis ends with a discussion and reflections followed by references and appendix.

Terminology

Catalogue houses	*Houses that can be bought from a catalogue of a house manufacturer. There are often several alternatives to choose from.*
Prefabricated houses	*A house that is pre-mounted before landing on the construction site. The level of detailing in prefabrication can vary.*
House buyer	*Person who is going to buy a house from a catalogue.*
House manufactorer	*Company that sells, builds and delivers a complete housing solution.*
LCA	*Life cycle assesment.*
CO2 footprint	*A total amount of carbon dioxide.*
Building climate declaration	*A calculation of the climate impact of a building.*
Environmental certificate	*Certificate that clarifies environmental impact.*
Environmental labelling	*Label that communicates environmental impact.*
EPD	*Environmental Product Declaration.*
Embodied	*Energy consumed by construction.*
Operational	*Energy consumed by users.*
CO2-Eq	*Carbon dioxide equivalents.*

PART ONE

Villa D



Villa C

Villa B

Villa A

Chapter one: LCA

LCA stands for Life Cycle Assessment, sometimes referred to as life cycle analysis. It is a method to calculate a product's environmental impact during the product's lifetime or lifecycle (Boverket, 2019a). LCA can be applied to different branches and products but in this thesis it will be referred to the building industry. When doing LCA of a building it is possible to compare different building parts. The calculation can show the designer which of the parts have the most negative CO2 impact. It will then become easy for the designer to troubleshoot if the walls or the foundation for example need to be optimised.

In a LCA the economic aspects are not included. As a complement to LCA it is possible to create a Life Cycle Costing, short named LCC. This is a process that identifies and documents the costs a product has over its lifetime (Boverket, 2019a).

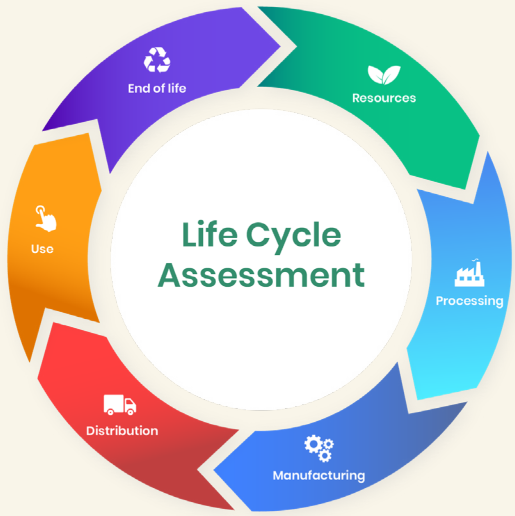


Figure 5: Life cycle assessment stages. One Click LCA, 2022a.

Climate Declaration

From 1st of January 2022 a new Swedish law came into force that affects the whole building industry. Every new building now requires an approved climate declaration before being built. The purpose of the law is to reduce the climate impact when buildings are erected. The responsibility for reporting and implementing the climate impact of a new building lies with the client (Boverket, 2022). The declaration is limited to these certain building parts:

- Building envelope
- Load-bearing structural parts
- Non-load-bearing interior walls

Parts that are not affected are earthworks, installations, furnishings, equipment and surface layers (Boverket, 2022). This new law does not affect all building types. According to Boverket (2022) does a building built by private individuals, where no business is taking place, exempted from the obligation to show a climate declaration. This means that catalogue houses fall into that category and are not yet affected by this law.

EPD - Environmental Product Declaration

When talking about climate declaration the word EPD is often mentioned. EPD was originally founded by the Swedish Environmental Protection Agency in 1998 and is an international program that follows different international ISO certifications and European EN standards. An EPD is used to declare the environmental impact of a product or system from a life cycle perspective (EPD, 2022). When doing an EPD of a building the results get registered in an open climate database. The data of the EPD is verified by an approved independent verifier before being registered and published at the international EPD System (Boverket, 2019b).

An EPD consists of three parts:

- Product data sheet
- Method choice
- Results from the environmental impact assessment

LCA Modules

Within a climate declaration there are something called LCA modules. The building life cycle modules can be explained as the different stages of a building's lifetime. These modules are defined for the European markets by EN 15978 and EN 15804 standards (One Click LCA, 2022b).

The different stages are named by a letter and categorised in chronicle order of the building's lifetime. For example the first stage of building a house is the product stage which is the A1- A3 module. This calculates the raw material extraction (A1), transport to manufacturing site (A2) and manufacturing (A3). Furniture or appliances such as kitchen equipment are not taken into account. Only the building and its parts are being calculated. The other stages assess construction, use stage, end of life and finally benefits and loads beyond the system boundary. If this stage is fulfilled the project becomes a so-called cradle to cradle project (One Click LCA, 2022b). The modules are also categorised to whether their carbon emissions have embodied or operational impact. Embodied impact refers to the greenhouse gas emissions from the manufacturing, transportation and installation of construction materials. Simply put: to build the building. The operational impact refers to the energy consumption of the building - the operational use of energy, heat lighting etc. (Carbon Cure, 2020).

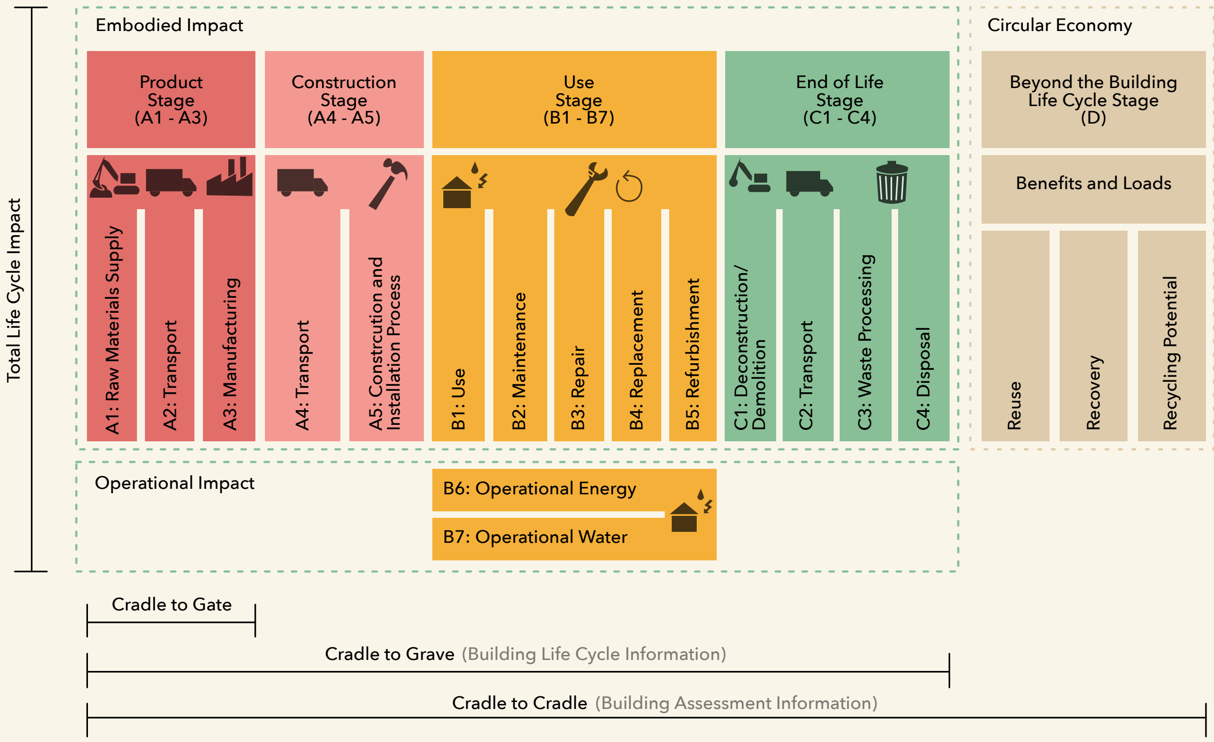


Figure 6: Life Cycle Modules.
Data from One Click LCA, 2022b.

Boverkets requirements today and in future

Climate calculations of different building parts that should be included in the declaration only requires an LCA on the modules A1 - A5. This means that the building's climate impacts are only being reported during the building process. The energy consumption over time is not included and it does not calculate the use phase or end phase, only the footprint of the building. Boverket (2020) has proposed that by 2027 the declaration should be extended to a full LCA which should include module B, C and D. Criticism has been levelled at Boverket for not having a limit value for how much emissions a building may have. Boverket (2022) says that this also will be introduced before 2027 with the goal of setting the rate at about 20–30 % lower emissions than the reference value.

LCA Calculators: CAALA - Computer Aided Architectural Life-Cycle Assessment

CAALA is a life cycle assessment tool with its main purpose to help architects at an early design stage to calculate and optimise buildings from an environmental and cost perspective. The tool calculates Life Cycle Assessment, LCA, which is both the operational energy and embodied energy. It also includes Life Cycle Cost Analysis, LCC, which calculates investment and operational costs (CAALA, 2022). CAALA is described as a Parametric LCA tool which means that you can analyse and make changes straight away in your design and compare the results in real time (A.Hollberg, personal communication, lecture 21 february, 2022). The program is most commonly used as a plugin to the modelling software Sketchup where the designer's construction is modelled as surfaces without thickness. Each area will then be assigned to a pre-installed CAALA layer. You can add your own material and component structure, including U-value and thickness to each layer. Then CAALA calculates the global warming potential, kg CO2-eq/ (m2NFAa), and the primary energy demand, kWh/(m2NFAa) (CAALA, 2022).

CAALA is based on the German regulations and standards where the demand is to declare the LCA modules A1 - A3, B4 + B6, C3 + C4 and D. This gives a more complete understanding of the building's environmental footprint compared to the Swedish climate declaration that today only requires a declaration of the product and construction phase. The materials are based on Germany's climate database Ökobau.dat where you find LCA data of different building materials.

Figure 7: CAALA logotype. CAALA, 2022.

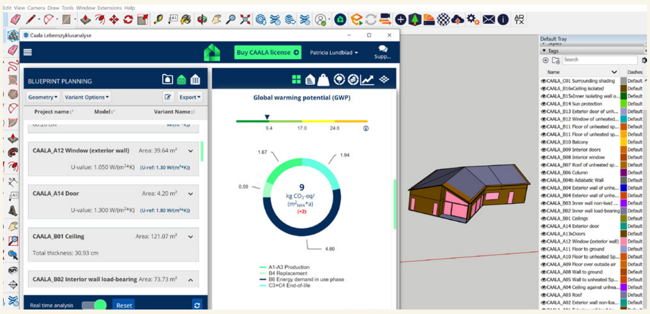


Figure 8: Printscreen CAALA used in Sketchup.

One Click LCA

One Click LCA is another life cycle assessment tool that is developed by Finish company Binova Ltd and was released in 2021. One Click LCA (2022c) is approved by Boverket and uses not only Boverkets Swedish climate database for materials but also the international EPD system and the German Ökobaudat. The program can be used as a plugin for BIM modelling programs such as Revit where the designer can add their specific materials and data of their own building model. Both LCA and LCC can be calculated. One Click LCA (2022c) can do calculations on all lifecycle modules but from the Swedish regulations, Boverket only demands a climate declaration of the early stages of the building process which includes stage A1 - A5.

Figure 9: One Click LCA logotype. One Click LCA, 2022.

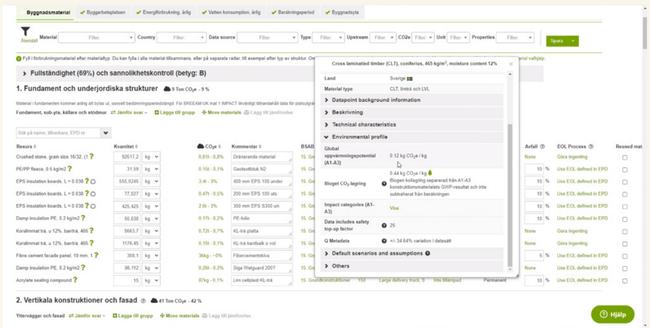


Figure 10: Printscreen One Click LCA interface.

Chapter two: Catalogue houses

In Sweden when talking about privately owned detached houses the word villa is commonly used. Swedes have got a saying "Villa, Volvo, Vovve" which stands for an idealisation of what many Swedish people dream of having in life. For a Swede the word villa does not necessarily mean a grandiose palace, which the origin word stands for. Historically, the term villa was first used in ancient Rome, where it meant larger palace-like buildings where the emperor and other distinguished patricians moved most of the year to get away from Rome's unhealthy urban environment (Björk et al., 2015). The idea of the villa is based on the idea of a healthy and wholesome life surrounded by nature in the countryside, away from the dirty city (Andersson et al., 2004).

Catalogue houses in Sweden

A house that you own yourself and whose design you have been able to influence is for many people the ideal dream of the perfect home. But not many people are able to build a house with the help of an architect or have the knowledge to design it themselves. From that point of view, the idea of catalogue houses began to take shape. The idea to sell houses via a catalogue got its breakthrough in Sweden 1910 with the company Borohus, who is still active today and was one of the first to develop the idea of catalogue houses. Myresjöhus, another catalogue house company who's still active today, was the first company to establish a finished catalogue in 1927. Myresjöhus is today the oldest catalogue house company in Sweden that has been continuously in operation.(Andersson et al., 2004).

Top 10 most common swedish catalogue house companies in 2019:

- Älvsbyhus, 440 (houses)
- Fiskarhedenvillan AB, 390
- Myresjöhus, 375
- Eksjöhus, 347
- Smålandsvillan, 303
- A-Hus AB, 243
- LB Hus, 202
- Hjältevadshus, 152
- Götenehus, 151
- Vårgårdahus, 148

Figure 11: House companies in Sweden. Data from Byggvärlden, 2020.

Around the time when Myresjöhus was established in the early 1900 the Swedish concept of "Folkhemmet" (home for the people) and "Egnahemsrörelsen" was created. The strongest motive to the rise of Egnahemsrörelsen was to counteract the emigration to America which took place in Sweden during 1860 - 1910, due to difficult and poor times with agriculture. People wanted to build better lives in either America or in the cities. To slow down the large influx of people moving from the countryside to the cities, Egnahem contributed with a loan from the state to those who wanted to build their own house. These loans were eventually extended to single-family homes, which gave rise to the detached house areas on the outskirts of the cities. During 1950 - 1980 almost 600 000 detached single-family houses were built (Andersson et al., 2004). That is almost 20 000 houses per year. This was around the same time as the construction of the Swedish Million program, which reached a larger publicity and statement in our history.

Sustainability of the catalogue house industry

At a first glance at the catalogue house companies websites and physical sales materials there is not much about the companies sustainability. The main homepage of their website pushes on costs and what different house models the company has got. When looking further onto the website of the ten largest catalogue house companies, most of them have got a selection that says sustainability where you can click and read about how the company works with sustainability. Most of them explain what different heating systems they have got for their houses and their building process of modules done in their own factory as arguments for their work with sustainability. Using wood as the main material and a well insulated building envelope is another reasoning.

Some of the companies state that they use different certifications and systems to label the environmental impact of their industry. These are the certifications that occur at the catalogue house companies today:

Energy classification

All homes that are sold or rented must account for energy declaration. This is in accordance with the law introduced by Boverket (2021a) in 2014 on behalf of the government. This law exists to promote energy savings in buildings and in a clear way report how high a home's energy use is for home buyers. As a property owner, you need to hire an energy expert who performs the energy declaration. In the case of a newly built house, an energy declaration must be made no later than two years after the house has been taken into use.

The energy use is reported in different energy classes on a colored scale from A - G, where energy class A stands for low energy use and G for high. This label is similar to the classification made today of electronic items such as TVs and refrigerators. Since most electronic products that are being sold today are mostly new products, they usually end up in energy classes A - C. When it comes to residential energy classes it is more common to see buildings with one of the low energy classes D - G since energy declarations of older buildings also are made. Today's new constructions must end up as a minimum in class C in accordance with the requirements set out in Boverkets (2021a) building regulations (Boverkets byggregler: BFS 2011:6).

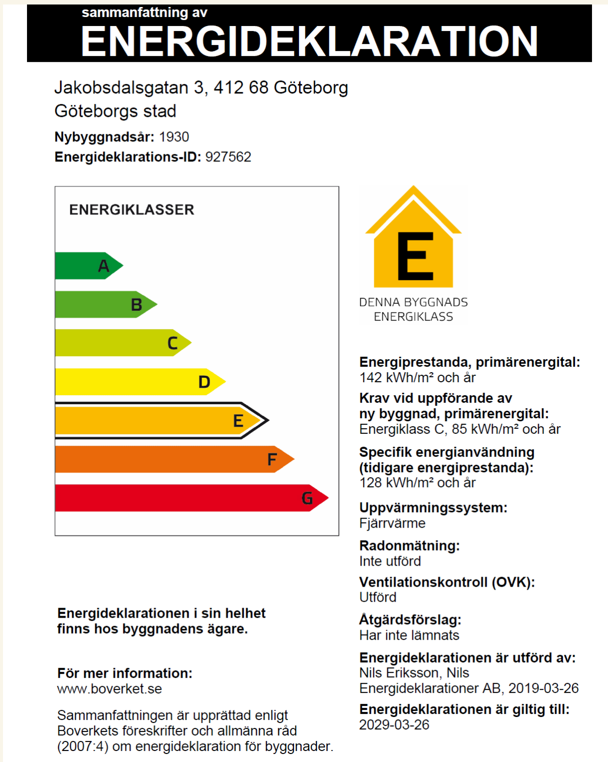


Figure 12: The Energy Declaration. Boverket, 2021a.

A: up to 45* Passive house
B: 46 - 67* Low Energy house
C: 68 - 90* Requirement for new buildings
D: 91 - 121* Low consumption
E: 122 - 162* Most existing buildings in Sweden
F: 163 - 211*
G: 212* and above
*kWh/m2/year

Data from Energisnåla hus, 2022.

Green Mortgage (Grönt bolån)

Many banks in Sweden today can offer something called Green Mortgages where their goal is to encourage their customers to build more sustainably. In this case, the banks have linked their interest rate to a building having a certain energy class in its energy declaration. If your building reports class A or B, the bank gives you a discount on the mortgage (Boverket, 2021b). This is something that is mentioned by several catalogue house companies, for example Fiskarhedenvillan (2022a) and Vårgårdahus (2022), who say that they can help customers build climate-smart houses by giving the customer the freedom to create an individual energy classification.

BREEAM

This is today's market's most used environmental building certifications and also the oldest. The performance of the building is assessed by energy use, indoor climate, water management and waste management. With the Swedish version BREEAM-SE it is possible to certificate a building according to the Swedish regulations and standards, and at the same time get a certificate that can be internationally compared. The building's total achieved points are generated to a grade. The different grades are Unclassified, Pass, Good, Very good, Excellent and Outstanding (SGBC, 2018).

Miljöbyggnad

One of the most well known building certifications in Sweden is Miljöbyggnad which is run by Sweden Green Building Council. Miljöbyggnad uses a grading system where a building gets certificated as either Bronze, Silver or Gold. The building is examined on the basis of its energy values, indoor climate and building materials. Within three years, an inspection of the building is carried out to see if the performance of the certification is still maintained (SGBC, 2021a).

Svanen

Svanen (2022a) is a Nordic ecolabel system which works with ecolabelling in many different areas, including buildings where both single-family houses, apartment buildings and buildings for schools and preschools can be labelled Svanenmärkt. The goal of this label is to create buildings with a healthy indoor environment and with as little impact on the environment as possible. Before creating an ecolabelling of a building, Svanen (2022a) examines the building from a life cycle perspective. Requirements are set for energy use, chemical products, construction products / materials and indoor environmental factors that are relevant to human health and the environment.

NollCO2

Another certification done by Sweden Green Building Council is NollCO2 which sets requirements for a building's emissions of carbon dioxide. It is a requirement that the entire building's life cycle analysis, LCA module A-D, is reported and balanced with climate measures to a net zero climate impact. The two main purposes of the certification is to heavily reduce CO2 emissions from the production of building components and construction and to balance the remaining climate impact of the building by compensating for it´s CO2 emissions. NollCO2 has to be used together with another certification such as Miljöbyggnad, Svanen or BREEAM-SE (SGBC, 2022).

Chapter three: Case study and LCA of Vårgårdahus

This thesis examines six different catalogue houses from Vårgårdahus. There are two examples in each three categories: 1-floor, 1.5-floors and 2-floors. They vary in square metre and shape but have the same construction principles. Vårgårdahus is informed that their houses are being analysed in this thesis and has participated in the work by contributing drawings to one of the case study houses. The reason why houses from only one company is analysed is because when comparing different catalogue houses from several companies one could tell that the main features do not vary between the companies. The building components, structure and energy system is basically the same. What differs is what kind of service the company can give to the customers. For example the possibility of personalising your house by bringing your own drawings or changing the floor plan from original house models.

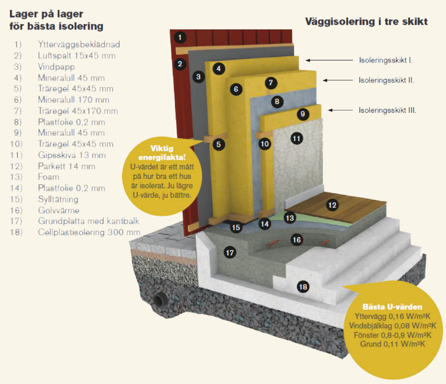


Figure 13: Wall section Vårgårdahus. Vårgårdahus, 2022.

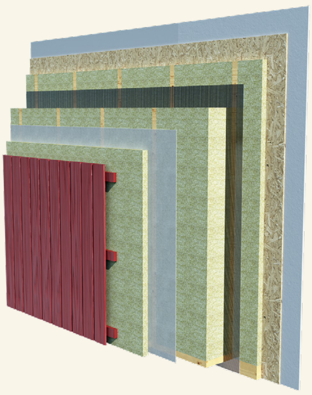


Figure 14: Wall section A-hus. A-hus, 2022.

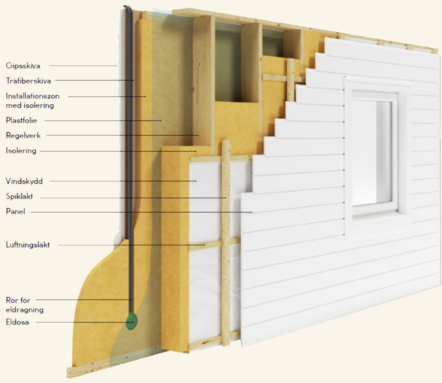


Figure 15: Wall section Trivselhus. Trivselhus, 2022.

Villa Djupvik

The first house of this LCA case study is the house model Villa Djupvik. This one floor, angled house is described as one of Vårgårdahus most popular models. The building is conventionally built with a structure of wood, foundation of concrete and a roof cladded with concrete tiles.

Total living area:
(NFA) 156,5 m2
Bedrooms: 4
Ridge height: 5 m
Building height: 3,2 m
House kit price from:
2 002 000:-

Figure 16: Perspektiv Villa Djupvik. Vårgårdahus, 2022.

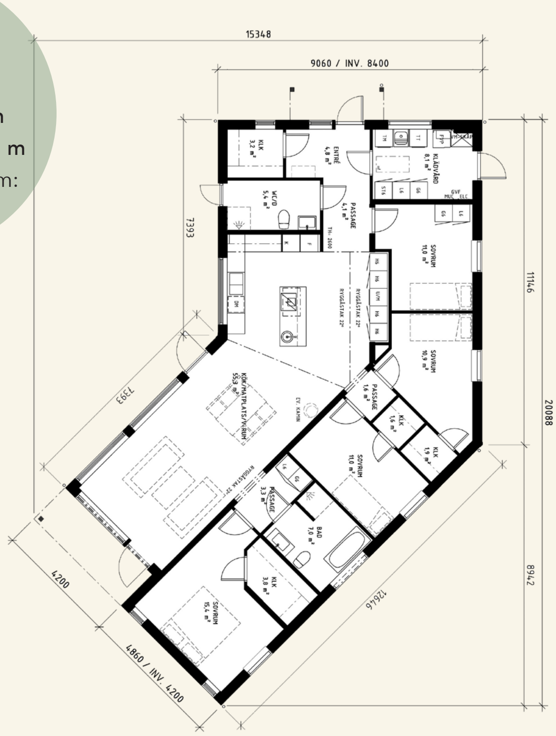


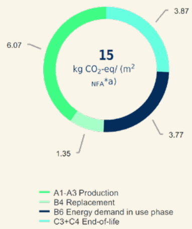
Figure 17: Plan Villa djupvik. Vårgårdahus, 2022.

CO2 results of the houses

Results of LCA calculations done in CAALA on the six houses from Vårgårdahus are shown below in the circle diagrams. They all have the same starting point with the same material and same structure in the building components. The results are shown in kg CO2-eq per NFA square meter times 50 years (based on the house lifespan of 50 years). The total CO2 emissions are shown with the big numbers in the middle of the circle and are based on the modules A1 - A3, B4, B6 and C3 + C4 which are shown with the colours in the outer circle. Calculations on life cycle costs and primary energy demand has not been taken to account.

1-floor

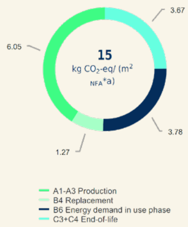
Villa Djupvik



NFA: 156 m2

4 bedrooms

Villa Vinö

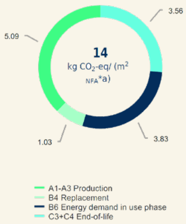


NFA: 146 m2

3 bedrooms

1.5-floor

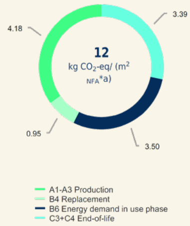
Villa Sävelund



NFA: 182 m2

4 bedrooms

Villa Hagalund

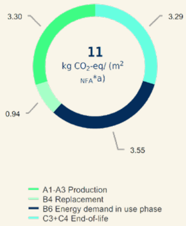


NFA: 138 m2

3 bedrooms

2-floor

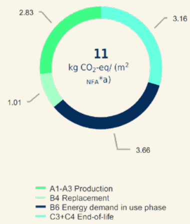
Villa Rosendal



NFA: 186 m2

4-5 bedrooms

Villa Ekerö



NFA: 195 m2

4-5 bedrooms

CO2-eq: The results shown in the circle diagrams are linked to GWP, Global Warming Potenital, which defines the building's CO2 emissions. GWP is a value of how much different greenhouse gases affect global warming (EPA, 2021). Gases such as carbon dioxide, methane and nitrous oxide have different effects on the climate and to be able to compare them, all gases are converted to carbon dioxide equivalents CO2- eq. The gas methane has a GWP value of 21, which means that emissions of one ton of methane heats the earth 21 times more than emissions of one ton of carbon dioxide (Klimatordlista, 2015).

Chapter four: Interviews and analysis

Summary of Interviews

Five catalogue house salespersons from different companies were interviewed to be able to understand the catalogue house market, business and the customer needs. The interview guide, that can be found in the appendix, was used in all interviews. One of the interviews was conducted by telephone but all the other four were performed face to face. The companies chosen for the interviews were A-hus, Eksjöhus, LB-hus, Smålandsvillan, and Vårgårdahus which all are from the top 10 of the biggest selling catalogue house companies in Sweden (Byggvärlden, 2020).

All of the five salespersons have been working with this type of business for at least 5 years. All of the interviewees were men between 32- 60 years old. They all come from different backgrounds, two of them have been studying at university where one of them has a masters degree in business and the other has a masters degree in law. The other half have started to work as salespersons directly after high school. Some of these salespersons work directly for the company which pays their salary and some are consultants, meaning that they only get a salary if they sell the product. Almost all of these salespersons have an office in connection to their companies' presentation houses that are all located in an area called Husknuten in Gothenburg. Husknuten contains 38 catalogue houses from different companies that can be visited. (Husknuten, 2022) This area is one of its kind in Sweden, there are only two of these presentation house areas in Sweden, one in Gothenburg and the other one in Arlanda, nearby Stockholm. All of these salespersons work in the Gothenburg area and the areas nearby.

All of these salespersons sell houses of their companies and the business idea is the same. The customer chooses a design from the company and the company helps the customer build the house. The product, the house, these salespersons are selling is more or less the same. Price, design, construction, the process from a calculation and drawing to a physical house differs little in between the companies.

The product is a catalogue house, a house that can be bought by a customer that owns a plot. According to the salespersons, the hardest part of their job is not to sell a house but to find a suitable plot. Some of these companies sell plots with some of their house models connected to the plot, some help their customers to try to find a plot and some just wait for the right customer with a plot to appear. There were also a couple of companies who purchased a bigger site and built more than one house and later on sold the house with a plot. During the last few years these companies have had a lot to do because people have had time to plan their future homes during the Covid-19 pandemic. People have mostly been at home and that has impacted how important the home or the house we live in is. All the salespersons state that the customer who owns a plot is the easiest customer to do business with.

"Word by mouth" is the best way to get in touch with new customers. This means that the customer has heard good things about the company and wants to build with them in future. Also marketing via Instagram works good when people are showing their houses both as finished but also during the building process."

The process when first meeting with the customer usually is about teaching the customer about their house, how it is built and what is the most common process from a drawing to a complete house. All the salesperson explained in one way or another that the most important thing is to create trust between the customers. Also the time aspect plays a big part when a customer plans to build a house.

About the process from plot to house

For all the customers the process before starting to build a house is similar. The most common way is that the customer has purchased a plot. They are aware of their budget and have certain dreams or fantasies of their future home. There are different houses to choose from and by meeting the sales representatives and salespersons from different companies they get a better idea of different companies, how they work and what they offer. Buying a house is one of the biggest private economic choices the customer makes during their lifetime and that is why the process looks different for different people. Two of the salespersons, these two who have worked as salespersons for more than 15 years, state that they have the possibility to choose the customer, the one they connect with. One of them stated that he only liked to work for nice people, and he said that he usually feels which customer is suitable and nice to work with. The other salespersons did not talk about choosing the customer, but all of them talked about how it is a journey with the customer, a contact that lasts about 1 - 2 years. When choosing the house type, some of the salespersons are more involved in the product and production cost calculations while others are more busy in drawing the dream house of their customers.

More expensive houses, with special solutions are more commonly purchased in the more expensive areas, and more simple house variants are purchased in other areas. The one floor houses are more common a bit outside of the cities because then the plots are often larger than in cities. The 1,5 floors and 2 floor houses are more commonly built around cities. Two interviewees also said that they always recommend building 2 floors instead of 1,5 floors but sometimes the detail plan delimits the height of the house and then 1,5 floors is a good alternative.

All the salespersons state that the budget is the biggest factor limiting the house affair. All of them mentioned that the people building houses are usually families in different stages of their lives, some of them are young couples often with smaller children but also older people who want to build their very last home. One of the companies, the one selling the cheapest house models and modular houses, states that their customers are often the ones buying and building their first house. Three of the salespersons stated that their houses are sold for all customer groups. Another stated that their customers often have owned a house earlier and they offer premium houses for the customers who have money to make the more exclusive choices in terms of more individual solutions when it comes to architecture and interior design in general. The company that sells the modular houses said their customers want to get as much of the house as possible for the money they have. They said that the customer often plans to build the upper level later on.

"Those who buy and are older have a different mindset. They have a different economy and want the process to be comfortable. They may prefer a one-story house. The younger ones who buy often want as many bedrooms as possible. The elderly may purchase the same model but they merge certain rooms or create a spa or another type of room instead of regular bedrooms."

Customers' design freedom

The open floor plan has been popular for a long time period but three salespersons said that customers now want the kitchen area or living room to be separated a little, but it is still important to have the connection between the spaces. The other salesperson said that the L-shape has become more popular, because it is easier to plan the floorplan and get good daylight inside. The kitchen is a room according to the premium brand where people put a lot of money. This salesperson thought that people spend more time around the kitchen table nowadays compared to the living room. "Nowadays people sit with their phones and Ipads instead of watching television together." He also stated that their customers earlier wanted to build large spa and saunas but nowadays that interest has decreased.

Two companies offer the possibility for customers to influence the design of their house both in the dimensions, such as extending and widening a finished house, or in drawing their own floor plan. The salesperson and the company's architects help to design so that the house meets the various requirements that are placed on, among other things, accessibility and fire.

"The biggest difference today compared to 10 years ago is that the customer is loaded with details, colours, thresholds, handles etc. They talk about different choices and are aware that there is a lot to choose from. I think this awareness rises because we follow social media."

When it comes to wrapping up the budget it often occurred to the customer that they should exclude some of their choices made in the beginning. The groundwork or other things such as the idea of a garage or a terrace come to their mind during the process and they need to re-prioritize their budget. The fireplace is often one of the details that will be excluded.

How is the house built?

All of these companies have a different style when it comes to building the house. There is one company which works with dimension CC 600mm. That means that the outer walls always have certain dimensions. This company pre-produces their walls in the house factory and then transports the premade walls to the plot. Some of these companies produce prefab walls but otherwise build all the rest from the beginning.

One of the companies offers houses built entirely in modules. These houses consist of mass-produced modules, which means that you as a customer do not have any greater freedom to change any of the house's design. Hence the low price of this type of house model. The less you can change as a customer and the more you can rationalise and simplify with a house, the cheaper it will be to build.

Building process

How much the salespersons are involved in the process when building the house differs between housing companies and customers. Some housing companies offer one contract for the whole production process, meaning that the customer pays money for the building at once. One of the companies addressed that they have different contractors, and that means that the customer pays for each and every builder for what they do. The company that offers this type of a solution for building the house says that the craftsmen are more committed to work and do a good job when they have direct connection to the customer and when they get paid for the job they performed. The other companies argued that it is easier and more comfortable for the customer to have contact with one project leader at the building plot and pay the whole production process bill at once.

The process also depends on the building permit, how long it takes to get an answer from the authorities and how many changes they ask for. The regulations according to accessibility can be hard to fulfil, so special solutions might be needed sometimes.

"A big task in the role of a salesperson is to try to get these documents to work together with rules and regulations so that the house can be approved for construction."

Complains

All the salespersons complain about the tuff building regulations in Sweden and how complicated the building permit process has become. One of the salespersons said that he thinks all the houses look more or less similar due to these regulations - when you need to have a bedroom, one master bedroom and a kitchen on the first floor the floor plans, they begin to remind each other. All of them were also disappointed about how long the building permit process takes and how much the process can differ in different municipalities or how much the result depends on one individual.

"The building industry is conservitive."

Sustainability

When it comes to sustainability the salespersons said that the customers were not interested about the subject when building their own house. They said that it is very seldom they have been asked questions connected to sustainability. All five salespersons talked about the passive house trend that they identified 10 years ago. Back then there were some customers who asked about the passive house but during that time it was very expensive to build a house with passive house standards. They did not offer passive house solutions because it was very expensive and too complicated to build. Three of the salespersons mentioned that some customers have asked about green roofs, sedum roofs, but no catalogue house company on the Swedish market offers that type of solutions.

"If all houses in the future need to meet the climate requirements set by climate declarations, I believe that a passive house must be built then."

One of the companies offered more sustainable appliances for the kitchen a couple of years ago. These appliances saved more energy compared to the standard refrigerator and freezer and were more sustainable. But none of their clients chose these appliances so the company decided to take away that choice.

When it comes to energy efficiency the customers were mostly concerned about today's rising energy prices. The discussion of different energy systems, both for warming the air and the water inside, have been more on the top of the table than earlier. All the catalogue house companies talked about the energy system they used and they also said that all the companies use the same because the system, called air heating system, is the best on the market. It is one of the most effective systems you can get for a reasonable amount of money. Some of the heating systems might be better but the pay-off time is way too long. One of the salespersons said that he asked his customers to visit the NIBE webpage (the biggest producer of heating systems) and calculated which energy system is most suitable for them. Economically nowadays the air heating system is the best on the market. Some of the customers have asked about the U-value of the walls or windows but that question is very seldomly asked, said the salespersons. Some salespersons knew what values they had, some did not remember that at all.

"The houses are well built today. About U-value, I do not know. When there are regulations that should be followed, then something will happen. Otherwise, it is too expensive to run such an environmental project in parallel to ordinary business. Ecolabelling - too much work."

The discussion about the lifetime of the catalogue house also came up. One of the interviewees from the premium brand said that their ambition is to build a house that lasts 100 years. Still there are many things to be maintained, rebuilt and changed but the ambition is that the house lasts over time. The oher companies mentioned 50 years. One of the salespersons continued and said that the house at least needs to be updated in terms of changing the roof, windows, warming system etc.

Some of them told us about their walls and that they have constructions that have been tested and are sustainable. With sustainability he meant that the material that is mostly used is wood and the construction has been designed in a way so that it would last long. One of the salespersons talked about the installation layer, that with the aid of the wall design the electrical installation can not be attached from inside. Wood as material used also raised up as a sustainable choice when building. Some of the salespersons still admitted that wood is chosen as material because it is also the most economical choice. The foundational work is usually made out of concrete. There is one company who told us about their foundation that there is more isolation and only a little concrete (isolergrund). He was not able to compare those two options but he said that it might be then better alternative than concrete foundation.

One of the salespersons said that he refuses to sell solar cells for his customers. He tells the customers that they need that money for some furniture, terrace, grill and so on. He recommends his customers to continue to live their life and do other things than only put all the money on the house. He also says that he tells the customers to wait a couple of years with solar cells because they are continuously being developed and there will be better and cheaper alternatives on the market in the future. The other salespersons said they sell solarsells, but it can vary depending on the customer's budget. The charging posts for electric cars are sometimes installed or if not, they might be prepared for the future.

"What attracts today's customers to buy and install solar cells is that it is an energy system that can "pay-off" after 10 years."

One good example that came up when talking about sustainability in general was that their supplier delivers more items than ordered. For example roof tiles - there are a lot more roof tiles delivered than ordered. He analysed that when it comes to roof tiles there is a big risk that part of the material gets broken during the delivery, transporting och during lifting the material to the plot. He also said that the delivery cost is a big cost compared to the material delivered and because of that it is better to deliver more than asked. He continued that it is good for the house owner to have some extra tiles if some might drop down or if the amount of tiles will cover a roof for a garage or other complement buildings.

We asked how many square metres per person the customers are planning to build the house for? All the salespersons answered that none of the customers think about how many square metres per person they should build. All the customers want to build a house as big as they can get with the money they have. If you do not have enough money to build as big as you wish, the customer saves money and sells the house after a couple of years to be able to move into a bigger house or build a bigger house of their own, and in that way make a housing career.

"Customers choose a house as big as they can afford. It is rare to think that we choose 15 square metres per person… but it may come in the future."

One of the questions asked was: what is sustainability for you? This question gave most different answers in between the attendances. Some of the attendees described what is important to think in terms of sustainability when it comes to the catalogue house business while others widened the perspective and talked about how we would live in the future. One described that it is important what materials are being chosen. He said that they have their product department who is dealing with these types of questions. The other salespersons said that their houses are so well optimised and built with high quality that their construction will last through all the wind and snow volumes that come in future. One also said that it is important to take care of the maintenance of the house. He said that they give the customer an USB stick with all the information about the house and the guarantees, as well as how the house should be maintained.

Recycling was another subject that came up but also buying less and consuming less, taking care of what we already have. One of the salespersons who has children also mentioned that the sustainability for him is that the future generations still can enjoy and live their lives as we have been able to do.

One of the companies had made a project house called "One Tonne Life" together with the architect Gert Wingårdh. The idea with this project was to, together with multiple sponsors such as Volvo and Vattenfall, raise awareness of different building techniques and that it is possible to build a house with a low carbon dioxide footprint and simultaneously being a house that is as energy efficient as a low energy house. The project was successful, it gained a lot of attention especially in the building sector. Still the project did not raise that much attention among ordinary people, people that are building- or planning to build a house. One reason for that could have been that the technical solutions were complicated and expensive.

What do companies have in their minds for the future?

The premium house company said that they have the certification Svanenmärkt for all their houses and that they are about to do ISO- certification for all of the houses. One of the companies said that they could do something with their concrete ground. Foam glas could be a more sustainable alternative.

Salespersons quotes

Money

"If you could get a lower CO2 footprint for the same money, then it might work."

Customer needs

"In ten yeras people will have a different mindset!"

Sales persons attitudes

"The only thing that never changes is that everything around us changes all the time!"

"Climate declaration? Yes it will come for sure. Then there will be another document that need to be filled in and ticked off. No one ever reads all the paperwork the customer receives."

"The materials used in the houses are durable and tested, so I do not know if we can do more."

Marketing material: catalogues and internet

All the companies have more or less the same material introduced on their website and in their catalogues. Overall, the information is easier to find on websites, but the local information and more details is easier to get when contacting the salespersons. Catalogues differ between the companies. Some of the companies have more up to date material, others have more old pictures. The difference is quite big because the interior pictures and atmospheres between the companies differ. All the catalogues contain a lot of information and there are several books and papers that are given for a house buyer. The material is quite spread and you need to read through all the material to be able to address that specific company's agenda.

The sustainability could not be seen in the catalogues. Some Svanen label or a section about energy efficiency was introduced. Otherwise there was nothing about sustainability in those catalogues we were able to gather when visiting Husknuten. When visiting the websites of the ten biggest catalogue house companies, there were only two companies that had their own "chapter" to a site called sustainability. The other companies mentioned sustainability when they talk about the house construction qualities or about the age of the house. Also due to the energy efficiency law, all the companies show their energy efficiency qualifications.

Future catalogue house buyers

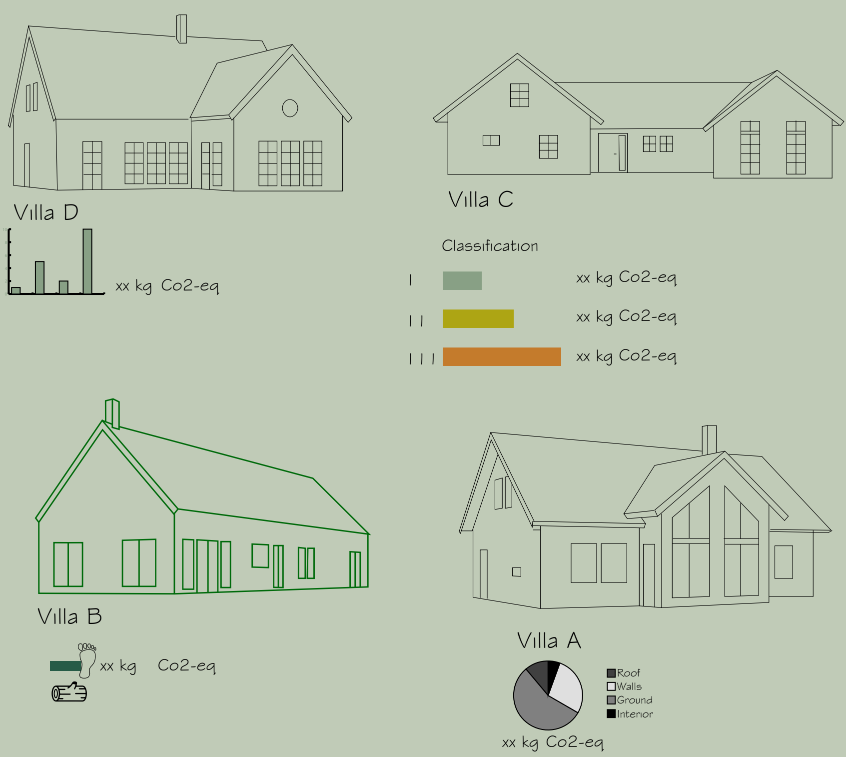
One of the reasons why we believe that the interest among house buyers will demand more sustainable houses in the future is because of what we see around us in the media right now. Examples of sustainable houses and new ways of building are being exposed to us through Swedish architecture tv-shows such as the popular Husdrömmar or Grand Designs. People get served with new knowledge and inspiration. There's also examples of famous people who are involved in environmental housing solutions, like the Swedish skii star Anja Pärson, who together with her wife has got a YouTube series where the viewer can follow the couple when building their new house with the aim to be the most sustainable house in Sweden. Another example of a project that tries to push the boundaries of sustainability within the housing industry is this thesis' reference project Villa Zero. A project with the aim to transparently reach out in several media platforms.

We believe that media exposure like this has an effect on people's demands and way of thinking when wanting to build their own house. The knowledge no longer stays with the architects or builders, but also reaches out to the house buyers who nowadays come with a lot of their own ideas for new solutions.

Summary

- House buyers will build a house as big as they can get when it comes to their budget or the limitations on the plot.
- The awareness in environmental questions is not raised, there are many other big and small decisions that need to be made.
- The companies could teach or educate the customer to think about the CO2 emissions and the future of our planet.
- The customer follows trends - we hope it will be a trend in future to build sustainable houses.
- When the climate declaration will become actual for the catalogue house industry then the majority of companies need to start with climate calculations - at least.

PART TWO


Villa D
xx kg Co2-eq
Villa C
Classification
I
II
III
xx kg Co2-eq
xx kg Co2-eq
xx kg Co2-eq
Villa B
xx kg Co2-eq
Villa A
Roof
Walls
Ground
Interior
xx kg Co2-eq

Chapter five: Reference project Villa Zero

"Form follows footprint"

Figure 18: Villa Zero. Fiskarhedenvillan, 2022b.

In 2021 the construction of the development project Villa Zero took place. A project with the goal to build a carbon neutral detached house with sustainable construction solutions and building materials that will be done in 2022. Villa Zero is built in Borlänge and is a collaboration between the architecture firm Mondo arkitekter, catalogue house company Fiskarhedenvillan and construction company Structor. The project is also being partly funded by the municipality of Dalarna (Fiskarhedenvillan, 2022b).

M. Gesar and J. Grundström (personal communication, 13 April, 2022), who is one of the architects and one of the engineers working with Villa Zero says the project started with the question "what would a house look like if the climate is the customer?", which led to the project's concept "form follows footprint". The team had a hard time finding a client willing to live in this house since it is an experimental project with its purpose to educate the building industry. In the end, the CEO of Fiskarhedenvillan became the client of the house and the one who is moving in. One requirement from the user was to keep the house on one floor and to have a flexible floor plan with a rentable part. The house ended up being one floor of 104 m2 and designed to still fit a regular family of four persons with two adults and two children.

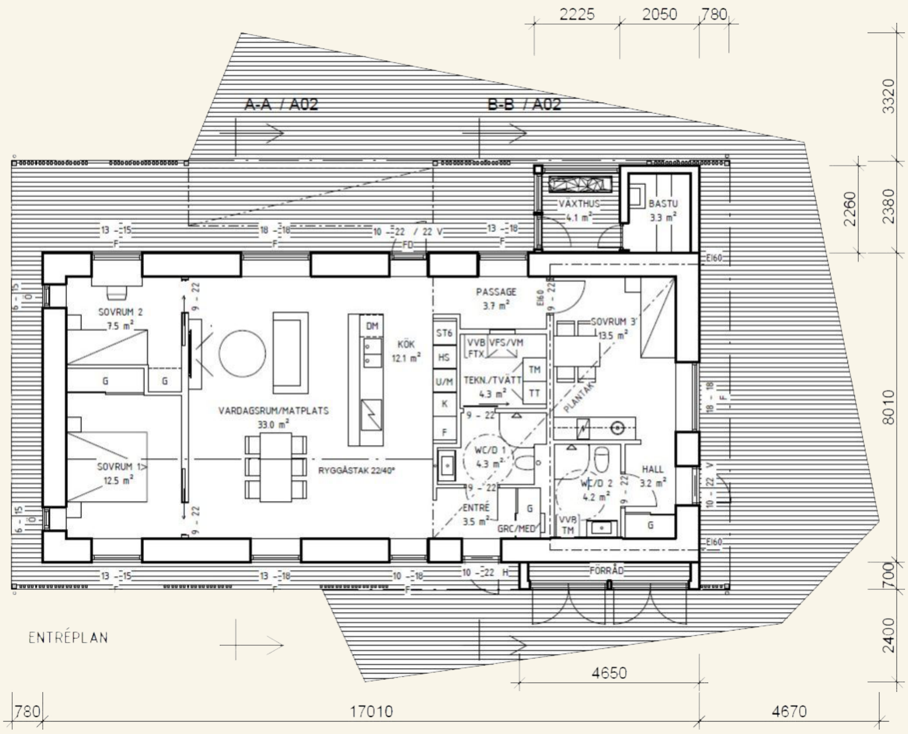
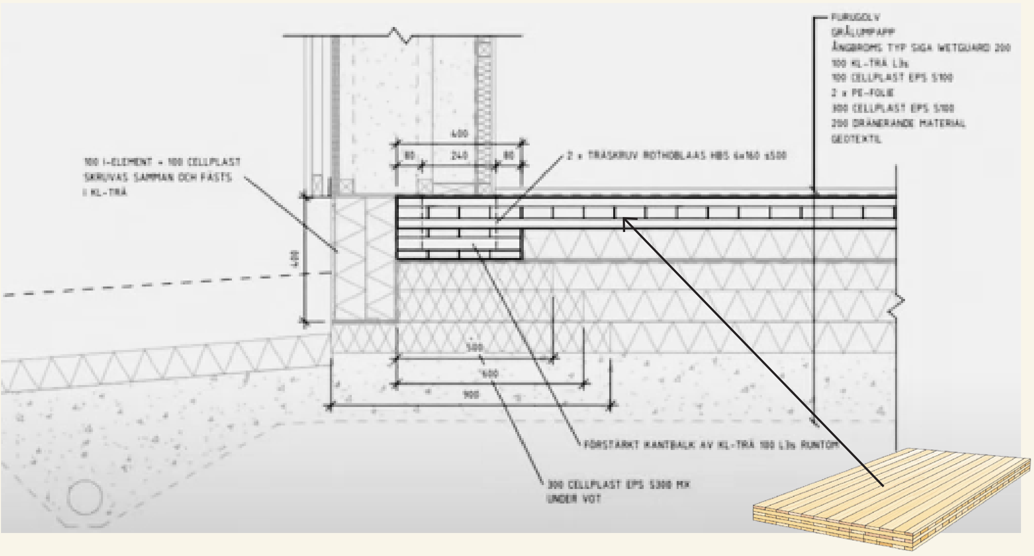


Figure 19: Villa Zero. Fiskarhedenvillan, 2022b.

Figure 20: Interior & exterior. Fiskarhedenvillan, 2022b.

Construction

A main approach in this project has been to test whether it is possible to replace the concrete with wood since concrete is a big contributor to the houses CO2 emissions. M. Gesar and J. Grundström says that idea was born when they did the first LCA calculationsions of the house with conventional materials and saw that the foundation and the roof had the biggest CO2 impact. Therefore, the decision was made to replace the concrete slab at the base and the concrete tiles on the roof with CLT-wood. To build with CLT-wood in the foundation is often met with critique because of the risk for humidity in the construction. With Villa zero, this issue has been solved first by insulating well as it counteracts rising moisture. They have chosen to use a protective membrane that is glued to the CLT plate which is moisture-repellent. Then it is required that you constantly measure the moisture content in the slab, which is done, among other things, by several moisture sensors that are installed in the foundation and on the roof (Fiskarhedenvillan, 2021). The house is built on site but M. Gesar and J. Grundström believes it could be constructed as a modular house and safely produced in large quantities and function as a catalogue house.

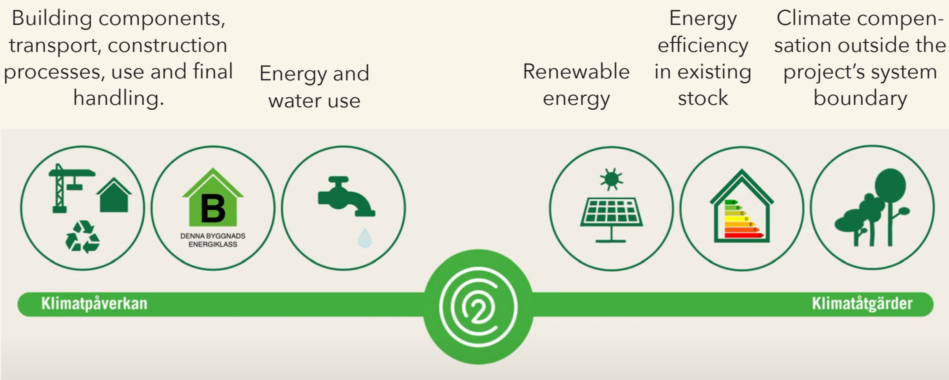


Section:
-Pine floor
-Gray lump cardboard
-Steam brake type SIGA
-WETGUARD 200
-100 KL wood L3s
-100 Cellplast EPS S100
-2 x PE foil
-300 Cellplast EPS S100
-200 Draining material
-Geotextile

Figure 21: Construction detail of foundation. Fiskarhedenvillan, 2021.

Carbon neutrality

The zero in Villa Zero is there because one main goal is to make the house carbon neutral, based on the certificate Svanen and NollCO2 where the requirement is that the house should repay its climate debt in fifty years. By optimising the houses materials and using solar panels they will achieve a carbon neutral house within 10 says M. Gesar and J. Grundström. To make something carbon neutral you need to compensate for the emissions in some way. These three ways are: use renewable energy such as solar cells or wind power, energy efficiency and climate compensation such as planting new trees.



In NollCO2's net zero model, the climate impact is balanced with climate measures to reach net zero.

Figure 22: Net zero balance. SGBC, 2022.

Chapter six: Laborating with different materials

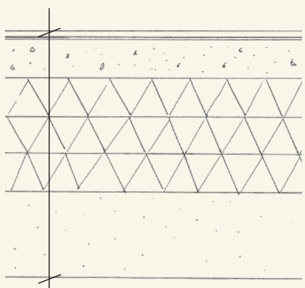
According to the calculations done on the houses from Vårgårdahus, the biggest CO_2 emissions come from the roof, the exterior walls and the fondation. These three house components are changed to be able to see how much it will affect the house's total CO_2 emissions. Different materials and constructions are tested to achieve reduction of CO_2 emissions. The constructions chosen are partly inspired by Villa Zero, but also from sustainable, possible and available constructions that exist today. Construction and choices of materials are still made in order to match conventional building materials which means materials that can be used today in buildings in Sweden.

Construction details

The constructions that have been used for conventional Vårgårdahus villa look like this:

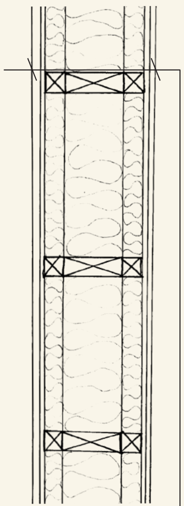
- Concrete foundation
- Wood exterior wall
- Brick roof

Type 1 - Vårgårdahus construction



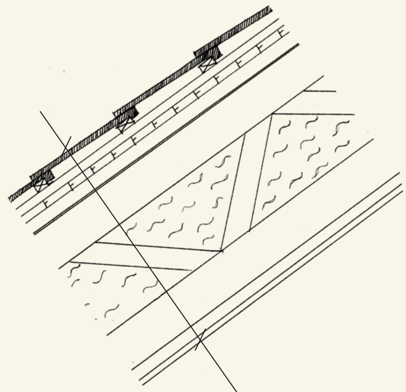
Concrete foundation

13	parquet flooring
0,2	plastic
0,2	plastic
100	concrete
300	cellular plastic
200	macadam
0,2	filter cloth



Wood exterior wall

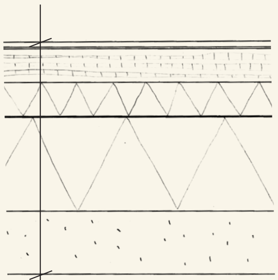
22	wooden cladding
15	air
0,2	windboard
45	wooden latches + mineral wool
170	wooden latches + mineral wool
0,2	plastic foil
45	wooden latches + mineral wool
12	chipboard
13	plasterboard



Brick roof

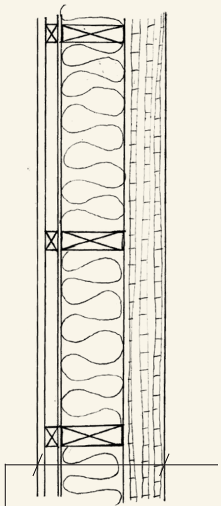
20	concrete tiles
25	batten + air
25	counter batten + air
0,2	cardboard
20	tounged and grooved board
38	wooden latches + air
3,2	windboard
460	roof truss + loose wool
0,2	plastic foil
28	cover boarding + air
13	plasterboard

Type 2 - Wood construction



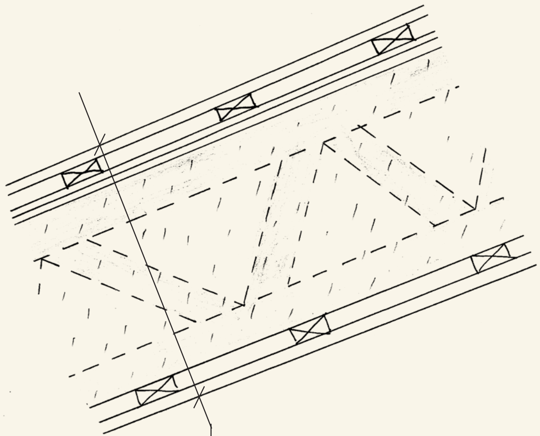
Wooden foundation

13	parquet flooring
0,2	plastic
0,2	plastic
100	CLT-wood
100	EPS
0,2	PE foil
0,2	PE foil
300	EPS
200	macadam
0,2	filter cloth



CLT-wood exterior wall

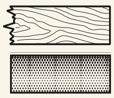
22	wooden cladding
30	batten + air
13	windboard
170	wooden latches + mineral wool
0,2	vapour barrier
100	CLT-wood plate

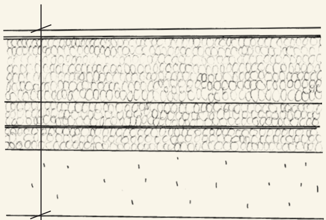


Wooden roof

22	wooden panel
28	counter batten + air
22	batten + air
0,2	plaster membrane
0,3	polypropylene underlay membrane
22	tounged and grooved board
720	wood fibre isolation + wooden latches
0,2	underlay membrane
28	cover boarding + air
22	inner roof cladding

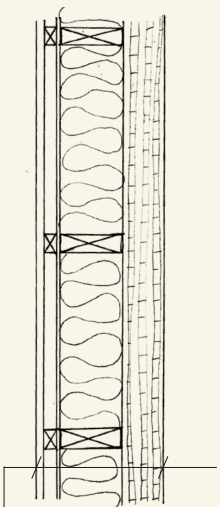
Type 3 - Wood & foamglas construction





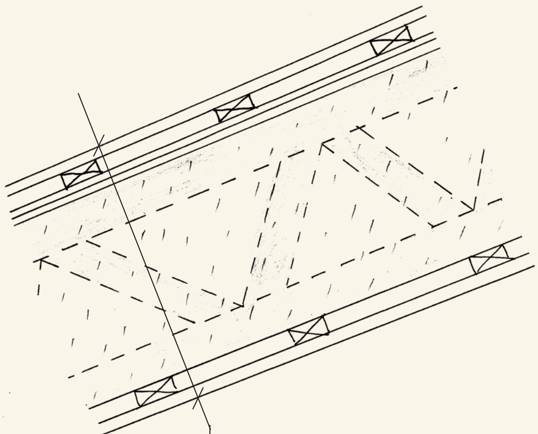
Foamglas foundation

13	parquet flooring
0,2	plastic
0,2	plastic
210	foamglas + aluminium
50	foamglas
0,2	radon cloth
50	foamglas
150	macadam
0,2	filter cloth



CLT-wood exterior wall

22	wooden cladding
30	batten + air
13	windboard
170	wooden latches + mineral wool
0,2	vapour barrier
100	CLT-wood plate



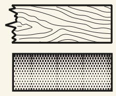
Wooden roof

22	wooden panel
28	counter batten + air
22	batten + air
0,2	plaster membrane
0,3	polypropylene underlay membrane
22	tounged and grooved board
720	wood fibre isolation + wooden latches
0,2	underlay membrane
28	cover boarding + air
22	inner roof cladding

Comparison

The life cycle analysis with CAALA is performed for six different Vårgårdahus houses: Villa Djupvik, Villa Rosenlund, Villa Hagalund, Villa Sävelund, Villa Vinö and Villa Ekerö.

The comparison is made in between 3 different types:

Type 1 - Vårgårdahus construction	Type 2 - Wood construction	Type 3 - Wood & Foamglas construction
Concrete foundation	Wooden foundation	Foamglas foundation
Wood exterior wall	CLT-wooden exterior wall	CLT-wooden exterior wall
Brick roof	Wooden roof	Wooden roof
		

Villa Djupvik is used as an example to show how the different constructions perform. The constructions are put in CAALA and the following results are received:

Villa Djupvik - 1-floor plan

Figure 16: Perspektiv Villa Djupvik. Vårgårdahus, 2022.

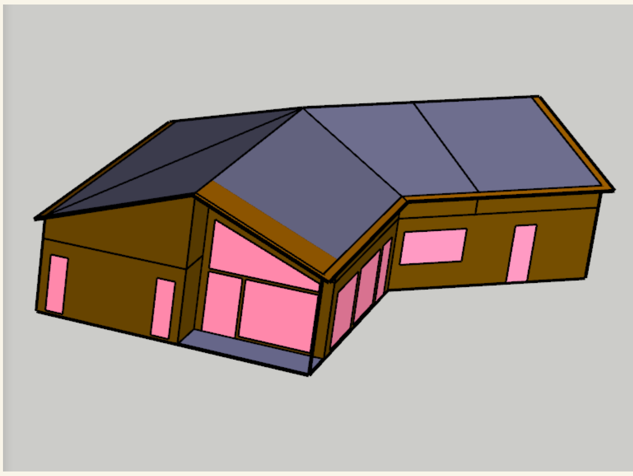
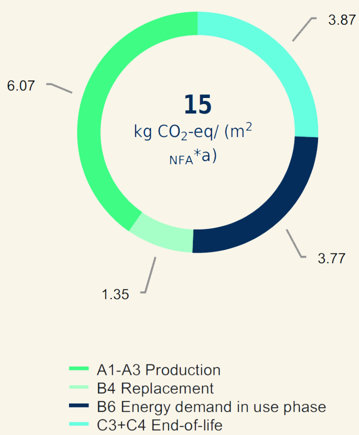
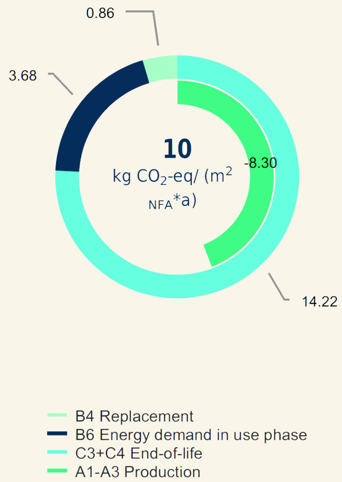


Figure 23: Villa Djupvik 3D model in SKetchUp.

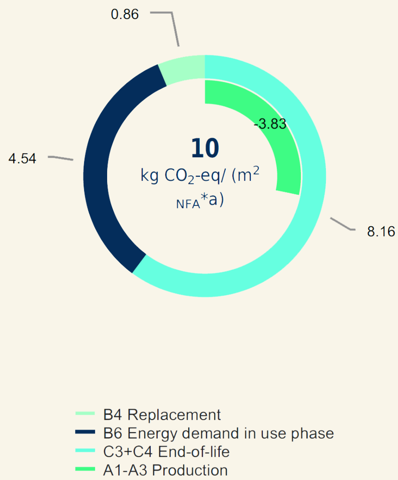
Type 1



Type 2



Type 3



Circle diagrams from CAALA showing the outcome of the LCA calculation of CO2 emissions. The big number in the middle of the circle shows the total CO2 emissions, while the colours in the outer circle show the CO2 from the different modules.

Chapter seven: Labelling

Labelling introduction

Validating and comparing different alternatives for a product makes it possible for the customer to make more conscious decisions related to the environment. We can easily make trade-offs between the alternatives and ensure that we have made a more sustainable choice.

To be able to compare different house's CO2 footprints it is important to create a scale that gives the customer an indication of the specific house in terms of the CO2 footprint. The label should simultaneously express if the value of the footprint is good or bad and how big the CO2 footprint of the house is.

Labelling inspiration

There are many existing actors in different businesses showing the climate impact of their product and service. The climate impact can be communicated in different ways. The source for our inspirations have been collected and shown in this chapter.

How do different industries account for their CO2 impact? Some show donuts, some show staples and grafs. Others put you in categories which define how green you are, while others give you a classification of gold, silver or bronze. There are many ways to expose the CO2 footprint and it is something that more companies are starting to do. Most probably this will only increase and will be something we have to get used to.

Spark Sustainability

Spark sustainability is a tool that helps the user to understand our total individual carbon dioxide emissions per year. This tool is a good start when trying to figure out your carbon footprint as it calculates it very briefly. We find the tool's design and how the information is communicated inspiring. The circle consists of six different sections that change their proportiotions to each other when the values are changed. The total amount of carbon footprint is shown in the middle. By clicking each section the total amount of carbon dioxide in that category is shown as well as the percentage of it compared to other sections (Spark Sustainability, 2022).

Figure 24: Carbon donut. Spark Sustainability, 2022.

H&M climate impact calculator

H&M climate calculator shows different levels of sustainability for each of their pieces of clothing. The basic level is their basic production. The higher levels show how much less the clothing piece has affected the CO2 emissions compared to similar products with different materials. This scale is confusing because you are not able to see how much the "average" footprint is and what the total footprint of the piece of clothing you buy is. Still, it is a good idea to start to show the climate impact of the products the customers purchase (Higg, 2021).

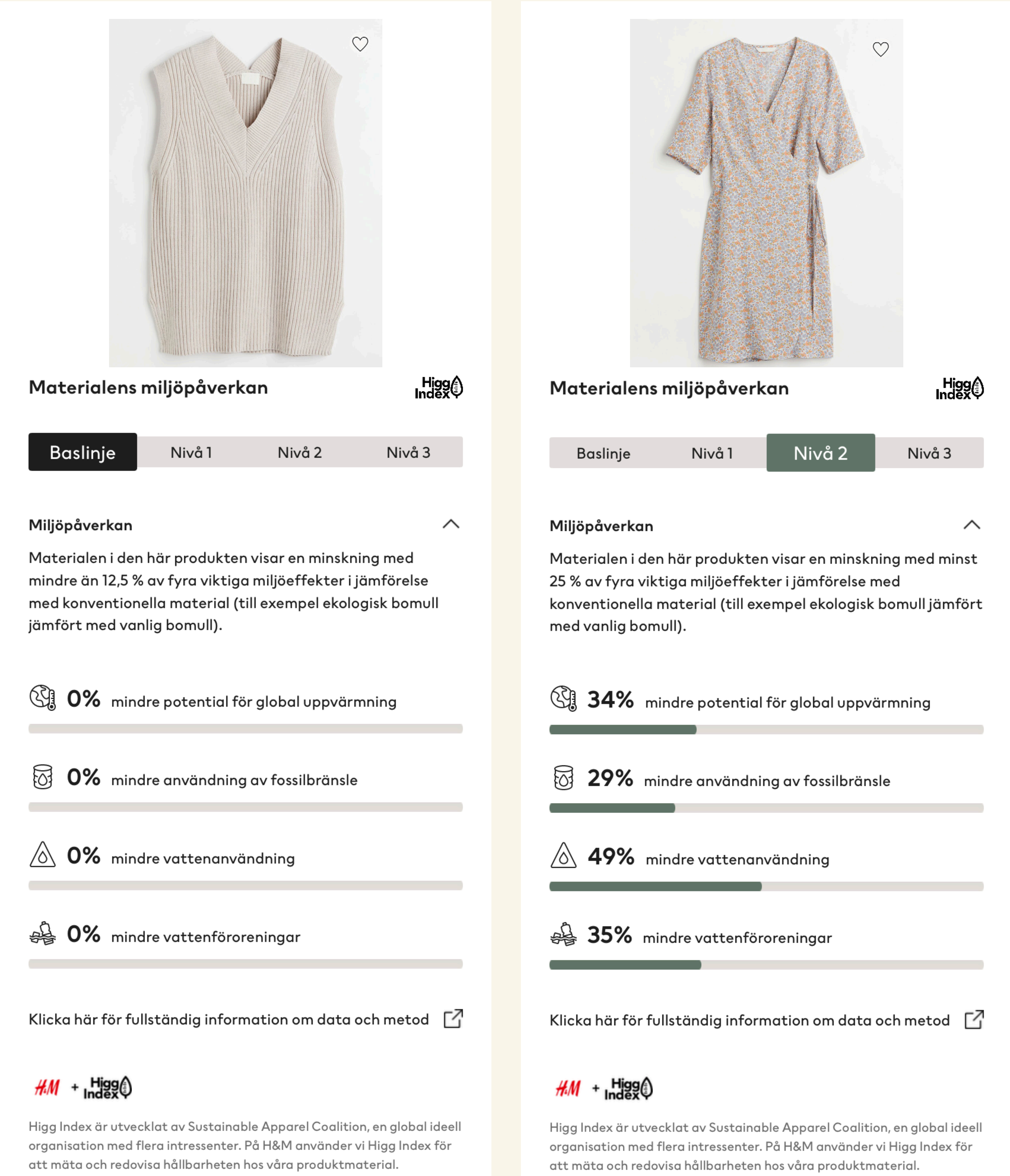


Figure 25: The environmental impact of the material. H&M, 2022.

Systembolaget

Systembolaget shows the customer the CO2 footprint of the packages of their product. The climate footprint is calculated on the production and sealing of each packaging. These data are converted to carbon dioxide emissions per litre of beverage to be comparable (Systembolaget, 2022). The graphical layout is clear and easily shows the package which has the most impact on climate. It is unclear if aspects of recycling are included. There could also be a "winner" in this category, meaning that one package type could be recommended for the customer who wants to make a conscious choice.

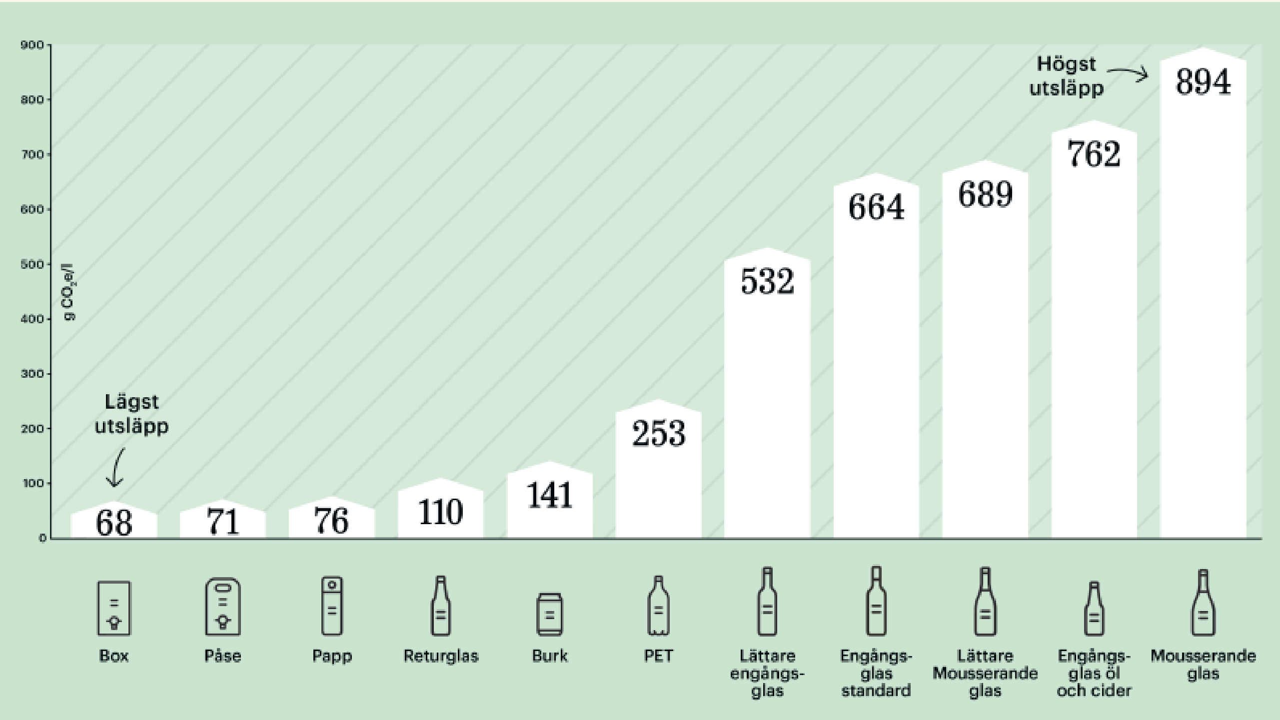


Figure 26: Climate impact of beverages packaging. Systembolaget, 2022.

Chalmers lunch menu

Chalmers University of Technology shows the CO2 footprint of each lunch portion they serve in the school kitchen Kårrestaurangen. The colour coding together with the digits amount of CO2 footprint communicates enough information that the customer needs to be able to make a decision. The illustration with a line and foot in combination is easy and understandable. Together with traffic light colours it is easy to understand the impact and compare between the other portions on the menu.

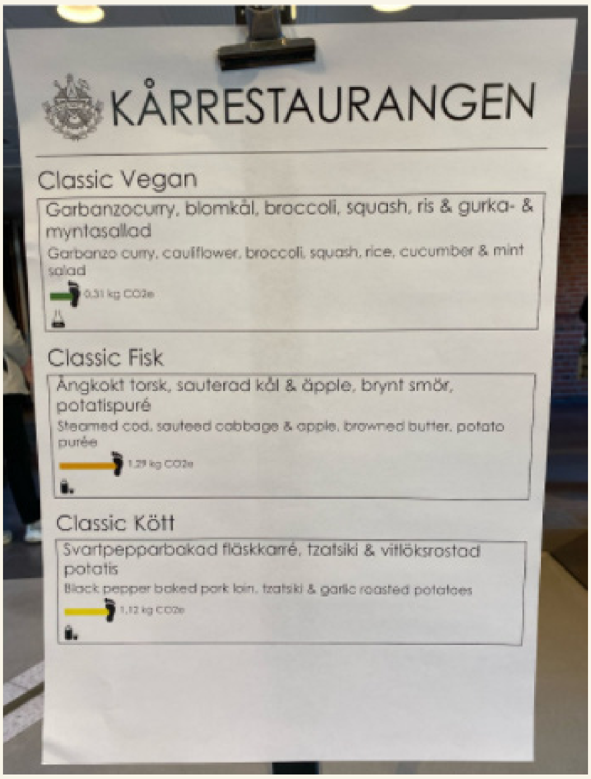


Figure 27: Chalmers Kårrestaurang menu.

Volvo Cars

Polestar declared a LCA comparison between the XC40 Volvo car, run on petrol and the electrical vehicle Polestar to show the difference in CO2 emissions. This is shown in a bar graph. In this diagram Volvo have divided production and end of life in a grey bar and the user phase in an orange bar. Here, the production and end of life differs most between the petrol and electric car due to batteries and other electronics that raises the CO2 footprint. On the other hand, the use phase in electric cars generates less CO2 emissions.

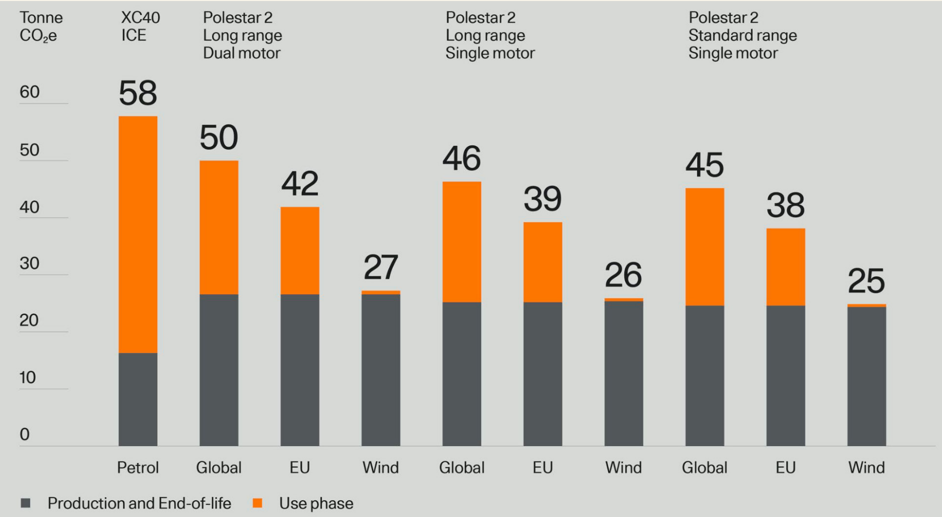


Figure 28: Carbon footprint of the three Polestar 2 variants and Volvo XC40 ICE. Polestar, 2022a.

Figure 29: Polestar 2 CO2 label. Polestar, 2022b.

Volvo Cars have made a LCA rapport and transparently describes how they have done calculations and where the values come from. They show their methods used, what materials are included in analysis and they also compare different models with each other. They also conclude and summarise their findings (Volvo Cars, 2020).

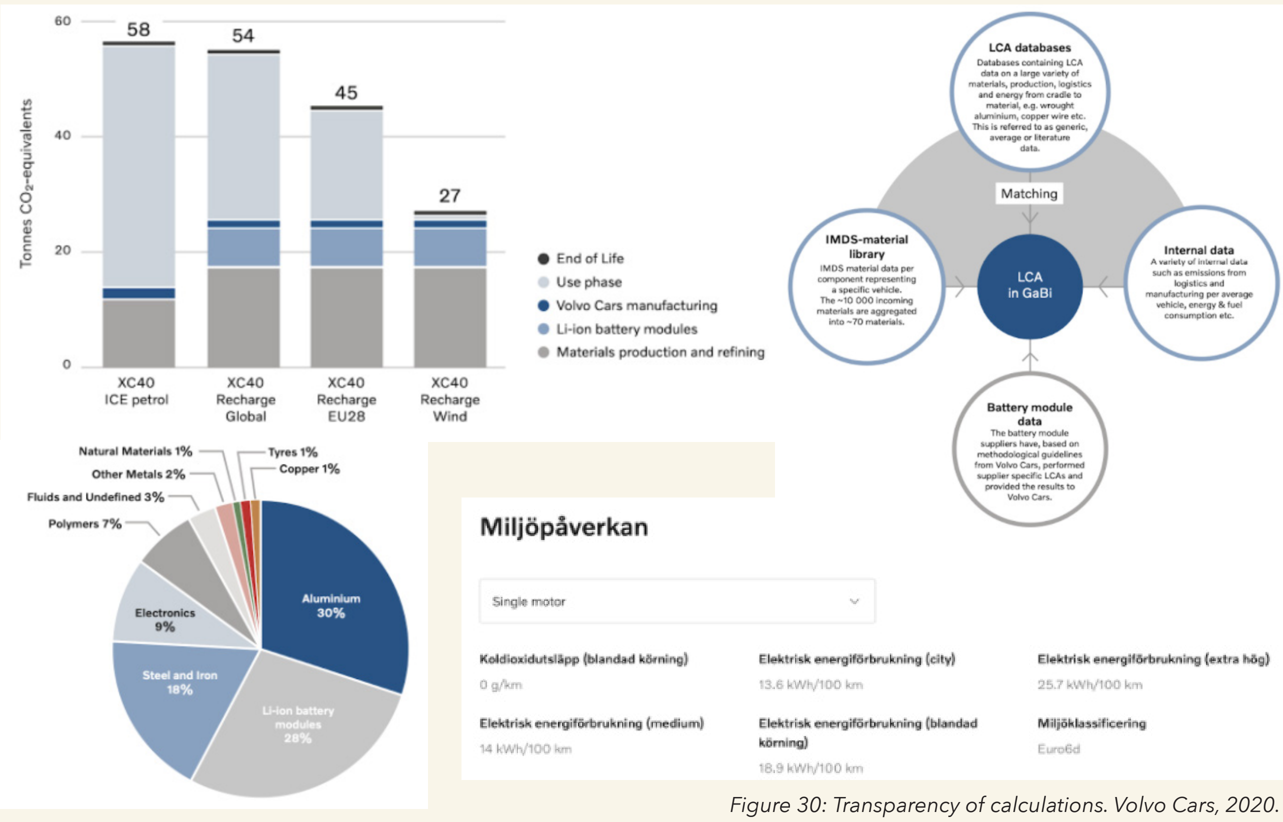
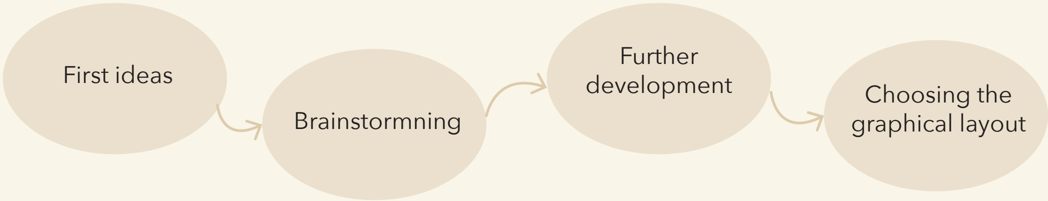


Figure 30: Transparency of calculations. Volvo Cars, 2020.

Design proposal labelling

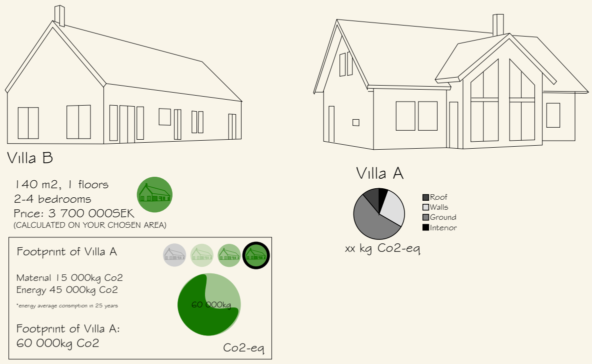
The process when designing the labelling consists of various steps. Evaluation and discussion of all the proposals is done during each step. The steps taken in this process are named the following:



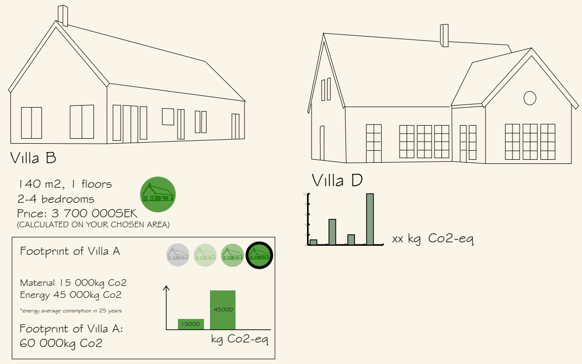
1. First ideas

There are many ways to communicate the CO2 impact of a house. Our first sketches, some graphical proposals for labelling ideas of the catalogue houses, looked like the following:

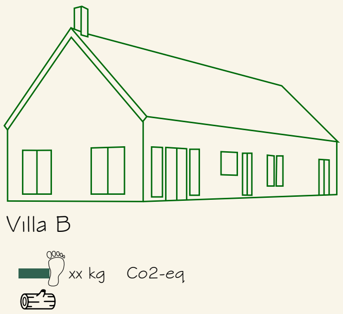
Circle diagram



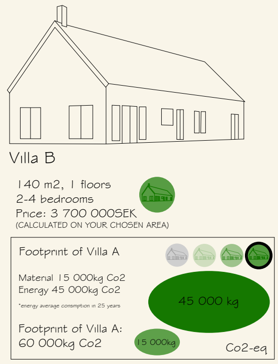
Vertical bar graph



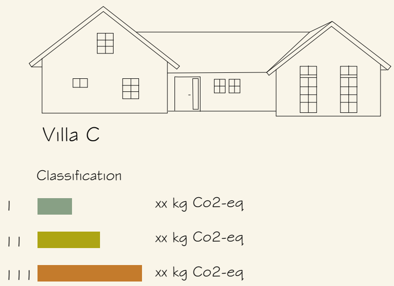
Foot diagram



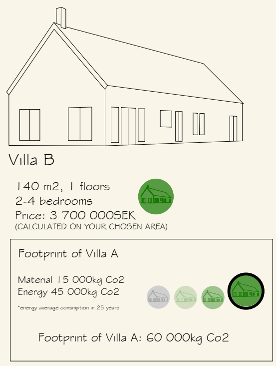
Bubble diagram



Horizontal bar graph



4-step diagram



Evaluation of first ideas

To be able to evaluate and compare these labelling ideas, following attributes were decided:

- Understandable - Can the customer understand that the CO2 footprint is communicated? By seeing the label the customer should directly understand what the label shows. The customer should understand that the CO2 footprint is communicated.
- What does the label tell? Is the CO2 footprint good or bad? What information is presented? What text and numbers are crucial? How easy is it to read the information? What colours are used? What do the colours tell?
- Level of information - Too little / Ok / Too much. How much information needs to be given to the customer that makes the label understandable and easy to read.

The ideas are systematically evaluated throughout these attributes. A matrix for this evaluation is created.

	Understandable	Good or bad footprint	Level of information
Circle diagram	Yes	No info about that (The scale on the other picture describes it)	Too much
Foot diagram	Yes	Info available	Ok
Horizontal diagram	No	No info	Too little, Hard to understand
Vertical diagram	Yes	No info	Too much
Bubble diagram	Yes	Info available	Ok
Four step diagram	Yes	Info available	Ok

Discussion

First impressions of the labels:

Circle diagram

Easy to understand what values create the total amount of the CO2 footprint. It might be too complicated to read as the CO2 footprint is communicated for the first time. The customer is not able to see if the label of CO2 footprint is good or bad.

Bar graph horizontal with foot

Easy to read and understand. The extra label of wood needs more explanation.

Bar graph horizontal

No information about if the values are good or bad. It is unclear what bar present.

Bar graph vertical

No information about if the values are good or bad. The overall intention is not communicated.

Bubble diagram

Information easily available. The CO2 footprint is presented in two categories. The label is communicated both with scale and value.

Four step diagram

Describes that the house belongs to the best category, other information is not that clearly communicated.

The most important thing with the labelling is to see what the label is about, that the CO2 footprint is communicated. The other important thing is to understand if the footprint is good or bad. The third thing is to be able to compare the houses between each other.

Ideas and thoughts for the next step: Comparison between different houses

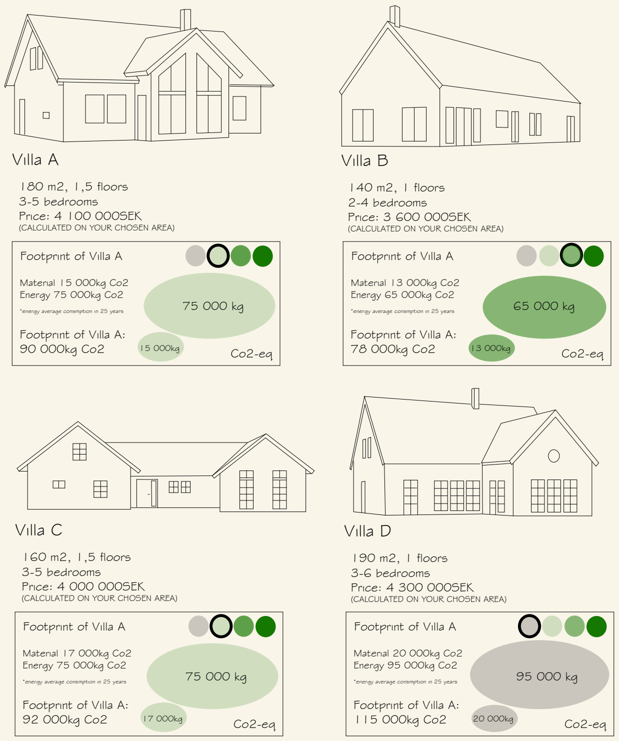
- What does it look like when we start to compare different houses between each other? The labelling should be a tool for the customer to be able to compare the houses. Can houses that are 1- floor, 1,5 - floor and 2 - floor be compared to each other?

- With different categories the houses can be compared to each other. How many categories are needed to be able to communicate the difference between houses? Where is the limit between good and bad? What does it mean if the house belongs to the good/bad category?

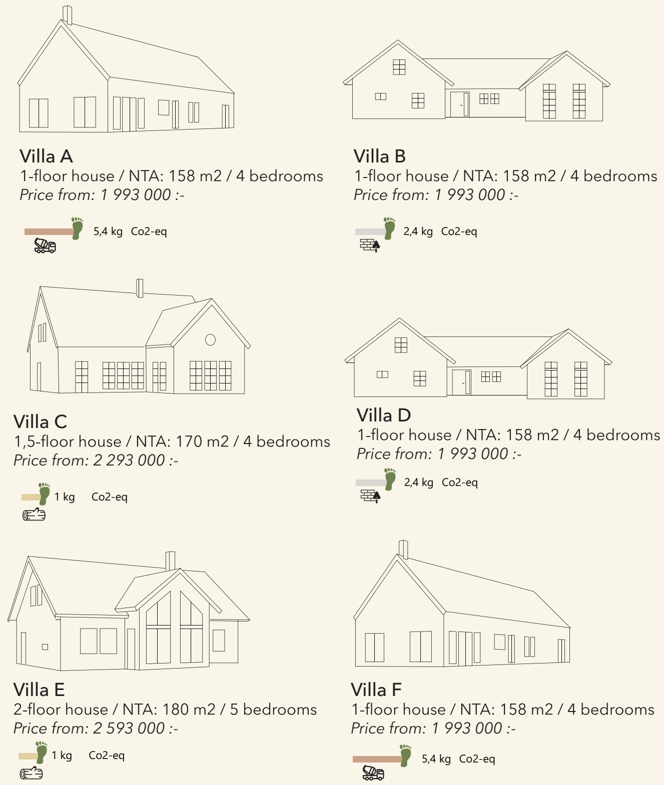
2. Brainstorming

The comparison between the label values is crucial and that is why "how to categorise and set categories for label values" was the biggest topic during this phase.

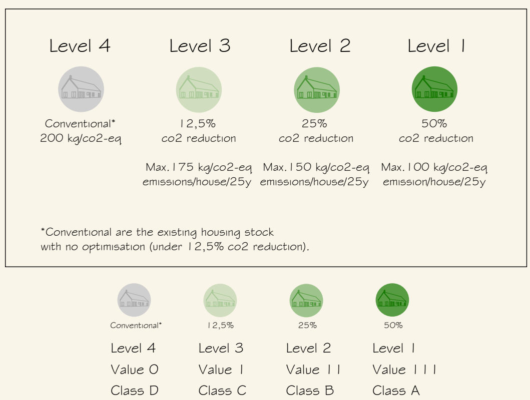
Bubble diagram comparison with level-scale



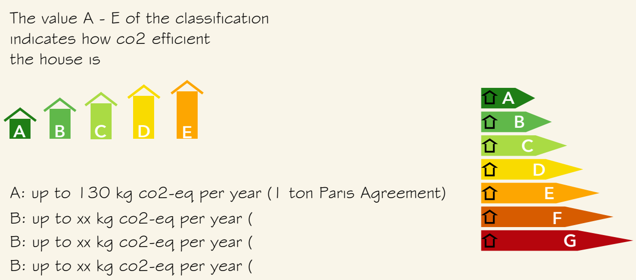
Foot diagram comparison without seperate scale



Level-scale green



Level-scale energy declaration inspired



Evaluation of brainstorming

	Understandable	Good or bad footprint	Level of information
Level scale green	Yes	Is the light green still good?	Ok
Level scale energy inspired	Yes	Easier to understand	Ok
Bubble diagram comparison	Yes	Scale above tells the position	Too much
Foot diagram comparison	Yes	No info other than colour	Too little

Discussion
The first impression of the labels:

Scales
The scale from red to green is the easiest to read and it tells directly which end is good and which end is bad. There is no need to have too many steps, the middle values are quite confusing and can be mixed together. The information about the scale is quite detailed and might not be needed when the scale is first seen. The scale and the limits of the scale values could be shown on other information levels.

Diagram comparisons
It is important to show the total CO_2 footprint, not the footprint per sqm or the footprint divided into different categories when the number is for the first time communicated. The total CO_2 footprint for a house during a 50 year period of time is the value that needs to be shown. The colours should directly tell if the CO_2 footprint is good, ok or bad. The comparison between house models is easier to make if the scale is shown.

The colour scale inspired by the energy declaration is easier to interpret than the grey-green scale. The scale should not contain too many levels because it might be hard to see the difference between the middle values. Still there might not be a need for that many different colours. The traffic light colours could be the most intuitive and easiest to understand when evaluating different colour schemes. The red is bad and green is good, yellow is something in the middle. That is a clear way of communicating what is good and what is bad.

Ideas and thoughts for the next step:
Three-step label system could be tried out with green, yellow and red as the scale. The total amount of CO_2 footprint during a 50 year should be communicated together with the scale.

3. Further development

Ideas

Scales of green, yellow and red is tested in different formats.

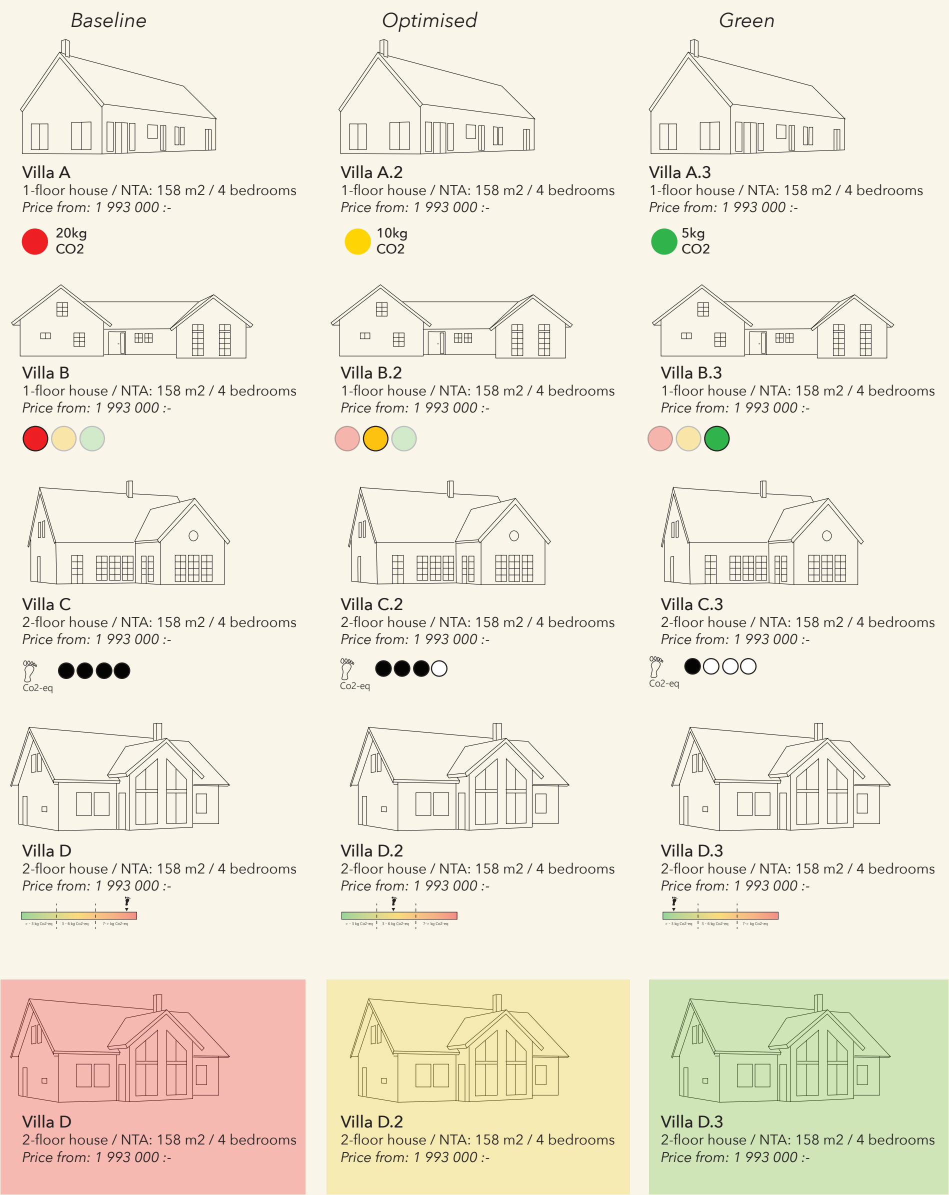
Point scale

Point scale with levels

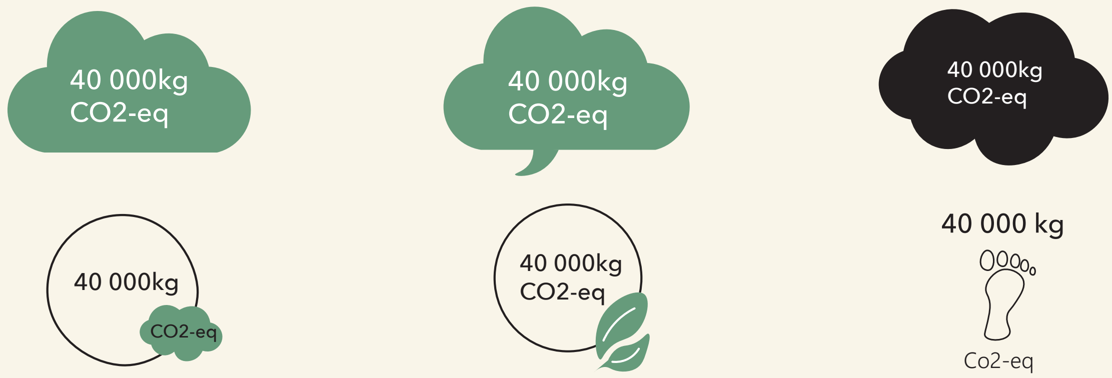
Black and white point scale

Gradient traffic light bar

Colour grouped scale



Different ways of communicating the CO2 footprint:



Evaluation of further development

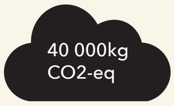
	Understandable	Good or bad footprint	Level of information
Point scale	Yes and no	Easy to see	Ok
Point scale with levels	Yes and no	Easy to see	Ok
Black and white point scale	Yes	Not easy to see	Ok
Gradient traffic light bar	Yes	Easy to see, shows also wider scale	Ok
Colour grouped scale	Yes	Easy too see, focus only on foot print	Ok, too much about CO2 footprint

Discussion

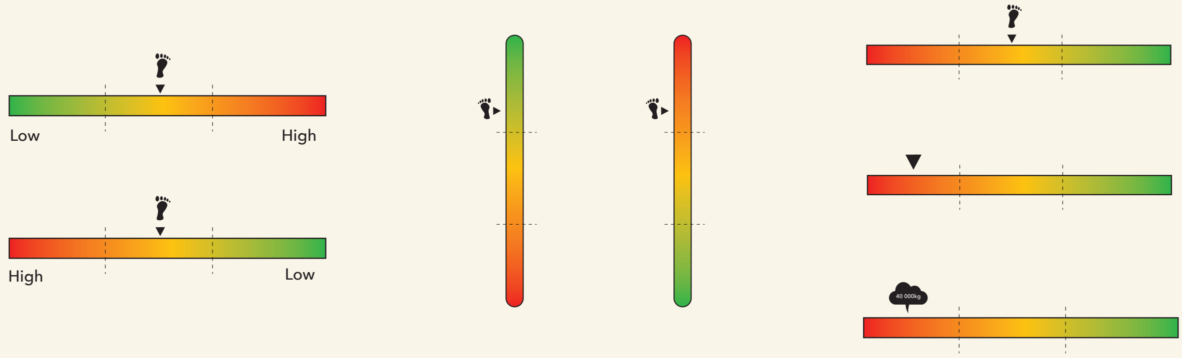
The scale that is most communicative and does not take over all the other important information is the gradient traffic light scale. It also gives the opportunity to place the house on the scale exactly where it belongs. In case if the house could lie on a limit between two colours it can now be directly seen on the scale. The other alternatives need some clarification about what is shown and what values could be possible for that specific house type.

4. Choosing the graphical layout for labelling

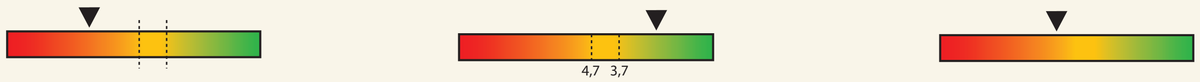
The following label type is chosen: Gradient traffic light bar and the CO2-cloud



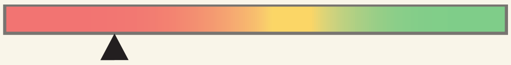
The gradient traffic light bar is further developed. It could be presented horizontal or vertical, from red to green or green to red. The lower the CO2 footprint the greener the house is. Often the higher amount represents better values but in our diagram it is the other way around. The way to mark where on the scale the specific house has its footprint can also be made in different ways.



A comparison of how much information that need to be exposed on the bar for the viewer to be able to understand how good or bad the house is has also been done:



The final choice:

Gradient traffic light bar from red to green (high - low CO2 emissions) together with the arrow	Text indicates that the bar shows CO-eq
	CO2-eq

Information level

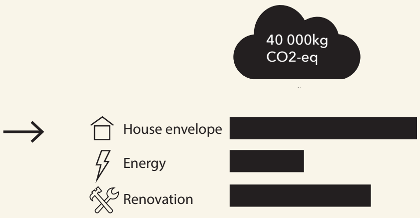
As the labelling system is being discussed and defined, the level of information has been decided to be divided into two levels.

Level 1

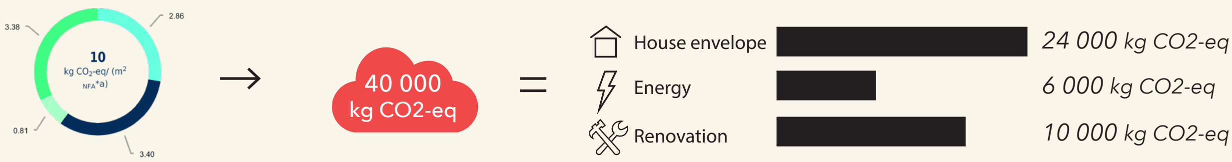
1. The first level of information that can be read from the arrows position on the bar is about if the house is green or not.
2. The other piece of information that can be found is the text CO2-eq that indicates what the red to green scale is showing.

Level 2

The information in level 2, that can be found when a specific house is being looked into, shows the total CO2 emission of the house. This number is then divided into different categories. These categories clarify what causes the total CO2 footprint.



The information in level 2 will show the total amount of a house's CO2 emissions in a red, yellow or green cloud depending on the house's performance. The total CO2 amount could then further be divided into three different blocks: House envelope, Energy and Renovation. The circle diagram from CAALA has been inspiration and been translated into a bar graph to clarify the results one step further. Illustrated icons together with text further supports the understanding of the bars. This means that the label on the second level will look like:



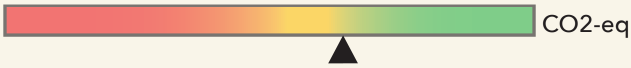
The values, where the total CO2 footprint and these three different categories come from, are presented in the following chapter eight.

Chapter eight: Refining labelling values

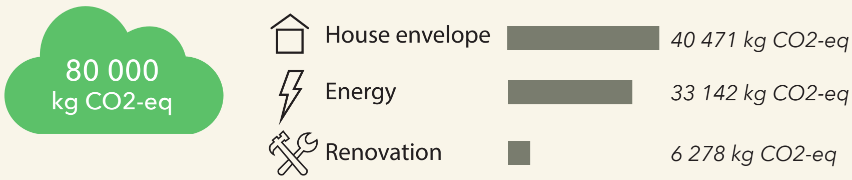
This chapter is about finalising and defining limits for our labelling system.

After the graphical layout is designed and set, the values shown in our labelling system are being defined. The level of information is divided into two phases: level 1 and level 2.

The chosen label type on information level 1 (label 1) looks like this:
The label describes how green the house is as well as the total amount of the CO2 footprint.



The chosen label type on information level 2 (label 2) looks like this:
The label describes where the CO2 footprint comes from.



The gradient bar exhibits how good or bad the house is when it comes to the emissions. The text below tells the total CO2-eq for a house during a 50 year period of time. The scale gives the opportunity to compare houses between each other. To be able to show where the amount of CO2 emissions come from more in detail, label type 2 specifies the emission sources. The cloud tells the total amount of CO2-eq.

Refining the limits for the traffic light label

Calculations have been performed to be able to identify the limits between red, yellow and green on our traffic light label. The principle when creating limits is inspired from the NollCO2 certificate. (SGBC, 2021b)

For a NollCO2 certificate there are a lot of different requirements connected to emissions and different LCA modules that need to be fulfilled. We have gained inspiration from the certification system when it comes to the values the certificate has set for baseline and limit value.

The following calculations explain how the baseline and limit value have been calculated for NollCO2 certificate. Baseline is based upon LCA modules A1- A3 and is calculated for 1 m2 GFA (gross floor area). Baseline GFA consists of light and dark GFA. Limit value is the sum of 70% of the light GFA and dark GFA (SGBC, 2021b).

Calculations that show how the baseline is being refined:

BTA	180 m^2
Ljus BTA	180 m^2
Mörk BTA	0 m^2
Total klimatpåverkan	39 tCO_2e
Klimatpåverkan ljus BTA	32 tCO_2e
Klimatpåverkan mörk BTA inkl. BSAB 15 Grundkonstruktioner	7 tCO_2e
Total baseline	217 $kgCO_2e/m^2$ BTA
Procentuell minskning av klimatpåverkan av ljus BTA	30%
Gränsvärde	164 $kgCO_2e/m^2$ BTA
Absolut CO_2e-minskning	10 tCO_2e
Procentuell minskning av A1-A3 CO_2e utsläpp	24%
Installationssystemens klimatpåverkan	12%
Byggnadens vikt för ljus BTA	240 kg/m^2 ljus BTA
Byggnadens densitet för ljus BTA	83 kg/m^3 ljus BTA
Byggnadens klimatdata för ljus BTA	0,737 $kgCO_2e$/kg byggnad

Figure 31: Example house by NollCO2. SGBC, 2021b.

GFA: 180m2
Total CO2 footprint : 39 000 kg CO2 eq
Baseline: 39000/180 = 217 kg CO2 eq /m2
Limitvalue: ((32 000/180)*0,7) + (7000/180) = 163,33 = 164 kg CO2 eq/m2

Figure 32:Villa Zero. Fiskarhedenvillan, 2022b.

Calculations done by NollCO2 for villa Zero:
GFA: 136m2
Total CO2 footprint: 32 500 kg CO2 eq
Baseline: 239 kg CO2 eq / m2
Limitvalue: 191 kg CO2 eq / m2

Villa zero reached following value: 176 kg CO2 eq / m2, meaning that the total footprint of A-module the villa is 176*136=23936 = ca 24000 kg CO2 eq / m2

24000 kg CO2 eq / m2 include phases A1- A3 during a 50 year period of time.

Creating baseline and limitvalue for our labelling system

To be able to implement baselines and limit values for our new labelling system the reference values are addressed from the baseline and limit values set by NollC02 certificate.

Values can be compared to the CAALA values if the amount of CO2 kg eq/m2 BTA is divided also with the "lifetime" that is counted to 50 years .

For Villa Zero it means following:

The baseline for Villa Zero is 239 kg CO2 eq/m2 GFA for 50 years.
For one year the value is: 239/50= 4,78 kg CO2 eq/m2 GFA*year

The limit value for Villa zero is 191 kg CO2 eq/m2 GFA for 50 years.
For one year the value is: 191/50= 3,82 kg CO2 eq/m2 GFA*year

The other baselines and limit values are referred to numbers created ny NollC02 certificate.

Floors	GFA (BTA)	For 50 years		For 1 year	
		Baseline	Limit value	Baseline	Limit value
1	136	239	191	4,78	3,82
1	120	220	195	4,4	3,9
1	140	242	193	4,84	3,86
2	140	236	178	4,72	3,56
2	180	248	194	4,96	3,88
2	180	217	164	4,34	3,28

	1 floor		2 floors		Both	
	base	limit	base	limit	base	limit
Highest value:	4,82	3,9	4,93	3,88	4,96	3,9
Lowest value:	4,4	3,82	4,34	3,28	4,34	3,28
Median value:	4,673	3,86	4,673	3,573	4,673	3,716

Highest value: Is the highest value picked from the table
Lowest value: Is the lowest value picked from the table
Median value: All the values are multiplied and divided by the amount of multiplied items

The final baseline and limit value create the boundaries for our labelling system:
Baseline: 4,7   Limit value: 3,7
..

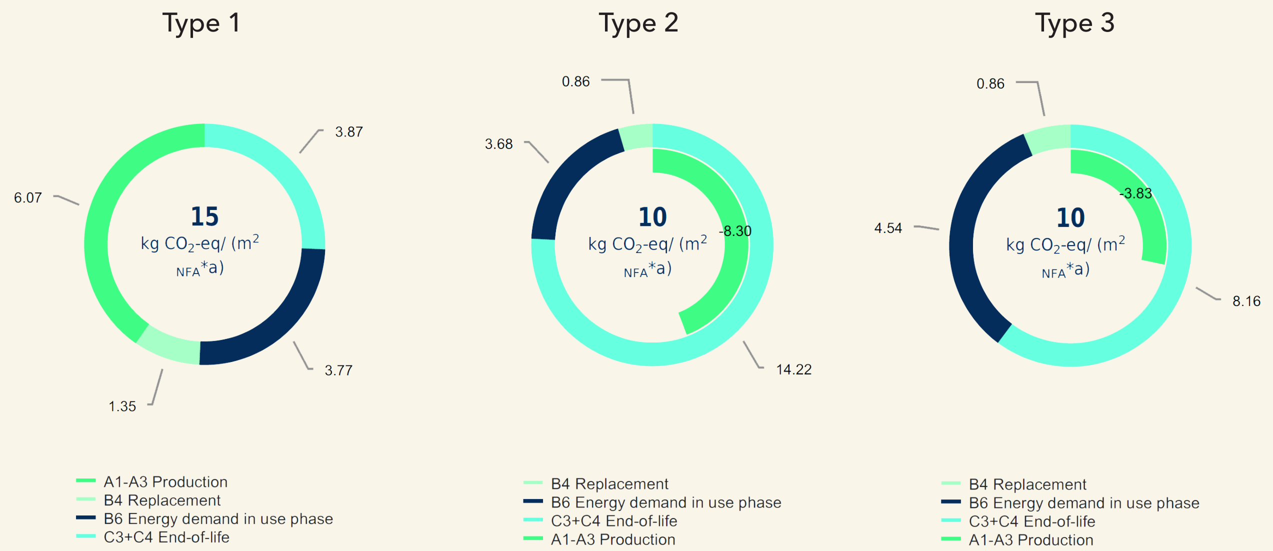
The scale is set from 10-0 due to the references found in the report from Switzerland about Calculation of Grey Energy and greenhouse gas emissions (Minergie, 2021).
The labelling with these values will then look like:

Implementation

The values received from CAALA differ between values from One click LCA, which is used for calculations for that specific NollCO2 certificate.

Baseline and limitvalue are calculated from modules A1-A3 within One click LCA. In the NollCO2 certificate the module C is set to 0 due to the Swedish climate regulations, according to the goal of reaching climate neutrality in 2040.

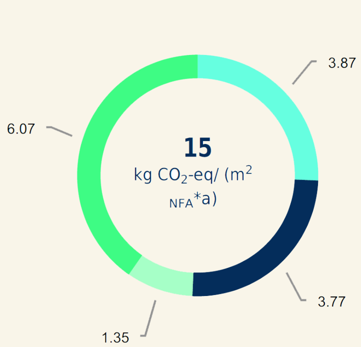
In CAALA, which is a German LCA calculator, the C module has a value, even though the age of the houses is set to 50 years. This C module in CAALA balances the A1-A3 modules for our type 2 and 3 constructions (wood and foamglas construction) due to the A values being negative.

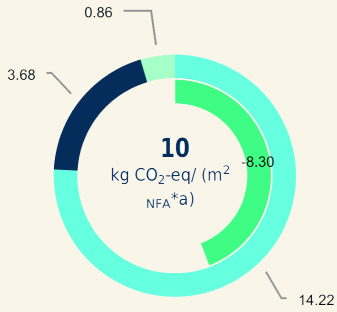


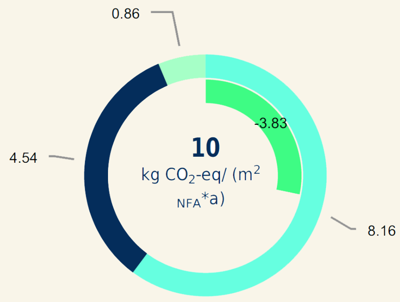
Above villa Djupvik CAALA values for type 1, 2 and 3 are shown. Modules A1-A3 and C3-C4 are chosen and translated into kg CO2 eq/ m2 GFA *year to be able to be compared on the gradient diagram.

Modules A1-A3 and C3-4 are multiplied with m2 NTA and year:
Kg CO2 eq /m2 NFA*year * m2 NFA * 50 year = kg CO2 eq

And then divided by m2 GTA and year to reach the same unit scale as our gradient diagram's baseline and limit value.
Kg CO2 eq / m2 GFA / 50 year = kg CO2 eq/ m2 GFA*year





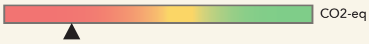


Labelling value
Placement for CO2 emission indicator

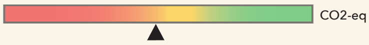
1 FLOOR
Villa Djupvik
157kvm

	Type 1	Type 2	Type 3
CAALA A1-A3 kg CO2eq/m2 NFA*year	6,07	-8,3	-3,83
CAALA C3-C4 kg CO2eq/m2 NFA*year	3,87	14,22	8,16
year	50	50	50
m2 NFA	146	146	146
CAALA A1-A3 kg CO2eq	44311	-60590	-27959
CAALA C3-C4 kg CO2eq	28251	103806	59568
CAALA A1-A3+ C3-C4 kg CO2eq	72562	43216	31609
year	50	50	50
m2 GFA	182	182	182
CO2 emission indicator value CO2eq/m2 GFA*year	7,97	4,75	3,47

Villa Djupvik
1-floor / NTA: 156,5 m2 / 4 bedrooms
House-kit price from: 2 002 000:-



Villa Djupvik
1-floor / NTA: 156,5 m2 / 4 bedrooms
House-kit price from:



Villa Djupvik
1-floor / NTA: 156,5 m2 / 4 bedrooms
House-kit price from:

Information level 2

The specific values that create the total amount of CO2 footprint are based upon the numbers from CAALA. CAALA showcases the values per square metre and year, meaning that all the numbers received from CAALA are multiplied with the house NFA (net floor area) and 50 years.

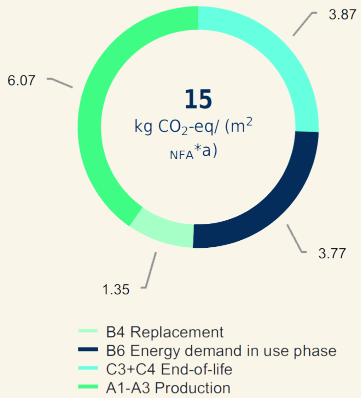
kg CO2 eq / m2 NFA year x m2 NFA x 50 year = kg CO2 eq

The categories that are defined in in this phase are called:

House envelope
Renovation
Energy

The categories received from CAALA are the following:

A1-A3 Production
B4 Replacement
B6 Energy demand in use phase
C3+C4 End-of-life



The categories from CAALA are matched with the categories that are defined for the customer. The amount of CO2 footprint for transportation and energy used when building (A4 and A5) are not shown in CAALA.

We need to assume how much kg CO2eq/m2 BTA year phases A4 and A5 cause because CAALA does not take these values into consideration. According to the NollCO2 certificate "The climate impact of A4-A5 shall not exceed the limit value of 55 kgCO2 eq/m2 BTA."

We can calculate how big part of the total amount of the baseline 55 kgCO2 eq/m2 BTA is according to the limit values shown in NollCO2 certification examples:

For a 2-floor house it means: A4-A5 / A1-A5: 55/(55+217)= 0,20
For a 1-floor house it means: Limitvalue A1-A5 & B4/limitvalue A4-A5: 55/(55+239)= 0,19

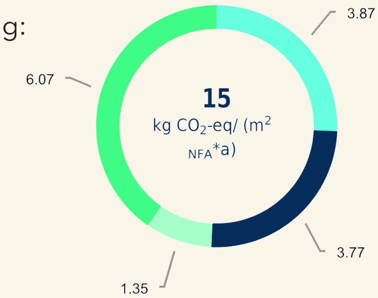
According to these calculations we end up with a value for modules A4-A5 that is 20% of CO2 footprint of phases A1-A5.

Due to these assumptions we will add 20% to module A.

The categories are matched to the following:

House envelope	A1-A3 + 20% and C3+C4
Renovation	B4
Energy	B6

Calculations for Villa Djupvik with Vårgårdahus construction looks following:



House envelope A1-A3 + 20% and C3-C4

A1-A3: 6,07 20% of A1-A3: 6,07 x 0,2 = 1,214

A1-A5: 6,07 + 1,214 = 7,284

C3-C4: 3,87

7,284 kg CO2 eq / m2 NFA year x 146NFA x 50 year = 53 173,2 kg CO2 eq

3,87 kg CO2 eq / m2 NFA year x 146NFA x 50 year = 28 251 kg CO2 eq

In total: 53173,2 + 28251= 81 424,2 kg CO2 eq

Renovation B4

1,35 kg CO2 eq / m2 NFA year x 146NFA x 50 year = 9855 kg CO2 eq

Energy B6

3,77 kg CO2 eq / m2 NFA year x 146 NFA x 50 year = 27521 kg CO2 eq

In total:

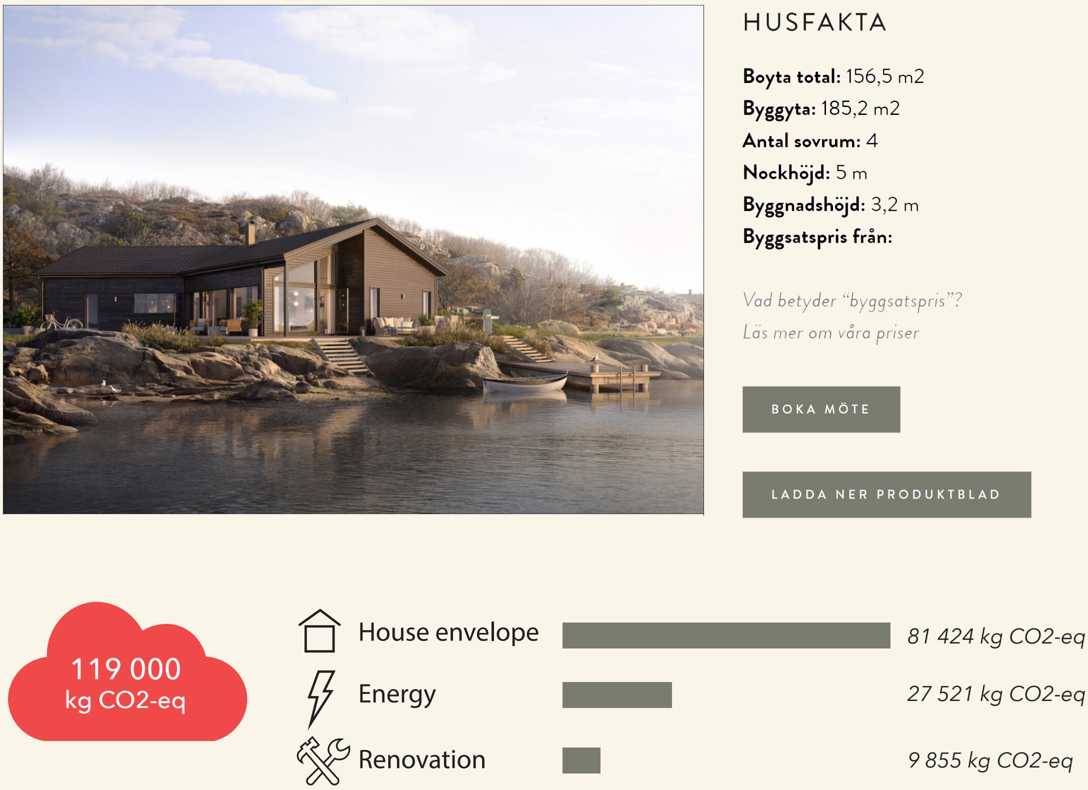
81 424,2 + 9855 + 27521= 118 800,2 kg CO2 eq

Total kg CO2 eq footprint (Amount of the total CO2 emission in the CO2 cloud)

Villa Djupvik, 157kvm

	Type 1	Type 2	Type 3
CAALA A1-A3	6,07	-8,3	-3,83
CALA A4-A5	1,214	1,214	1,214
CAALA A1-A5	7,284	-7,086	-2,616
kg C02 eq/m2 NFA *year			
CAALA module A1-A5	7,284	-7,086	-2,616
CAALA module B4	1,35	0,86	0,86
CAALA module B6	3,77	3,68	4,54
CAALA module C3-C4	3,87	14,22	8,16
year	50	50	50
NFA	146	146	146
kg C02 eq			
CAALA module A1-A5	53173,2	-51727,8	-19096,8
CAALA module B4	9855	6278	6278
CAALA module B6	27521	26864	33142
CAALA module C3-C4	28251	103806	59568
Total kg CO2 eq	118800,2	85220,2	79891,2
	119 000	86 000	80 000

Putting together all the elements for information level 2, the label will all in all look like this for Villa Djupvik:



Chapter nine: How green is your house?

The final labelling system

The labelling system shown for Villa Djupvik looks like the following:

Villa Djupvik - Type 1

Villa Djupvik

1- floor / NTA: 156,5 m2 / 4 bedrooms

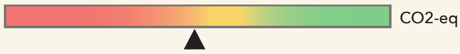
House-kit price from: 2 002 000:-

Villa Djupvik - Type 2

Villa Djupvik

1- floor / NTA: 156,5 m2 / 4 bedrooms

House-kit price from:



Villa Djupvik - Type 3

Villa Djupvik

1- floor / NTA: 156,5 m2 / 4 bedrooms

House-kit price from:

The comparison between houses can easily be made, due to the gradient traffic light bar. The label clearly shows if the footprint of a house is good or bad and it is easy to compare with the other houses.

When putting together all three design components (the bar, the arrow and the CO_2-eq) and placing them under each house that is build with Type 1, a spread in the catalogue will look like this:

1-floor houses

Villa Djupvik

1-floor / NTA: 156,5 m2 / 4 bedrooms

House-kit price from: 2 002 000:-

CO2-eq

Villa Vinö

1-floor / NTA: 146,8 m2 / 3 bedrooms

House-kit price from: 1 787 000:-

CO2-eq

1,5-floor houses

Villa Sävelund

1,5-floor / NTA: 182,4 m2 / 4 bedrooms

House-kit price from: 2 269 00:-

CO2-eq

Villa Hagalund

1,5-floor / NTA: 138,1 m2 / 3 bedrooms

House-kit price from: 1 912 00:-

CO2-eq

2-floor houses

Villa Rosendal

2-floor / NTA: 186,9 m2 / 4-5 bedrooms

House-kit price from: 2 253 00:-

CO2-eq

Villa Ekerö

2-floor / NTA: 195,6 m2 / 4-5 bedrooms

House-kit price from: 2 549 00:-

CO2-eq

Next spread in the catalogue shows houses build with Type 2, and will look like this:

Type 2:
CLT-wood

1-floor houses

Villa Djupvik

1-floor / NTA: 156,5 m2 / 4 bedrooms

House-kit price from:

CO2-eq

Villa Vinö

1-floor / NTA: 146,8 m2 / 3 bedrooms

House-kit price from:

CO2-eq

1,5-floor houses

Villa Sävelund

1,5-floor / NTA: 182,4 m2 / 4 bedrooms

House-kit price from:

CO2-eq

Villa Hagalund

1,5-floor / NTA: 138,1 m2 / 3 bedrooms

House-kit price from:

CO2-eq

2-floor houses

Villa Rosendal

2-floor / NTA: 186,9 m2 / 4-5 bedrooms

House-kit price from:

CO2-eq

Villa Ekerö

2-floor / NTA: 195,6 m2 / 4-5 bedrooms

House-kit price from:

CO2-eq

The third spread in the catalogue shows houses build with Type 3, and will look like this:

Type 3:
CLT-wood
+ foamglas

1-floor houses

Villa Djupvik

1-floor / NTA: 156,5 m2 / 4 bedrooms

House-kit price from:

CO2-eq

Villa Vinö

1-floor / NTA: 146,8 m2 / 3 bedrooms

House-kit price from:

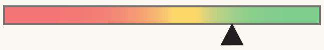
CO2-eq

1,5-floor houses

Villa Sävelund

1,5-floor / NTA: 182,4 m2 / 4 bedrooms

House-kit price from:

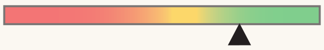


CO2-eq

Villa Hagalund

1,5-floor / NTA: 138,1 m2 / 3 bedrooms

House-kit price from:



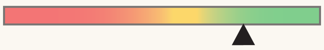
CO2-eq

2-floor houses

Villa Rosendal

2-floor / NTA: 186,9 m2 / 4-5 bedrooms

House-kit price from:

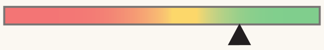


CO2-eq

Villa Ekerö

2-floor / NTA: 195,6 m2 / 4-5 bedrooms

House-kit price from:



CO2-eq

For a customer it might be interesting to see the same house with different constructions gathered on the same page to be able to make an easier comparison of the CO_2 emissions between the houses.

1-floor houses

Type 1

Villa Djupvik

1-floor / NTA: 156,5 m2 / 4 bedrooms

House-kit price from: 2 002 000:-

CO_2-eq

Villa Vinö

1-floor / NTA: 146,8 m2 / 3 bedrooms

House-kit price from: 1 787 000:-

CO_2-eq

Type 2

Villa Djupvik

1-floor / NTA: 156,5 m2 / 4 bedrooms

House-kit price from:

CO_2-eq

Villa Vinö

1-floor / NTA: 146,8 m2 / 3 bedrooms

House-kit price from:

CO_2-eq

Type 3

Villa Djupvik

1-floor / NTA: 156,5 m2 / 4 bedrooms

House-kit price from:

CO_2-eq

Villa Vinö

1-floor / NTA: 146,8 m2 / 3 bedrooms

House-kit price from:

CO_2-eq

For a customer it might be interesting to see the same house with different constructions gathered on the same page to be able to make an easier comparison of the CO2 emissions between the houses.

1,5-floor houses

Type 1

Villa Sävelund

1,5-floor / NTA: 182,4 m2 / 4 bedrooms

House-kit price from: 2 269 00:-

Villa Hagalund

1,5-floor / NTA: 138,1 m2 / 3 bedrooms

House-kit price from: 1 912 00:-

Type 2

Villa Sävelund

1,5-floor / NTA: 182,4 m2 / 4 bedrooms

House-kit price from:

Villa Hagalund

1,5-floor / NTA: 138,1 m2 / 3 bedrooms

House-kit price from:

Type 3

Villa Sävelund

1,5-floor / NTA: 182,4 m2 / 4 bedrooms

House-kit price from:

Villa Hagalund

1,5-floor / NTA: 138,1 m2 / 3 bedrooms

House-kit price from:

For a customer it might be interesting to see the same house with different constructions gathered on the same page to be able to make an easier comparison of the CO2 emissions between the houses.

2-floor houses

Type 1

Villa Rosendal

2-floor / NTA: 186,9 m2 / 4-5 bedrooms

House-kit price from: 2 253 00:-

Villa Ekerö

2-floor / NTA: 195,6 m2 / 4-5 bedrooms

House-kit price from: 2 549 00:-

Type 2

Villa Rosendal

2-floor / NTA: 186,9 m2 / 4-5 bedrooms

House-kit price from:

Villa Ekerö

2-floor / NTA: 195,6 m2 / 4-5 bedrooms

House-kit price from:

Type 3

Villa Rosendal

2-floor / NTA: 186,9 m2 / 4-5 bedrooms

House-kit price from:

Villa Ekerö

2-floor / NTA: 195,6 m2 / 4-5 bedrooms

House-kit price from:

By looking into one house more specifically, the total footprint of a house and explanation of what causes the total footprint is explained more in detail. The customer is then able to see:

1. How big the CO2 footprint of a house is when it is built and demolished.
2. How much CO2 footprint the energy usage causes.
3. The CO2 footprint of the material that after some time needs to be replaced.

All this information shows the customer the total CO2 footprint and gives a good understanding of where the CO2 emissions come from. Level 2 of information could be looked into like this:

Level 2 for type 2:

Type 1	Type 2	Type 3
		
Villa Djupvik	Villa Djupvik	Villa Djupvik
1-floor / NTA: 156,5 m2 / 4 bedrooms	1-floor / NTA: 156,5 m2 / 4 bedrooms	1-floor / NTA: 156,5 m2 / 4 bedrooms
House-kit price from: 2 002 000:-	*House-kit price from:*	*House-kit price from:*
CO2-eq	CO2-eq	CO2-eq

HUSFAKTA

Boyta total: 156,5 m2
Byggyta: 185,2 m2
Antal sovrum: 4
Nockhöjd: 5 m
Byggnadshöjd: 3,2 m
Byggsatspris från:

Vad betyder "byggsatspris"?
Läs mer om våra priser

BOKA MÖTE

LADDA NER PRODUKTBLAD

82 000
kg CO2-eq

House envelope	*52 078 kg CO2-eq*
Energy	*26 864 kg CO2-eq*
Renovation	*6 278 kg CO2-eq*

Level 2 for type 3:

Type 1

Villa Djupvik

1-floor / NTA: 156,5 m2 / 4 bedrooms

House-kit price from: 2 002 000:-

CO2-eq

Type 2

Villa Djupvik

1-floor / NTA: 156,5 m2 / 4 bedrooms

House-kit price from:

CO2-eq

Type 3

Villa Djupvik

1-floor / NTA: 156,5 m2 / 4 bedrooms

House-kit price from:

CO2-eq

HUSFAKTA

Boyta total: 156,5 m2
Byggyta: 185,2 m2
Antal sovrum: 4
Nockhöjd: 5 m
Byggnadshöjd: 3,2 m
Byggsatspris från:

Vad betyder "byggsatspris"?
Läs mer om våra priser

BOKA MÖTE

LADDA NER PRODUKTBLAD

80 000
kg CO2-eq

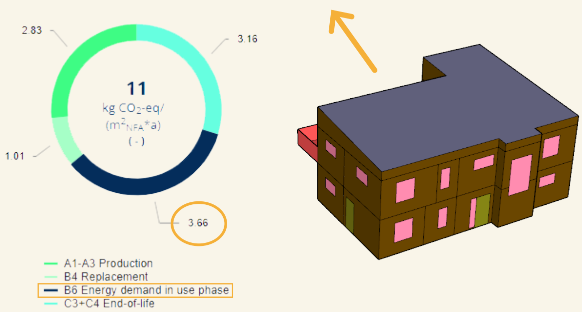
House envelope *40 471 kg CO2-eq*
Energy *33 142 kg CO2-eq*
Renovation *6 278 kg CO2-eq*

Laborating with latitudes and life span of a house

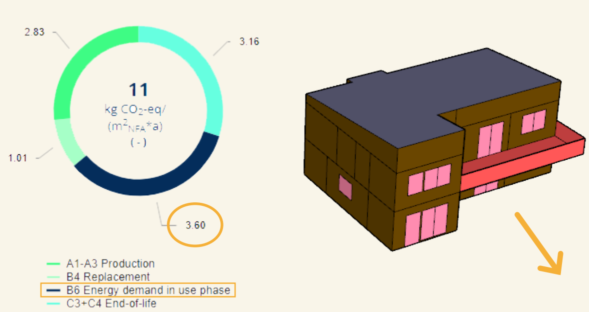
To continue trying to optimise and reduce a house's CO2 emissions, you can change more than just building materials. In addition we have chosen to make a comparison of values in CAALA on the house's orientation and on different lifespans for a house. What difference will it make if the facade with the largest window area faces north versus south? How much do the emissions in CAALA decrease or increase if a house is estimated to be 25-, 50-, 75- or 100 years old?

Different latitudes of Villa Ekerö

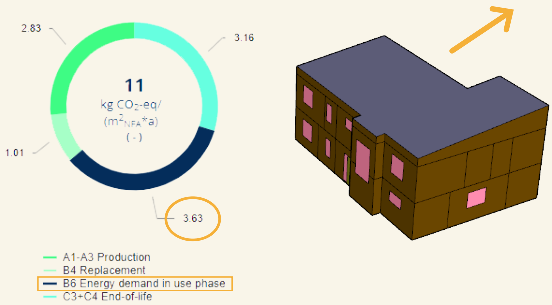
North



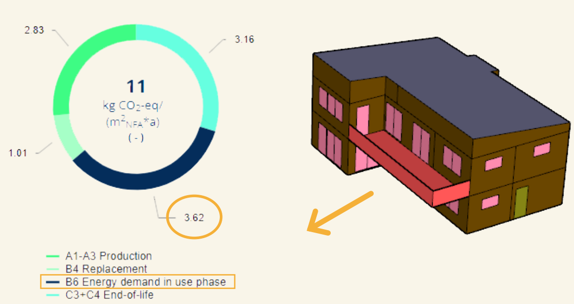
South



East



West



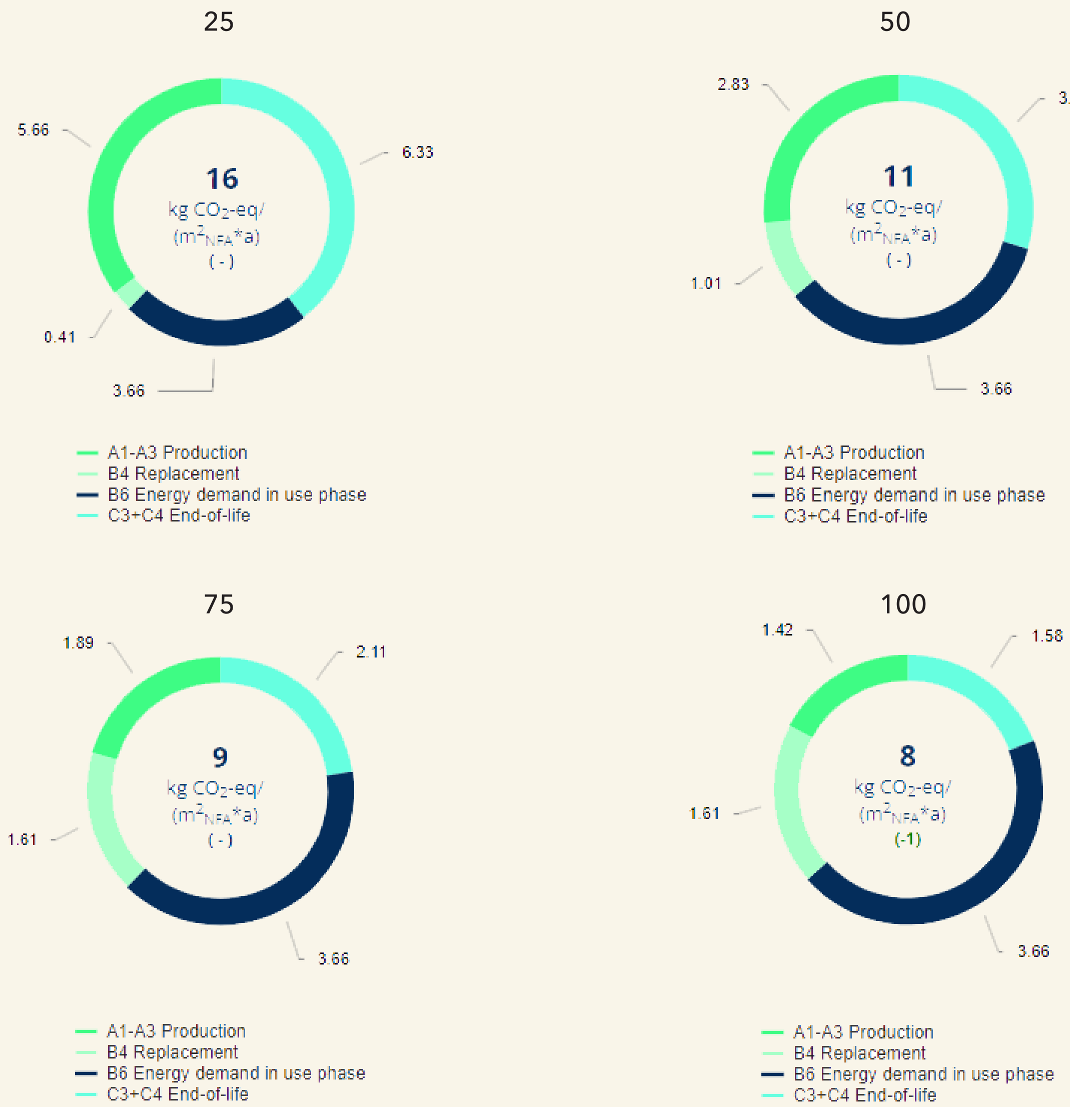
The total CO2-eq displayed in the middle of the circle doesn't change when trying out the different orientations. That is because the only part of the LCA that is affected is module B6, the house's energy demand in use phase. The biggest change of numbers is between north and south with a reduction of 0,06 kg CO2-eq. North gives 3,66 kg CO2-eq, south 3,60 kg CO2-eq, east 3,63 kg CO2-eq and west 3,62 kg CO2-eq. Turning the facade with the largest windows to the south is best from a CO2 emissions perspective and to the north is the worst.

The energy consumption decreases because the house is naturally heated by the sun when the largest window faces south. These calculations are made based on a Nordic climate. The values would have had a different outcome if the house had been calculated in a southern climate.

Different life span of Villa Ekerö

The starting point for the LCA calculations of the houses in this thesis has been a lifespan of 50 years. But the lifespan for a house can look very different and it is important to keep this in mind from the start when you design a house. It is also important for the house owner to know how the lifespan of a house affects the environment and CO2 emissions. With that information the house owner understands the importance of taking care of the house in a good way to prevent damages, which increases the chance of extending the life of the house.

Below are the calculations of different life span scenarios done in CAALA presented. It is a comparison between 25-, 50-, 75- and 100 years.



The numbers in the big circle are different for each year of life span. The modules that are affected are A1-A3 Production, B4 Replacement and C3 + C4 End of life. The results show that a house that lasts longer is better for the environment. One reason for this is partly that a house with a longer life span is reused by several households and minimises the upcoming of new houses. Building houses that stand for short periods means that more houses must be demolished and new houses must be built. The energy and emissions that are used to demolish a house and build a new one give large amounts of CO2 emissions. Another aspect is the carbon dioxide that building materials in wood stores during the lifespan of the house. These will be released during demolishment.

How green is your house?

Type 1 - Vårgårdahus construction

Concrete foundation

Wood exterior wall

Brick roof

Type 2 - Wood construction

Wooden foundation

CLT-wooden exterior wall

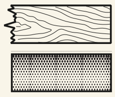
Wooden roof

Type 3 - Wood & Foamglas construction

Foamglas foundation

CLT-wooden exterior wall

Wooden roof



Results:

1-floor houses: Villa Djupvik, Villa Vinö


1-floor houses have the biggest foundation area when compared to the 1,5- and 2-floor houses. The area of the roof is also larger than in 2-floor houses. The area of exterior walls is smallest compared to the other categories.

The total amount of CO_2 emissions for type 1 constructions is average but the large area of foundation makes a big difference compared to other houses and that is why these houses are the most red ones on the label bar. The CO_2 footprint is the biggest for these houses per 1 m2 NFA. When construction types are changed to type 2 and 3 the CO_2 values decrease up to 32%, which is the biggest reduction made for the houses. Due to the large area of foundation and roof per house 1 m2 NFA the changes made in constructions cause the biggest effect.

1,5 floor houses: Villa Sävelund, Villa Hagalund


1,5-floor Villa Sävelund and Villa Hagalund have the largest CO_2 footprint when comparing houses between type 1, type 2 and type 3. These houses have the biggest roof and average m2 foundation. The wall area is also m2 average.

These villas have average scores on the labelbar. They both have red labels in type 1 construction but when doing changes in construction materials both villas score better and better values. Villa Hagalund has got a green label for type 2 construction and Villa Sävelund yellow for type 2 construction. Villa Hagalund label values reach almost 2-floor house label values but due to the kitchen and living room area that is open all the way up to the ridge the scores are lower. Both of these villas have a lot of roof and ground area that causes high CO_2 emissions if the constructions are not optimised.

2-floor houses: Villa Rosendal, Villa Ekerö


Villa Rosendal and Ekerö are the most green houses in all type 1, 2 and 3 categories. Both of these houses reach green label when changing the construction to type 2 and 3. If comparing the existing house models (Vårgårda construction type 1) these houses have the lowest emissions today. Villa Ekerö is the biggest house we have chosen to compare other houses with, but it is the best house when it comes to the total CO2 footprint due to the small area of roof and foundation. According to CO2 footprint, these houses are the best ones due to the small area of foundation and roof compared to the square metres.

Research questions

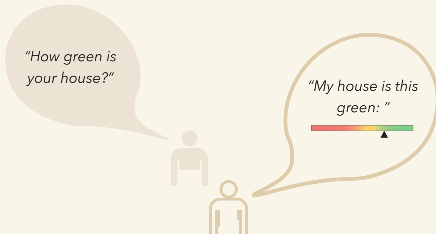
Let's get back to how this thesis started, with the first research question:

- *How can the CO2 footprint of catalogue houses be communicated to house buyers in an understandable way with the aid of LCA?*

By using the gradient traffic light bar under every house in the catalogue, the customer gets direct information if the house performs good or bad from a CO2 perspective. The red, yellow and green colours are instantly connected to our perception of good or bad which makes it clear to understand. The aim has been to use as little information as possible, which resulted in a simple arrow that indicates where on the bar the house performs and the text CO2-eq at the end of the bar that explains what the arrow shows. When a customer wants to learn more about the CO2 emissions of a specific house it is possible to click on the house to reach information level 2. Here the customer can see the total amount of CO2 emissions for that house and also get information of what category emits the most.

Research question two:

- *How much CO2 emissions can be reduced by optimising catalogue house's materials and building components with aid of LCA tools?*



The reduction made with the aid of new construction types is enormous. The biggest reductions made were between the construction type 1 and 3. The house where the emissions can be reduced most is villa Djupvik. The reduction is 32% of the ordinary Vårgårda construction. Foam glas foundation, CLT-exterior wall and wooden panel roof compared to the conventional construction reduces 32% CO2 emissions. The other houses gained 32-24% reduction between conventional construction and type 3 construction.

The reductions between construction type 1 and 2 are also significant. The biggest reduction is 27% and it is Villa Vinö, Villa Djupvik and Villa Hagalund that reach the highest reductions.The other villa's CO2 footprint reduction is counted up to 21%.

The biggest change can be seen in houses that have a big foundation and roof area. The catalogue houses that have more foundation and roof gain most benefit when changing the material. The houses that have a small area of foundation and roof, such as Villa Ekerö, are the most green houses.

Chapter ten: Design guidelines

This chapter summarises some various reflections that have emerged through the work with catalogue houses. This mainly applies to considerations about the relationship between house design and construction and its climate impact.

Reflections on sustainability when building a house:

- It is important that the house is built for many generations to come. Building a new house always causes emissions.
- The energy efficiency and usage of renewable energy sources is important.
- Energy used in a house is usually energy that is needed to warm or cool down the air and water. By designing the exterior house components, the building envelope, so that they reach as low U-value as possible, energy efficiency is created.
- Try to use less concrete och tiles.
- Use more wood.
- There is a lot of material for isolation used in every house so be extra careful with the choice of isolation.
- Use local materials.
- Always try to use recycled materials.

Sustainable dimensioning:

- It is best to build a house with an optimised living area. The best option is to build a house as small as possible or with a small footprint. The CO2 emissions are calculated per person, so it is good to think how many square metres per person the house is built for.
- The biggest emissions occur from the foundation and the roof. By optimising those components in accordance to the floor area the buildings CO2 emissions reduce.
  - That can be seen in calculations done for 1, 1,5 and 2 floor houses. The emissions per sqm is lowest for the 2 floor houses.
- With the aid of remodelling the roof, reducing the roof area the emissions will be reduced.
- The placement of the house in different latitudes affects the house’s CO2 emissions regarding energy demand.

Chapter eleven: Discussion and reflections

Informing the consumer about the environmental impact of products is a good way to try to change people's behaviour. Much can be done through knowledge and education but it is the actions that count. We as individuals can do a lot for the environment and try to tackle climate change through our own actions. If we are conscious about what we buy and what effects it has on our climate and globe we might start to make better decisions in future. With the aid of communicating the CO2 footprint, consciousness can be created. This thesis is about creating that consciousness for a customer, in this specific case for a house buyer. Through reference projects and LCA calculations we have created a solid base for the house buyer to be able to be conscious about their choices and the impact they have on the environment.

The reference project Villa Zero is a project by three companies collaborating and trying to change the conventional way of building houses and challenge the building industry by creating the first NollCO2 certificated detached house in Sweden. Villa Zero shows it is possible to build sustainably. With the aid of using mainly wood as material, using as much locally produced material, creating an efficient house envelope and producing more energy than the house itself needs, a NollCO2 certificate is possible to reach. Before people can start to make better and more conscious choices there has to be better sustainable options offered. To label catalogue houses' CO2 emissions can be one way to push people in the right direction. In future, we hope that there might not be a need for a green labelling system because all the alternatives offered should be green. Still that is not where we are right now and that is why labelling is the first step taken on this journey.

CO2 labelling has become more and more common when we look into different branches. It is up to date to show the emissions and clarify where they come from. More information about producers and the product itself is available and can be compared. The topic is accurate and more and more people are learning about climate change and how we as individuals can affect it.

There is a big focus on sustainability in the construction industry when it comes to large buildings and progress is being made in terms of climate declaration and more consciousness of material choices in Sweden. But the catalogue house industry is still a side track from the construction industry, where neither architects nor politicians have shown any greater interest through the years despite the fact that it is one of Sweden's most common types of housing and a service that large parts of the population use. We believe that a good step forward in the climate discussion for detached houses would also be to conduct climate declarations. When conducting a climate declaration it clarifies where the emissions come from and what alternatives are better in terms of CO2 footprint.

The big building companies have got more requirements to live up to and therefore have come much further in their sustainable work within the company. Is it because of tougher demands from the government or increased requests from customers? We see a difference between "apartment buyers" and "house buyers". The marketing towards the two different groups is not equal. It is more about sustainability when talking about apartments than it is when talking about private single houses. Once again, is this because of an increased request of sustainable options from the customers or is it because of legislation?

Catalogue houses

In Sweden, there is a tendency among architects not showing any interest in the catalogue house industry. This category is somewhat tabooed by architects. Maybe because catalogue houses are predesigned and not designed according to the site's specific conditions and qualities, which goes against the architecture that is place driven, creative and a unique piece of building. But these occupations could have a lot to learn from each other. More architectural qualities could be implemented into the catalogue houses. Also a more systematic and efficient way when it comes to building the house could be learned from the catalogue house industry. Both occupations are designing houses for the future and should both consider how to build more sustainable.

The business of catalogue houses

As we have understood, when it comes to the catalogue house business it is the amount of money a customer has that affects the choice of a house the most. There are many decisions to be made and unfortunately the facts about CO2 emissions are not communicated at all during the process. The customers usually want to build a house as big as they can afford for the money they have. Trends are also something that steer the choice of a house model. The trends identified by the catalogue housing companies were mostly about kitchen, toilet, bathroom/spa, and the floorplan. We believe trends in catalogue house business will turn towards more sustainable solutions due to the trend within sustainability in other fields. Also energy prices that are increasing can affect people to think how they could save energy or build even more energy efficient. People and especially younger generations are more aware of the environment and hopefully they, together with climate declarations, laws and requirements will put pressure on catalogue house companies in future that will result in more sustainable solutions.

CAALA

The energy mix chosen in CAALA makes the biggest difference in the calculations. The German energy mix produces much more CO2 footprint compared to the Swedish energy mix since the German energy comes from more carbon dioxide-intensive sources such as oil and coal. Swedish energy is mostly produced from renewable energy sources such as wind power, hydropower and nuclear power. That is why this is such an important factor to consider when typing in the values in CAALA in order to get the right results.

Also the heating system is taken into account in CAALA. It makes a small difference in the B-module when changing it in the calculations. The heating system we chose for our calculations was an air-water heating system. The CO2 emissions from heating can also vary depending on where the house is located.

The values gained from CAALA represent the CO2 footprint per square metre and year. That is why the values are multiplied with year and NFA to be able to calculate the total amount of emissions.

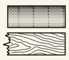
When comparing the CO2 emissions with data from One Click LCA some assumptions were made in order to be able to compare the emissions. One Click LCA takes modules A1-A5 into account whereas CAALA takes A1-A3, B4, B6, C3+C4 into account. The modules are also presented as one cluster, so the program does not clarify how big the amount of each module is separately. Module C is also a bit unclear, because if we in Sweden plan to be climate neutral in 2045 or earlier we cannot emit any CO2 at the end of the product's lifecycle. We asked about the module C for Villa Zero and heard that the C-module is set to 0 due to the Swedish climate goals. In CAALA the program always calculates the C-module, and it is a bit unclear where those numbers come from. We noticed that for wooden material the module A is often negative and that the module C balances the CO2 emissions. Wood binds CO2 but the amount of CO2 is released to the atmosphere when the wood is burned.

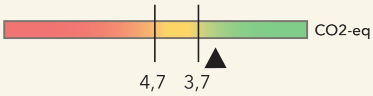
In a real project the calculations are easier to perform because then the location of the project is known and exact values for transportation and energy can be calculated. In a real project the certain products are also decided more in detail so the real CO2 value can then be more detaily accessed.

We can see that the LCA tools for the building industry are not fully developed yet and there is still a lot to do to be able to compare values and results between different programs.

NollCO2 certificate

The NollCO2 certification system has given us a better understanding of how the compensation for CO2 works. But during our work we have questioned the way it is spoken about how to make a house carbon neutral. Basically you cannot compensate for any emissions you have let out to the atmosphere because the harm is already done. So saying a house can reach net 0 emissions is giving the wrong message.

Villa Vinö (Type 3) 



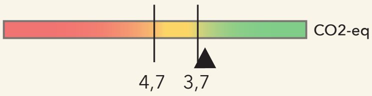
147 m2

Total 29 000kg CO2-eq (A1-A3 + C)

Total 73 000 kg CO2-eq (A-C)

*50 year lifetime period

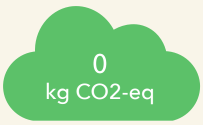
Villa Zero



107 m2

Total 24 000kg CO2-eq (A1-A3 + C)

Total 0 kg CO2-eq (A-C)



*50 year lifetime period

We made a comparison between Villa Zero and Villa Vinö - which is the smallest villa with one floor we looked into from Vårgårdahus. These two projects, which are calculated in two different LCA programs, complicated the comparison. We had to translate the numbers from each LCA to match each other units. When comparing these villas between each other Villa Vinö is greener when looking into the label. But when looking at the emissions during the 50 year period of time Villa Zero compensates the energy by producing more energy than the house itself is in need of and due to that it lowers its emissions to zero. If Villa Vinö would compensate for energy, for example by installing solar panels, it could also reach zero.

The lack of officially available limit values for what is classified as a good or bad detached house from an environmental perspective makes it difficult to compare houses against each and see what should be classified as green. A global or national system for limit values should exist in order for the declarations to be used to their full potential. Boverket has received criticism regarding this and issued a statement during spring that they will come up with a new proposal regarding limit values and climate declarations before 2027. NollCO2 was a good support for us in the work of figuring out what limit values our labelling system needed to have. Without NollCO2's guidelines, it would have been difficult to set any own limit value.

Results and guidelines

The results from CAALA's LCA calculations are interesting. The houses that have the biggest foundation and roof have the biggest CO2 impact. The houses that are two floors and have less roof and foundation have the best CO2 footprints, even though these houses are the biggest in this comparison. It is still surprising that a one floor house with a smaller living area but bigger foundation and roof area is worse than a bigger house with two floors after 50 years.

We thought that the houses with 1,5 floors would be the best houses when it comes to the CO2 footprint. Those 1,5 floors houses that we choose från Vårgårdahus have a huge roof area. The foundation is also big compared to the living area. Both of these houses have parts where the second floor does not cover the first floor. That means that the foundation and roof area are still big, as big as the parts in the one floor buildings.

The Vårgårda houses with original Vårgårdahus construction tested were more green than we thought from the beginning. The catalogue house producers have needed to change their houses constructions during the last years due to the new energy legislations, which has made the houses reaching good u-values which is sustainable, meaning that the need of energy is less than earlier.

The biggest difference that can be seen, that affects the CO2 emissions most, is the type of energy used. Renewable energy is the most efficient way of reducing CO2 emissions.

Are CO2 optimised houses at risk of losing architectural qualities? Trying to optimise the floor area in relation to foundation, roof and exterior wall make the biggest impact for CO2 footprint. There are still many ways to create architectural qualities with the aid of windows, openings, different levels and roomhights. The awareness in materials used makes the biggest impact, as well as the lifetime of a house.

Next steps

We have deliberately chosen not to focus on the costs of the catalogue houses in this thesis, due to the time given. But trying to optimise a house so that it both has a lower climate footprint and reduces costs is the optimal solution required for it to work on the market. Next step would be to calculate material costs and see where reduction of cost can be made.

Further work can also be done to try to optimise the materials and constructions. We have chosen to work with two types of new constructions. There are many more new materials and constructions to be tested in order to reduce the CO2 emissions. The possible materials for the catalogue house construction could have been worked together with the catalogue house company. If changing the house construction then tests and pilot projects need to be done to be able to find the most suitable and green constructions for the houses.

Personal gains from the work this thesis

For us it has been very interesting to listen and learn about how the process of building a catalogue house works. A one family house has been a good learning point in how to grasp the question of ecologically sustainable architecture, more in detail, how we understand the CO2 emissions of a house.

The example project Villa Zero has been a big inspiration and source of learning about new materials, new ways of building a house and thinking about sustainability in general. But there are also concerns and questions that have been brought up during the work. Especially about having CLT-wood in the foundation construction. How will it perform in a couple of years ahead? How does it work if a damage occurs in the CLT-wood slab and you have to replace it? It has given us lessons to think about for future construction in our work as architects. With that said, it is inspirational to see a project like Villa Zero where different companies that have gone together and work towards the same goal. The boldness of doing an experimental project with the purpose to educate and push the boundaries is something we need to see more of in order to reach further within sustainability.

Implementing the learnings and summary from our design guidelines into new architectural solutions will be something we take with us from this thesis. Having a greater understanding of what causes a house's CO2 emissions gives us a larger and more varied toolbox to work with as architects. We see this labelling as a first step in the right direction for the housing industry to reach the climate goals, but still it's not enough. More things need to be solved in this complicated question and that is one of all challenges we look forward to working with as architects in the future!

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CHALMERS UNIVERSITY OF TECHNOLOGY
Department of Architecture and
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Architecture and urban design
Master's thesis in Architecture
ACEX35 - *Housing*
Spring semester 2022

Patricia Lundblad & Julia Ribeck

Supervisor: Kaj Granath
Examiner: Ola Nylander

CHALMERS
UNIVERSITY OF TECHNOLOGY

APPENDIX

Interview guide
Values of the labelling
CAALA Djupvik construction Type 1
CAALA Djupvik construction Type 2
CAALA Djupvik construction Type 3

Interviewguide (in Swedish)

Basic info
Namn:
Hur länge har du jobbat med att sälja?
Vad har du för bakgrund?
Vilka uppgifter ingår i ditt arbete?
Vad är hållbarhet för dig?

Om kunder:
Vad har ni för kunder?
Vilka kundsegment/kundgrupper kan du identifiera?
Ålder på kunder?
Hur många personer ingår i ett sådant typiskt hushåll?
Varför väljer dem att bygga ett typhus?
Varför kommer dom till er?
Vad är kunderna mest intresserade om?
Hur ser kundmötena ut?

Scenario 1: Om vi framställer oss ett scenario där en familj ska köpa hus från er:
Vad är det dom värderar mest? Vad efterfrågar dom?
Hur skulle du beskriva deras behov?
Vilka faktorer begränsar deras val? Hur ser deras ramar ut? (ekonomi, tomt, mm.)
Har kunderna frågat om hur ni jobbar med hållbarhet?
Har kunderna fråga er om mer hållbara lösningar? Isf vad?

Scenario 2: Ett annat scenario, tex med äldre par
Vad är det dom värderar mest? Vad efterfrågar dom?
Hur skulle du beskriva deras behov?
Vilka faktorer begränsar deras val? Hur ser deras ramar ut? (ekonomi, tomt, mm.)
Har kunderna frågat om hur ni jobbar med hållbarhet?
Har kunderna fråga er om mer hållbara lösningar? Isf vad?

Extra:
Efterfrågan om hur många plan?
Vilka behov utav storlek, funktioner och användning av utrymmen?

Hållbarhet hos kunderna
Pratas det om hållbarhet i någon utsträckning? (Hållbarhet kan ju innefatta social, ekonomisk eller ekologisk hållbarhet)
Frågar kunderna efter hållbara lösningar?
Ser du någon nytta med hållbarhet utifrån sälj perspektiv? Tycker du det hade kunnat vara ett argument i köpläge?
Vad tänker du om hållbarhet kommer spela för roll om 10 år?
Hur tror du kundernas behov och efterfrågan kommer skilja sig från idag?

Hållbarhet inom företaget
Vad gör ert företag för hållbarhet? Hur jobbar ni med det?
Vad erbjuder ni för hållbara lösningar i dagsläget?
Hur länge beräkna ni att era hus står? Livslängd
Vad har ni för u-värden?
Har ni några miljöcertifieringar?
Vilka krav uppfyller ni?
Görs det några LCA-beräkningar?
Om en mer hållbar huslösning (exempelvis passivhus) hade kostat 10% mer, tror du kunderna hade kört på det?

Avslut
Hur du tror ditt jobb kommer se ut i framtiden?
Vad har ert företag som framtidsvisioner?
Hur tror du hållbarhet speglas i ert arbete i framtiden?
Vad är det bästa med ditt jobb?
Vad är det sämsta med ditt jobb?
Vill du berätta något mer?
Finns det någon kundundersökning från er som vi kan ta del av?

Values of the labelling

Calculations for gradient traffic light bar values of each house:

Labelling value	1 FLOOR			1 FLOOR			1,5 FLOOR		
Placement for CO2 emission indicator	Villa Djupvik			Villa Vinö			Villa Sävelund		
	157kvm			147kvm			183kvm		
	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3
CAALA A1-A3 kg CO2eq/m2 NFA*year	6,07	-8,3	-3,83	6,05	-8,25	-3,83	5,09	-7,03	-3,41
CAALA C3-C4 kg CO2eq/m2 NFA*year	3,87	14,22	8,16	3,67	14,05	8,06	3,56	12,3	7,38
year	50	50	50	50	50	50	50	50	50
m2 NFA	146	146	146	134	134	134	184	184	184
CAALA A1-A3 kg CO2eq	44311	-60590	-27959	40535	-55275	-25661	46828	-64676	-31372
CAALA C3-C4 kg CO2eq	28251	103806	59568	24589	94135	54002	32752	113160	67896
CAALA A1-A3+ C3-C4 kg CO2eq	72562	43216	31609	65124	38860	28341	79580	48484	36524
year	50	50	50	50	50	50	50	50	50
m2 GFA	182	182	182	168	168	168	230	230	230
CO2 emission indicator value									
CO2eq/m2 GFA*year	7,97	4,75	3,47	7,75	4,63	3,37	6,92	4,22	3,18

	1,5 FLOOR			2 FLOOR			2 FLOOR		
	Villa Hagalund			Villa Rosendal			Villa Ekerö		
	139kvm			187 kvm			196kvm		
	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3
CAALA A1-A3 kg CO2eq/m2 NFA*year	4,18	-6,86	-3,56	3,3	-6,13	-3,49	2,83	-5,61	-3,38
CAALA C3-C4 kg CO2eq/m2 NFA*year	3,39	11,28	6,76	3,29	10,22	6,61	3,16	9,56	6,55
year	50	50	50	50	50	50	50	50	50
m2 NFA	202	202	202	175	175	175	177	177	177
CAALA A1-A3 kg CO2eq	42218	-69286	-35956	28875	-53637,5	-30537,5	25045,5	-49648,5	-29913
CAALA C3-C4 kg CO2eq	34239	113928	68276	28787,5	89425	57837,5	27966	84606	57967,5
CAALA A1-A3+ C3-C4 kg CO2eq	76457	44642	32320	57662,5	35787,5	27300	53011,5	34957,5	28054,5
year	50	50	50	50	50	50	50	50	50
m2 GFA	253	253	253	218	218	218	221	221	221
CO2 emission indicator value									
CO2eq/m2 GFA*year	6,04	3,53	2,55	5,29	3,28	2,50	4,80	3,16	2,54

Calculations of total CO2 footprint:

	1 FLOOR			1 FLOOR			1,5 FLOOR			1,5 FLOOR			2 FLOOR			2 FLOOR		
	Villa Djupvik			Villa Vinö			Villa Sävelund			Villa Hagalund			Villa Rosendal			Villa Ekerö		
	157kvm			147kvm			183kvm			139kvm			187 kvm			196kvm		
Total kg CO2 eq footprint	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3
CAALA A1-A3	6,07	-8,3	-3,83	6,05	-8,25	-3,83	5,09	-7,03	-3,41	4,18	-6,86	-3,56	3,3	-6,13	-3,49	2,83	-5,61	-3,38
CALA A4-A5	1,214	1,214	1,214	1,21	1,21	1,21	1,018	1,018	1,018	0,836	0,836	0,836	0,66	0,66	0,66	0,566	0,566	0,566
CAALA A1-A5	7,284	-7,086	-2,616	7,26	-7,04	-2,62	6,108	-6,012	-2,392	5,016	-6,024	-2,724	3,96	-5,47	-2,83	3,396	-5,044	-2,814
kg CO2 eq/m2 BTA *year																		
CAALA module A1-A5	7,284	-7,086	-2,616	7,26	-7,04	-2,62	6,108	-6,012	-2,392	5,016	-6,024	-2,724	3,96	-5,47	-2,83	3,396	-5,044	-2,814
CAALA module B4	1,35	0,86	0,86	1,27	0,82	0,82	1,03	0,63	0,63	0,95	0,57	0,57	0,94	0,65	0,65	1,01	0,79	0,79
CAALA module B6	3,77	3,68	4,54	3,78	3,67	4,51	3,83	3,75	4,51	3,5	3,43	4,18	3,55	3,47	4,03	3,66	3,57	3,99
CAALA module C3-C4	3,87	14,22	8,16	3,67	14,05	8,06	3,56	12,3	7,38	3,39	11,28	6,76	3,29	10,22	6,61	3,16	9,56	6,55
year	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
NFA	146	146	146	134	134	134	184	184	184	202	202	202	175	175	175	177	177	177
kg CO2 eq																		
CAALA module A1-A5	53173,2	-51727,8	-19096,8	48642	-47168	-17554	56193,6	-55310,4	-22006,4	50661,6	-60842,4	-27512,4	34650	-47862,5	-24762,5	30054,6	-44639,4	-24903,9
CAALA module B4	9855	6278	6278	8509	5494	5494	9476	5796	5796	9595	5757	5757	8225	5687,5	5687,5	8938,5	6991,5	6991,5
CAALA module B6	27521	26864	33142	25326	24589	30217	35236	34500	41492	35350	34643	42218	31062,5	30362,5	35262,5	32391	31594,5	35311,5
CAALA module C3-C4	28251	103806	59568	24589	94135	54002	32752	113160	67896	34239	113928	68276	28787,5	89425	57837,5	27966	84606	57967,5
Total kg CO2 eq	118800,2	85220,2	79891,2	107066	77050	72159	133657,6	98145,6	93177,6	129845,6	93485,6	88738,6	102725	77612,5	74025	99350,1	78552,6	75366,6
	119 000	82 000	80 000	108 000	78 000	73 000	134 000	99 000	94 000	130 000	94 000	89 000	103 000	78 000	75 000	100 000	79 000	76 000

	Villa Djupvik		Villa Vinö		Villa Sävelund		Villa Hagalund		Villa Rosendal		Villa Ekerö	
GFA	182	m2	168	m2	230	m2	253	m2	218	m2	221	m2
NFA	146	m2	134	m2	184	m2	202	m2	175	m2	177	m2
foundation	182	m2	168	m2	164	m2	154	m2	115	m2	112	m2
exterior wall	174	m2	172	m2	193	m2	173	m2	193	m2	240	m2
roof	189	m2	170	m2	215	m2	230	m2	149	m2	113	m2

Caala Report

For Project: house djup

Table of Content

1. Object data

1.1. Object

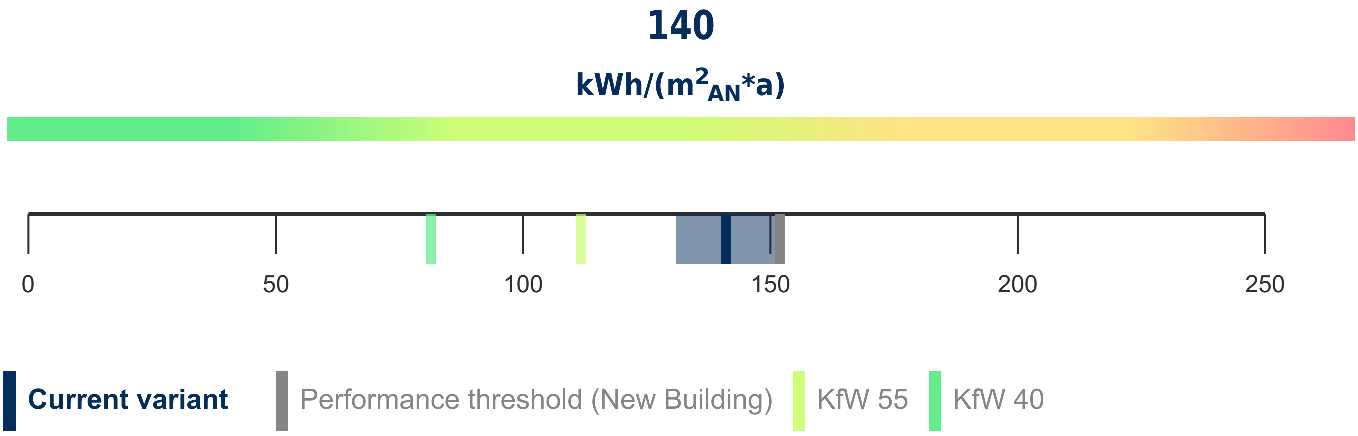
Model	VILLA DJUPVIK 2102
Scope of analysis	Full Life Cycle
Level of detail	Blueprint planning
Building type	Single family house
Energy standard	EnEV 2016
Reference study period	50 Jahre
Climate region - reference location	Region 10 - Hof

1.2. Geometry

Average floor height	2.70 m
V	817.53 m^3
GFA th.	302.79 m^2
NFA	242.23 m^2
Reference area	261.61 m^2

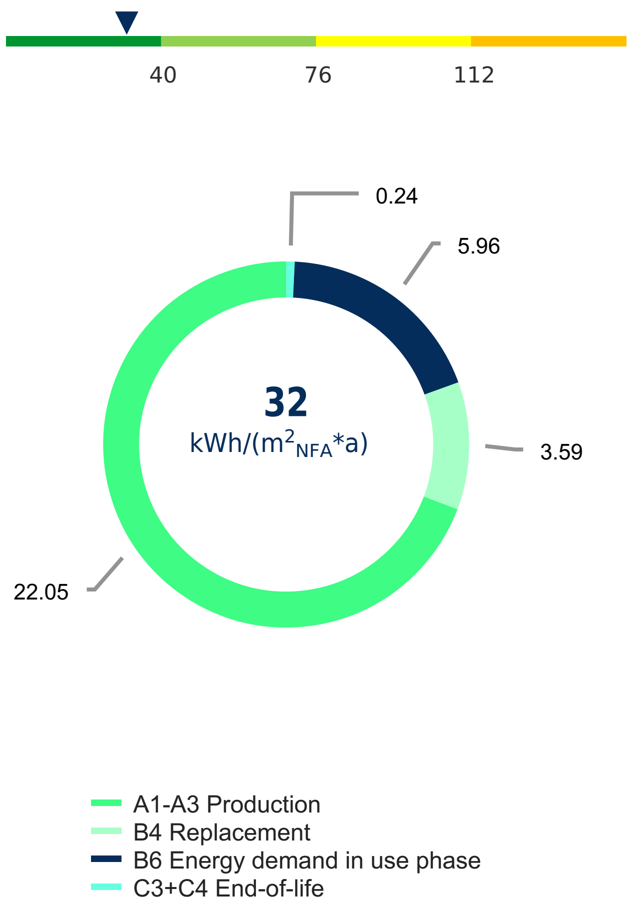
2. Overview

2.1. Primary energy demand

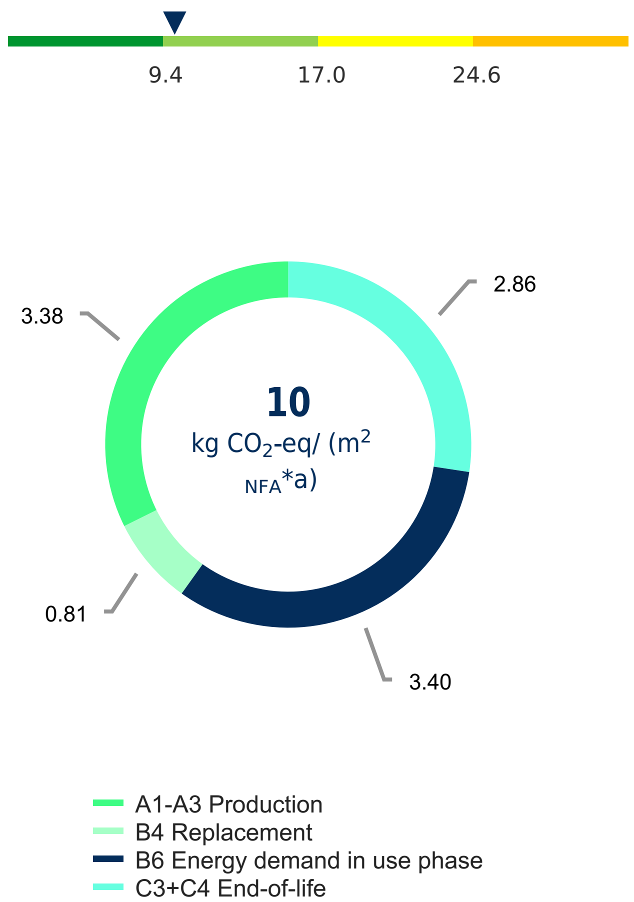


2.2. Life Cycle Assessment

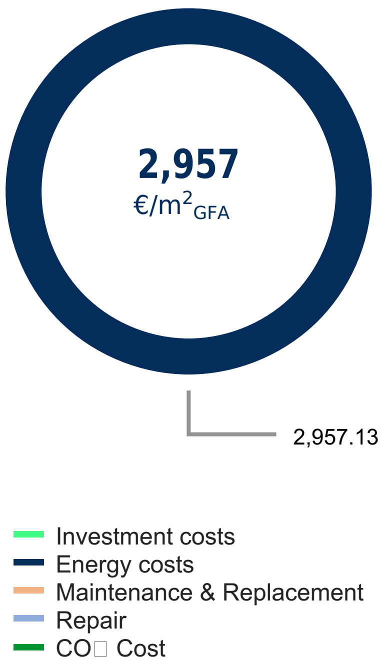
Primary energy non renewable (PENRT)



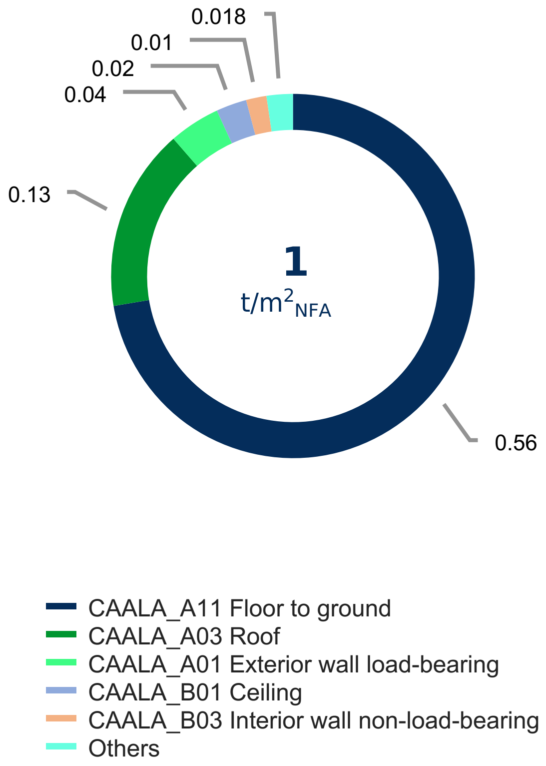
Global warming potential (GWP)



Life cycle costs

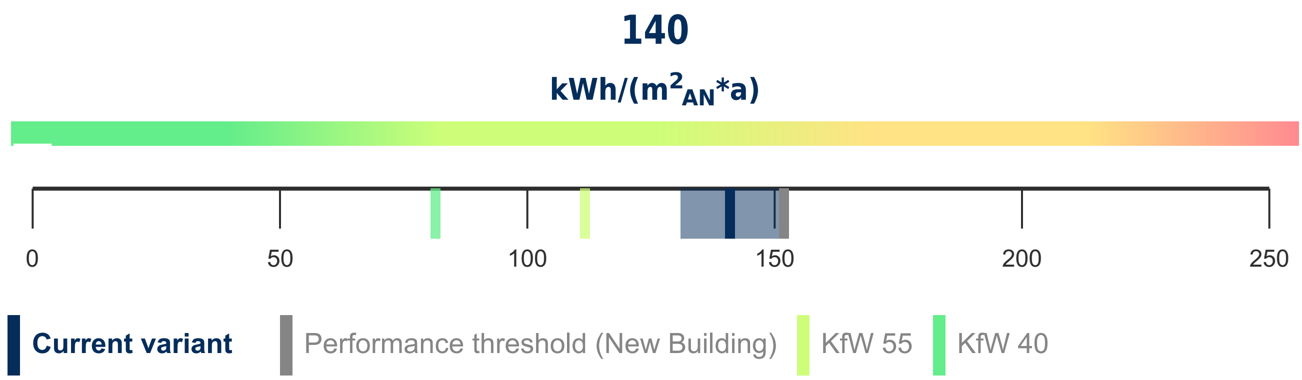


Mass Balance



3. Operational energy demand

3.1. Overview



Annual energy requirement operation

Primary energy demand		140 kWh/(m^2_{AN}*a)
End energy demand	Electric heat pump air-water	84 kWh/(m^2_{AN}*a)
	Hot water	9 kWh/(m^2_{AN}*a)
	Auxilary electricity	2 kWh/(m^2_{AN}*a)
	User Electricity	40 kWh/(m^2_{AN}*a)
Useful energy requirement	Space heating	84 kWh/(m^2_{AN}*a)
	Hot water	9 kWh/(m^2_{AN}*a)

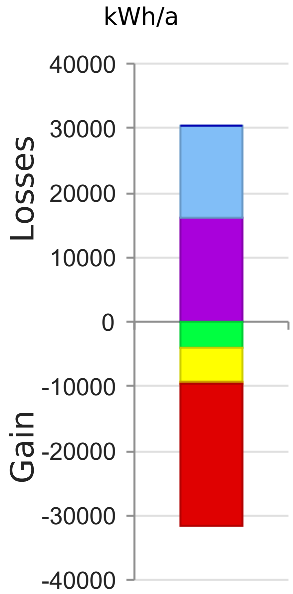
Energetic parameters

Energy reference area	261.61 m^2
Specific area-based transmission heat loss H'_T	**0.29 W/(m^2*K)**
Max. specific area-based transmission heat loss H'_T	0.35 W/(m^2*K)

3.2. Result per year

Legend

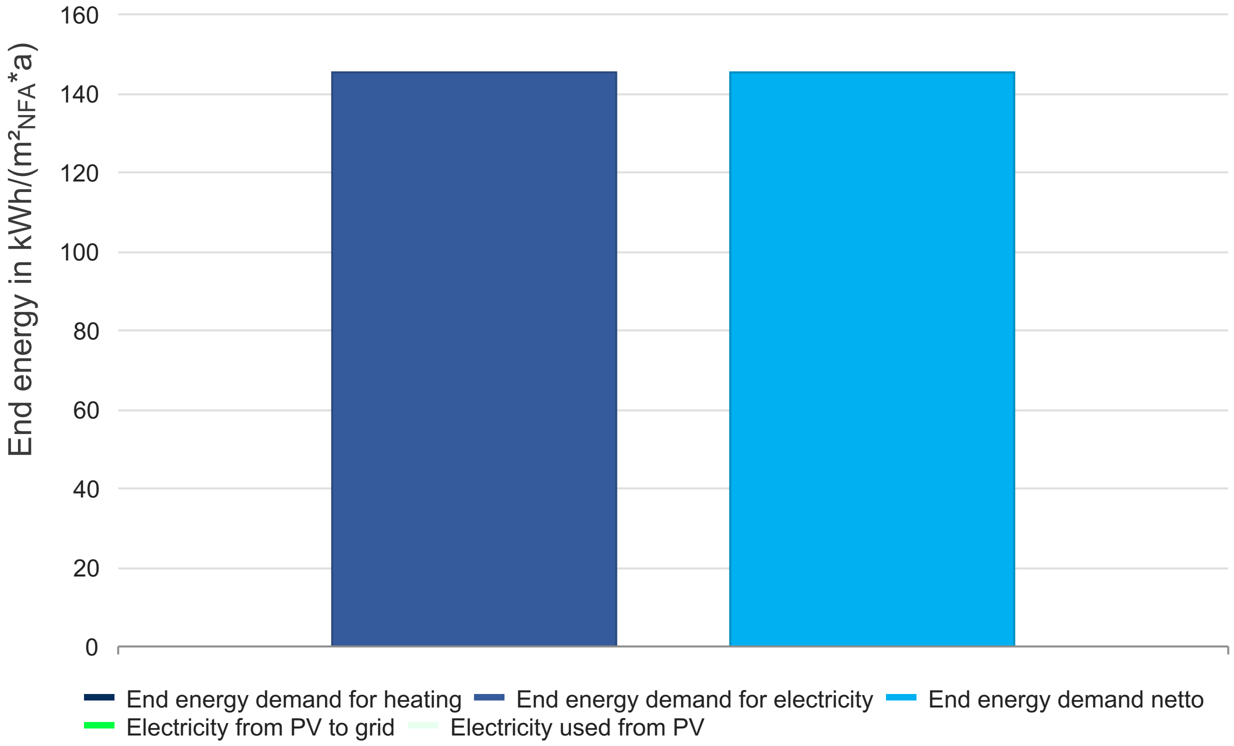
Losse	Solar losses opaque	97 kWh/a
	Ventilation heat losses	14,461 kWh/a
	Transmission heat losses	15,974 kWh/a
Gain	Internal gains	3,972 kWh/a
	Solar gains transparent	5,252 kWh/a
	Solar gains opaque	352 kWh/a
	Heating demand	**22,103 kWh/a**



Annual balance of energy generation on site (photovoltaics)

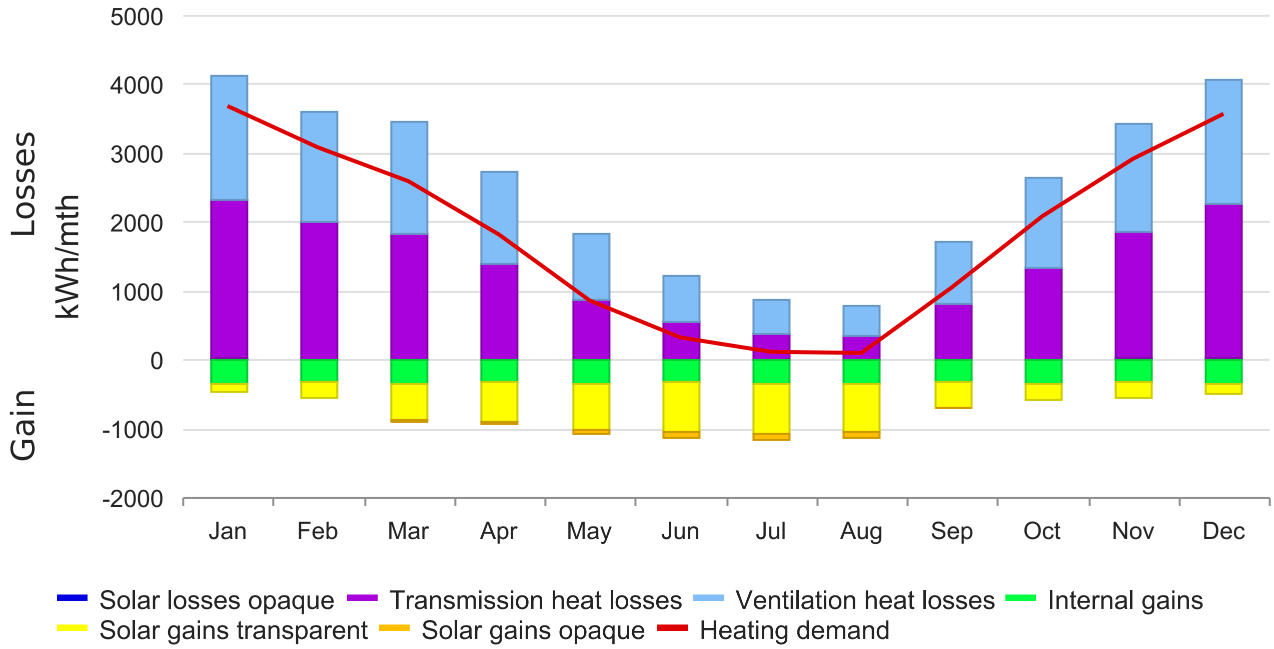
Electricity harvested	0 kWh/a
Electricity demand	35,184 kWh/a

Annual balance of end energy demand with potential for on-site energy generation (photovoltaics)

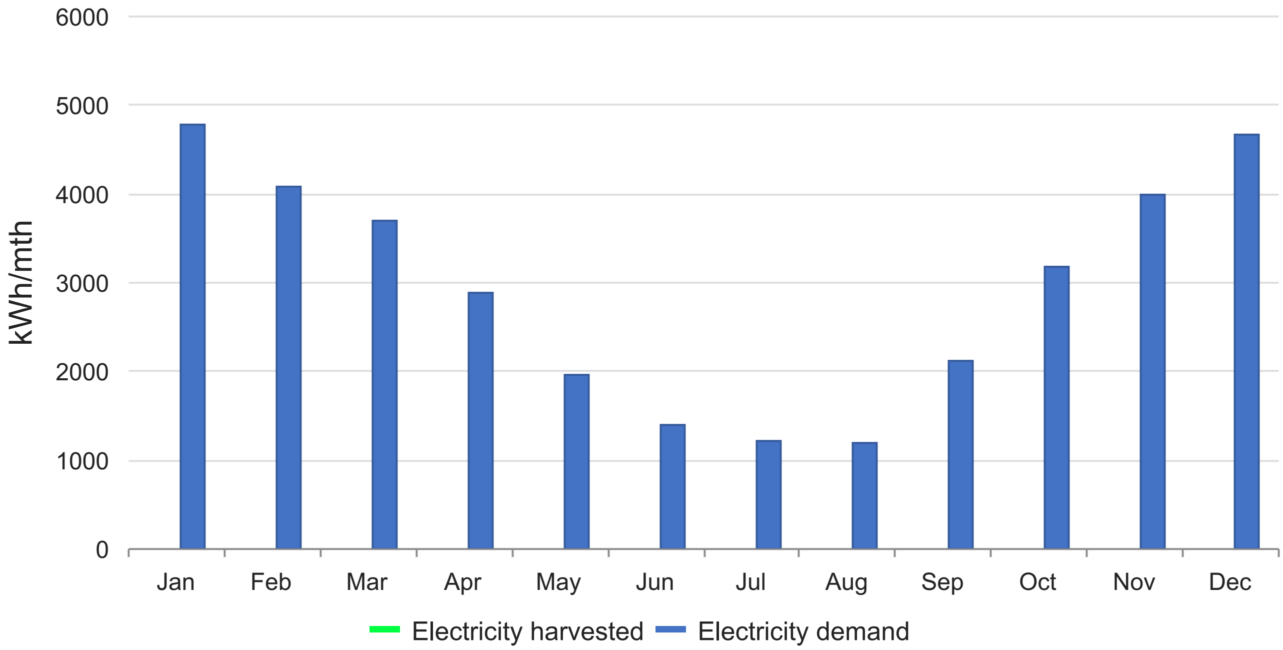


3.3. Result monthly per year sheet

Monthly energy balance



Monthly energy harvesting on site (photovoltaics)



Monthly values

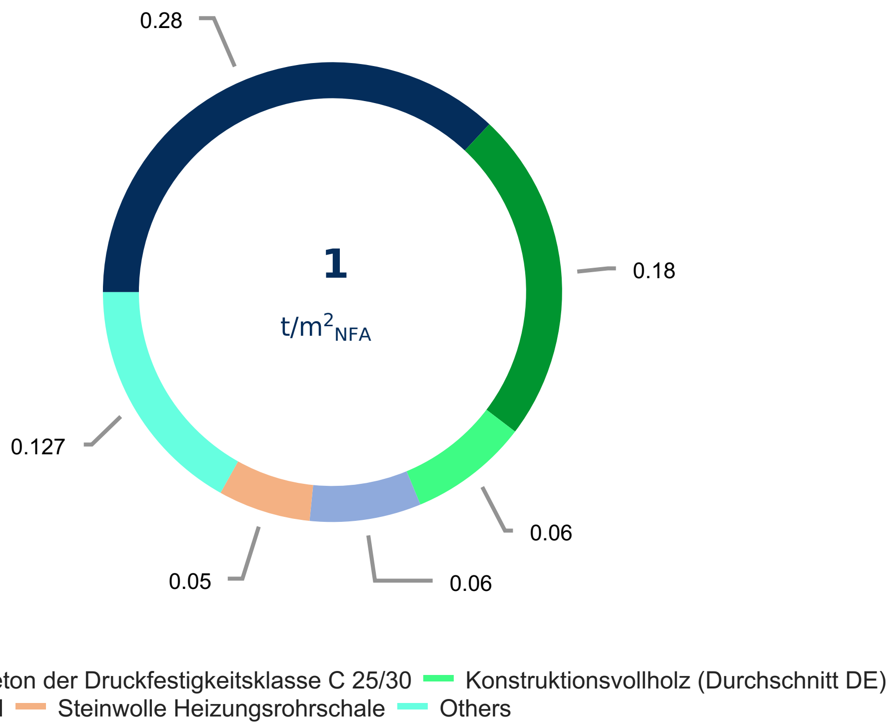
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Natural ventilation $H_{V, win, mth}$ (W / K)	66.1	68.9	80.1	93.5	111.4	121.3	127.6	128.7	112.5	97.0	78.4	67.8
Ref: Natural ventilation $H_{V, win, mth}$ (W / K)	72.8	75.9	88.2	102.9	122.7	133.5	140.5	141.6	123.8	106.8	86.3	74.7
Internal temperature balance(°C)	18.2	18.3	18.4	18.8	19.2	19.5	19.7	19.7	19.3	18.9	18.4	18.3
Ref: Internal temperature balance(°C)	18.2	18.2	18.4	18.7	19.2	19.5	19.6	19.7	19.2	18.8	18.3	18.2
Transmission heat sinks QT_{sink} (kWh)	2,296.8	1,991.7	1,844.3	1,390.5	890.0	570.7	396.7	364.6	830.1	1,329.6	1,836.7	2,239.4
Ref: Transmission heat sinks QT_{sink} (kWh)	2,867.8	2,486.8	2,301.3	1,735.1	1,110.5	712.1	495.1	454.9	1,035.9	1,659.1	2,291.8	2,796.2
Ventilation heat sinks QV_{sink} (kWh)	1,812.1	1,606.7	1,618.5	1,337.3	956.4	648.7	466.8	431.4	897.7	1,308.2	1,591.5	1,791.7
Ref: Ventilation heat sinks QV_{sink} (kWh)	1,477.4	1,319.9	1,364.9	1,157.5	851.2	584.7	423.8	392.1	800.0	1,139.2	1,337.0	1,467.7
Solar gains transparent $QS_{tr,source}$ (kWh)	123.9	230.0	525.1	567.6	666.7	713.6	747.7	716.8	361.7	236.4	211.1	157.8
Ref: Solar gains transparent $QS_{tr,source}$ (kWh)	123.9	230.0	525.1	567.6	666.7	713.6	747.7	716.8	361.7	236.4	211.1	157.8
Solar gains opaque $QS_{opaq,source}$ (kWh)	0.0	0.0	22.1	39.3	62.9	74.8	76.0	63.4	14.1	0.0	0.0	0.0
Ref: Solar gains opaque $QS_{opaq,source}$ (kWh)	0.0	0.0	33.2	64.3	106.5	127.7	129.2	106.0	22.2	0.0	0.0	0.0
Solar losses opaque $QS_{opaq,sink}$ (kWh)	29.0	11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.1	19.0	27.4
Ref: Solar losses opaque $QS_{opaq,sink}$ (kWh)	29.0	11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.1	19.0	27.4
Internal heat sources QI_{source} (kWh)	337.9	305.2	337.9	327.0	337.9	327.0	337.9	337.9	327.0	337.9	327.0	337.9
Ref: Internal heat sources QI_{source} (kWh)	337.9	305.2	337.9	327.0	337.9	327.0	337.9	337.9	327.0	337.9	327.0	337.9
Utilization factor η^M	1.0	1.0	1.0	1.0	0.9	0.8	0.7	0.6	1.0	1.0	1.0	1.0
Ref: Utilization factor η^M	1.0	1.0	1.0	1.0	0.9	0.8	0.7	0.6	1.0	1.0	1.0	1.0
Heat demand $Q_{h,b}$	3,676.3	3,074.7	2,583.4	1,808.8	852.3	316.1	107.6	90.1	1,043.6	2,076.8	2,909.9	3,563.2
Ref: Heat demand $Q_{h,b}$	3,936.0	3,294.0	2,776.3	1,950.0	930.0	353.5	126.0	107.7	1,143.7	2,247.9	3,127.7	3,819.0
Electricity demand (kWh)	4,783.8	4,093.0	3,690.9	2,886.5	1,959.7	1,393.8	1,215.0	1,197.5	2,121.3	3,184.3	3,987.6	4,670.7

Monthly energy harvesting on site (photovoltaics)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Electricity harvested plant 1 (kWh/mth)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electricity harvested plant 2 (kWh/mth)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

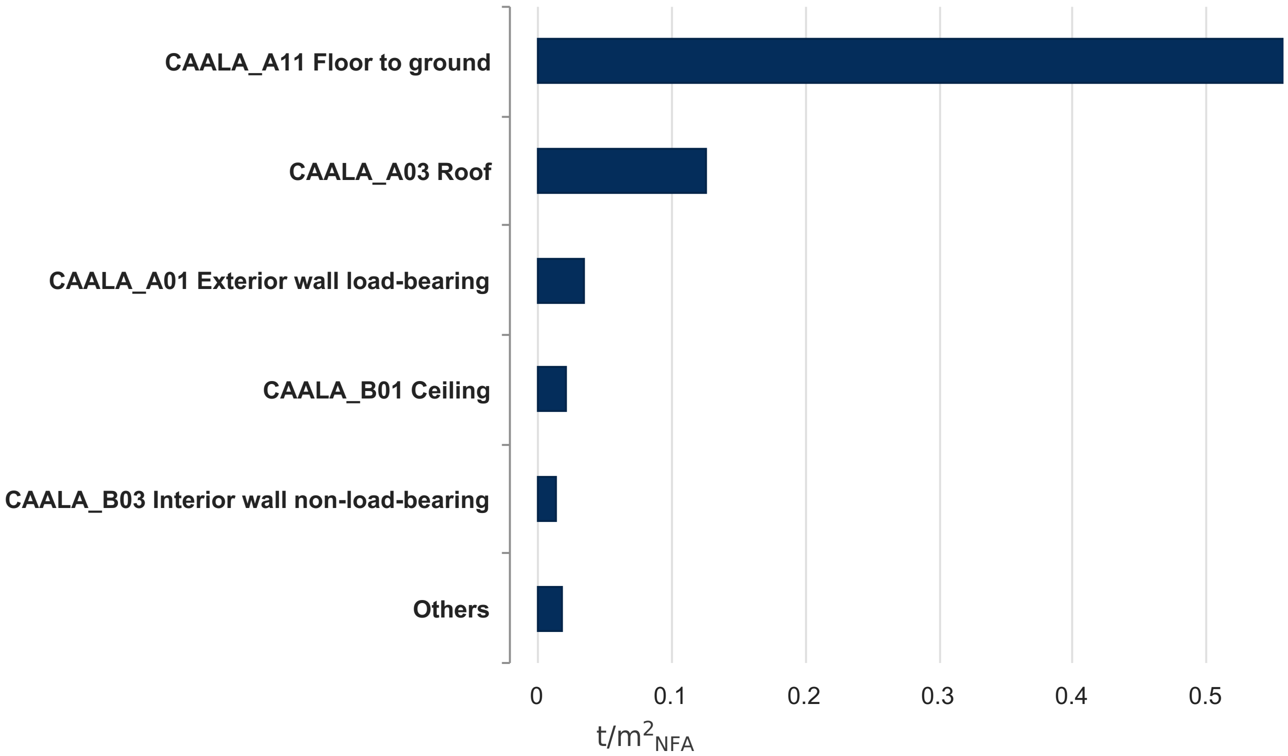
4. Mass Balance

4.1. Masses per material

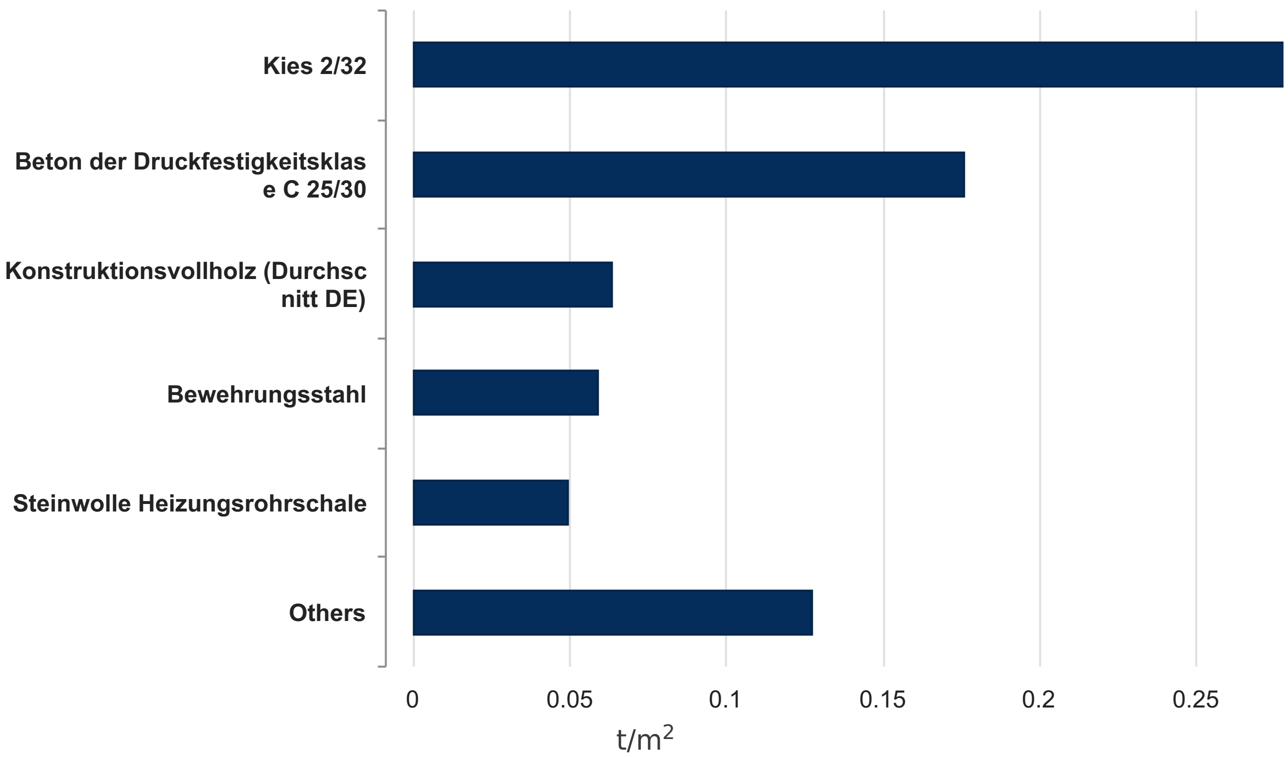


4.2. Masses per layer & Masses per material

Masses per layer



Masses per material



NFA

4.3. Detailed results

Masses per layer

Layer	SELECTED ELEMENT	AREA m²	WEIGHT t/m²NFA
Layer: CAALA_A01 Exterior wall load-bearing		**174.36**	**0.03**
CAALA_A01 Exterior wall load-bearing	Vårgårda bärande yttervägg		
CAALA_A01 Exterior wall load-bearing	Panel vårgårda		
CAALA_A01 Exterior wall load-bearing	Gips och färg		
Layer: CAALA_A03 Roof		**188.43**	**0.12**
CAALA_A03 Roof	Vårgårda isolerat tak		
CAALA_A03 Roof	vårgårda betongtakpannor		
CAALA_A03 Roof	Vårgårda innertaks beklädnad		
Layer: CAALA_A11 Floor to ground		**181.72**	**0.56**
CAALA_A11 Floor to ground	- empty -		
CAALA_A11 Floor to ground	Vårgårda floor to ground		
CAALA_A11 Floor to ground	vårgårda parkett		
CAALA_A11 Floor to ground	- empty -		
Layer: CAALA_A12 Window (exterior wall)		**39.64**	**0**
CAALA_A12 Window (exterior wall)	Fenster, Dreifach-Isolierverglasung, Holz-Alu-Rahmen, U=1,05, g=0,35		
Layer: CAALA_A14 Door		**4.2**	**0**
CAALA_A14 Door	Eingangstür, Holz, U=0,9		
Layer: CAALA_B01 Ceiling		**121.07**	**0.02**
CAALA_B01 Ceiling	vårgårda bjälklag		
CAALA_B01 Ceiling	- empty -		
CAALA_B01 Ceiling	- empty -		

Layer: CAALA_B02 Interior wall load-bearing		**73.73**	**0.01**
CAALA_B02 Interior wall load-bearing	Vårgårda bärande innervägg		
CAALA_B02 Interior wall load-bearing	- empty -		
CAALA_B02 Interior wall load-bearing	- empty -		
Layer: CAALA_B03 Interior wall non-load-bearing		**119.05**	**0.01**
CAALA_B03 Interior wall non-load-bearing	Vårgårda icke bärande innervägg		
CAALA_B03 Interior wall non-load-bearing	- empty -		
CAALA_B03 Interior wall non-load-bearing	- empty -		
Layer: CAALA_B07 Roof (unheated room)		**24.96**	**0.01**
CAALA_B07 Roof (unheated room)	vårgårda oisolerattak		
CAALA_B07 Roof (unheated room)	vårgårda betongpannor		
CAALA_B07 Roof (unheated room)	- empty -		

Masses per material

Material	Weight t/m^2_{NFA}
Kies 2/32	0.28
Beton der Druckfestigkeitsklasse C 25/30	0.18
Konstruktionsvollholz (Durchschnitt DE)	0.06
Bewehrungsstahl	0.06
Steinwolle Heizungsrohrschale	0.05
Dachziegel	0.04
Mineralwolle (Flachdach-Dämmung)	0.03
Gipsfaserplatte	0.03
Massivholzparkett (Durchschnitt DE)	0.02
Mineralwolle (Fassaden-Dämmung)	0.01

5. Life cycle assessment

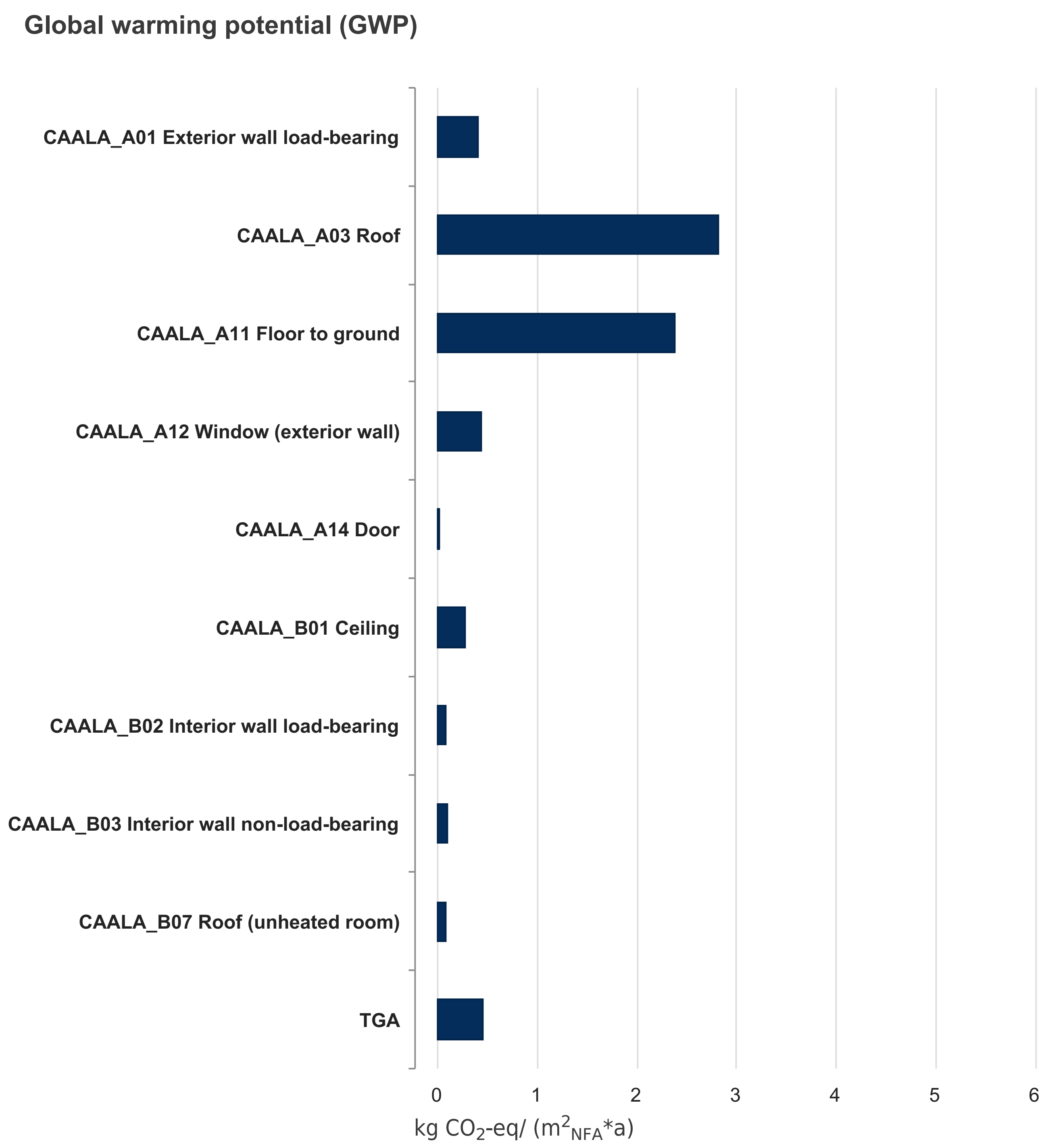
5.1. Boundary conditions

Assessment period	50 Jahre
Net floor area (NFA)	242.23 m²
Database	Ökobau.dat 2016
Assessed life cycle modules	A1-A3, B4, B6, C3+C4

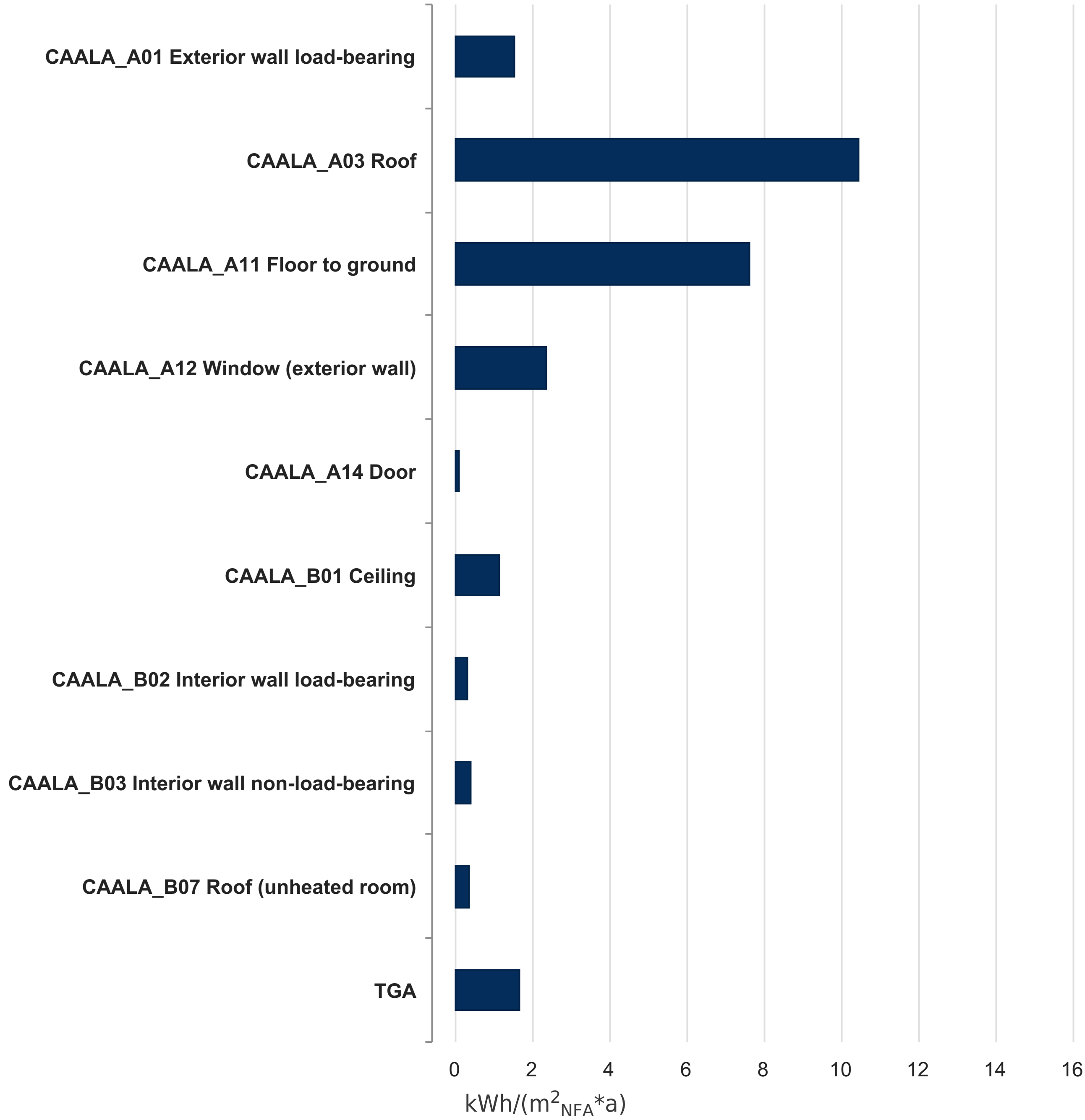
5.2. Overview of the results

	MODULE	GWP	ODP	POCP	AP	EP	PENRT	PERT
Embodied	A1-A3, B4, B6, C3+C4	7.06	4,542e-7	3,283e-3	2,801e-2	3,817e-3	25.87	11.13
Operational	B6	3.4	1,080e-10	3,996e-4	4,845e-3	5,461e-4	5.96	363.62
Total		10.45	4,543e-7	3,682e-3	3,286e-2	4,363e-3	31.84	374.75

5.3. Results for integrated environmental impacts



Primary energy non renewable (PENRT)

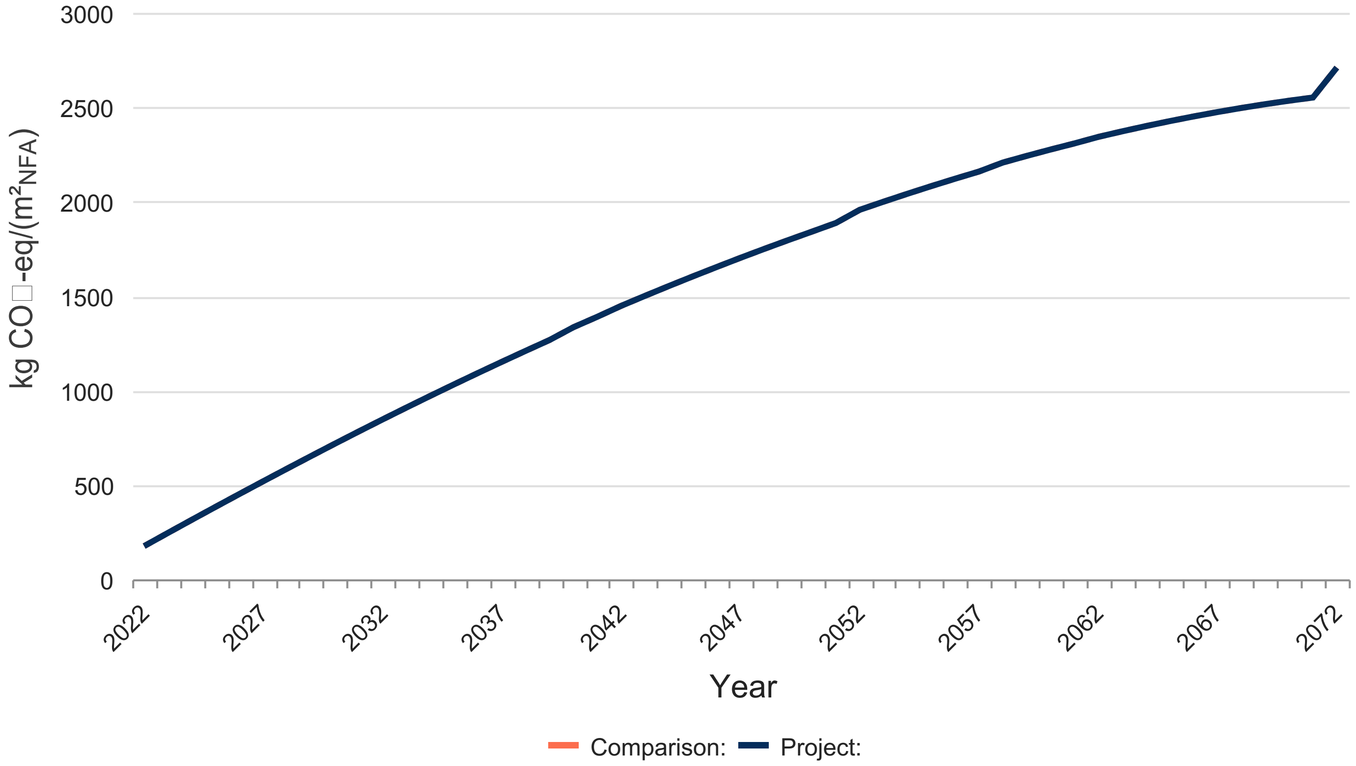


5.4. Results for integrated environmental impacts per layer

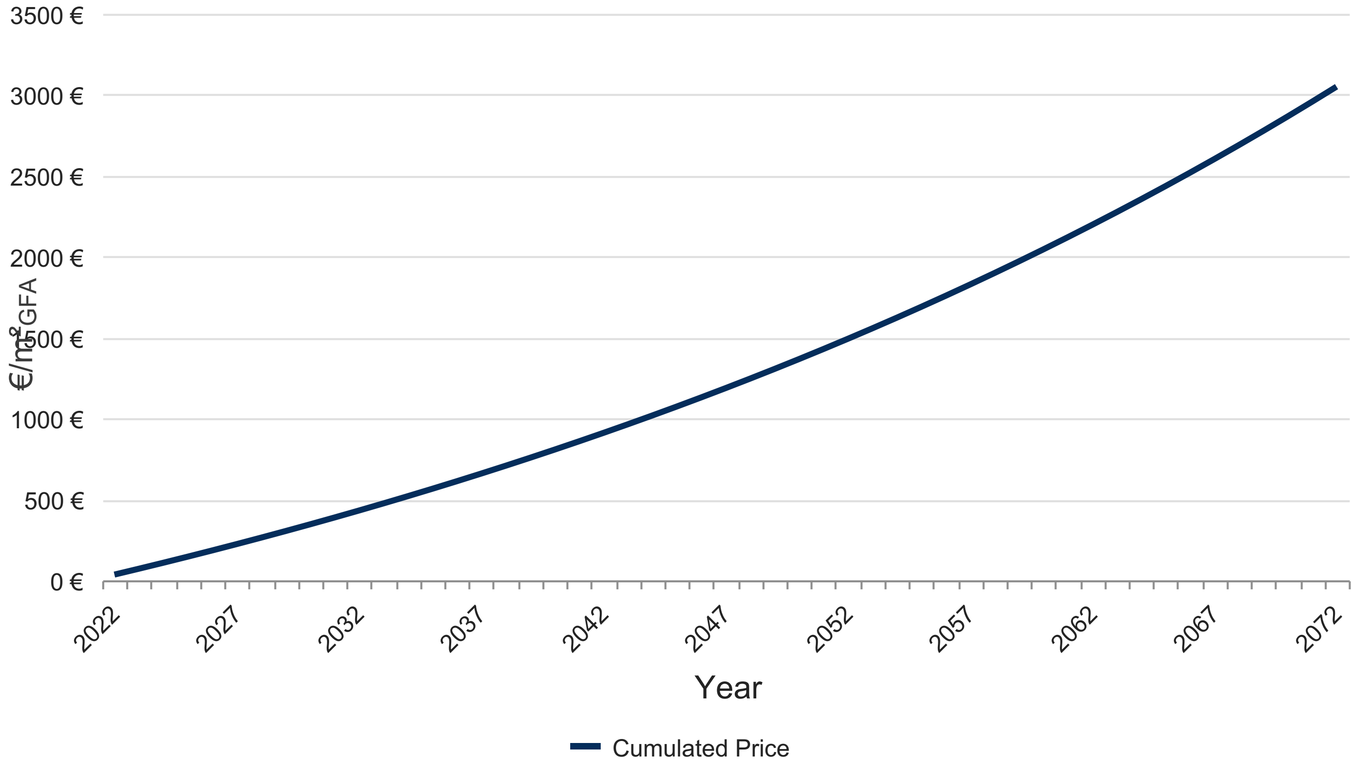
	m^2	GWP	ODP	POCP	AP	EP	PENRT	PERT
CAALA_A01 Exterior wall load-bearing	174.36	4	1,265e-11	1,921e-4	1,745e-3	2,598e-4	1.51	0.66
CAALA_A03 Roof	188.43	2	1,768e-10	1,223e-3	1,173e-2	1,409e-3	10.46	2.14
CAALA_A11 Floor to ground	181.72	2	1,340e-9	8,383e-4	8,621e-3	1,117e-3	7.6	3.11
CAALA_A12 Window (exterior wall)	39.64	4	5,046e-11	5,159e-4	2,247e-3	3,553e-4	2.37	2.86
CAALA_A14 Door	4.2	1	3,297e-9	2,426e-5	6,497e-5	8,503e-6	0.09	0.15
CAALA_B01 Ceiling	121.07	2	1,611e-10	2,393e-4	1,282e-3	2,307e-4	1.12	1.73
CAALA_B02 Interior wall load-bearing	73.73	8	2,256e-12	2,704e-5	2,504e-4	4,112e-5	0.32	0.07
CAALA_B03 Interior wall non-load-bearing	119.05	9	2,761e-12	3,033e-5	2,343e-4	4,237e-5	0.39	0.1
CAALA_B07 Roof (unheated room)	24.96	8	2,528e-12	4,547e-5	1,957e-4	3,309e-5	0.37	0.12
TGA	0	4	4,492e-7	1,468e-4	1,638e-3	3,196e-4	1.65	0.18

6. Cumulative emissions & costs

6.1. Cumulative emissions



6.2. Cumulative costs



Cumulative emissions & costs

Year	Ref. Factor kg CO_2-eq/kWh	Ref. Emission kg CO_2-eq/(m^2_{NFA})	Cur. Factor kg CO_2-eq/kWh	Cur. Emission kg CO_2-eq/(m^2_{NFA})	Cost €/m^2_{GFA}
2022	0.05	176.15	0.05	176.15	35.54€
2023	0.49	246.16	0.49	246.16	71.76€
2024	0.49	315.56	0.49	315.56	108.69€
2025	0.48	384.32	0.48	384.32	146.34€
2026	0.48	452.46	0.48	452.46	184.72€
2027	0.48	519.96	0.48	519.96	223.84€
2028	0.47	586.85	0.47	586.85	263.73€
2029	0.47	653.10	0.47	653.10	304.38€
2030	0.46	718.73	0.46	718.73	345.83€
2031	0.46	783.43	0.46	783.43	388.08€
2032	0.45	847.21	0.45	847.21	431.15€
2033	0.44	910.07	0.44	910.07	475.06€
2034	0.44	972.00	0.44	972.00	519.82€
2035	0.43	1,033.01	0.43	1,033.01	565.45€
2036	0.42	1,093.10	0.42	1,093.10	611.97€
2037	0.42	1,152.26	0.42	1,152.26	659.39€
2038	0.41	1,210.50	0.41	1,210.50	707.73€
2039	0.40	1,267.82	0.40	1,267.82	757.01€
2040	0.40	1,335.41	0.40	1,335.41	807.25€
2041	0.39	1,390.68	0.39	1,390.68	858.46€
2042	0.38	1,448.54	0.38	1,448.54	910.66€
2043	0.37	1,501.57	0.37	1,501.57	963.88€
2044	0.37	1,553.48	0.37	1,553.48	1,018.14€
2045	0.36	1,604.26	0.36	1,604.26	1,073.44€
2046	0.35	1,653.92	0.35	1,653.92	1,129.82€
2047	0.34	1,702.78	0.34	1,702.78	1,187.30€

2048	0.33	1,750.19	0.33	1,750.19	1,245.89€
2049	0.33	1,796.49	0.33	1,796.49	1,305.62€
2050	0.32	1,841.66	0.32	1,841.66	1,366.51€
2051	0.32	1,887.26	0.32	1,887.26	1,428.58€
2052	0.31	1,957.00	0.31	1,957.00	1,491.85€
2053	0.30	2,000.12	0.30	2,000.12	1,556.36€
2054	0.29	2,041.97	0.29	2,041.97	1,622.11€
2055	0.29	2,082.53	0.29	2,082.53	1,689.15€
2056	0.28	2,121.76	0.28	2,121.76	1,757.48€
2057	0.27	2,159.66	0.27	2,159.66	1,827.15€
2058	0.26	2,207.39	0.26	2,207.39	1,898.16€
2059	0.25	2,242.54	0.25	2,242.54	1,970.56€
2060	0.24	2,276.28	0.24	2,276.28	2,044.36€
2061	0.23	2,308.58	0.23	2,308.58	2,119.59€
2062	0.22	2,343.14	0.22	2,343.14	2,196.28€
2063	0.21	2,372.51	0.21	2,372.51	2,274.47€
2064	0.20	2,400.39	0.20	2,400.39	2,354.17€
2065	0.19	2,426.74	0.19	2,426.74	2,435.42€
2066	0.17	2,451.54	0.17	2,451.54	2,518.24€
2067	0.16	2,474.78	0.16	2,474.78	2,602.68€
2068	0.15	2,496.42	0.15	2,496.42	2,688.75€
2069	0.14	2,516.46	0.14	2,516.46	2,776.50€
2070	0.13	2,534.85	0.13	2,534.85	2,865.94€
2071	0.12	2,551.59	0.12	2,551.59	2,957.13€
2072	0.11	2,710.18	0.11	2,710.18	3,050.09€

B4 Replacement

	Replacement Year	Name	GWP kg CO_2-eq/(m^2_{NFA})
◢ Replacement Year: 2040			

	2040	Strom Wärmepumpe (Luft-Wasser) 14kW	11.20
			Sum: 11.20
Replacement Year: 2042			
	2042	Pufferspeicher (Edelstahl)	3.71
			Sum: 3.71
Replacement Year: 2047			
	2047	Innenfarbe Dispersionsfarbe scheuerfest	0.32
			Sum: 0.32
Replacement Year: 2052			
	2052	Dachziegel	12.88
	2052	Fenster, Dreifach-Isolierverglasung, Holz	10.78
	2052	Dachziegel	1.71
			Sum: 25.37
Replacement Year: 2058			
	2058	Strom Wärmepumpe (Luft-Wasser) 14kW	11.20
			Sum: 11.20
Replacement Year: 2062			
	2062	Pufferspeicher (Edelstahl)	3.71
			Sum: 3.71
Replacement Year: 2072			
	2072	Luft	0.00
	2072	Kraftpapier	0.00
	2072	Mineralwolle (Fassaden-Dämmung)	0.00
	2072	Konstruktionsvollholz (Durchschnitt DE)	0.00

	2072	Dampfbremse PE	0.00
	2072	Holzfaserdämmplatten	0.00
	2072	Gipsfaserplatte	0.00
	2072	Innenfarbe Dispersionsfarbe scheuerfest	0.32
	2072	Steinwolle Heizungsrohrschale	0.00
	2072	Beton der Druckfestigkeitsklasse C 25/30	0.00
	2072	Bewehrungsstahl	0.00
	2072	Mineralwolle (Flachdach-Dämmung)	0.00
	2072	Kunststoffmodifizierte Bitumendickbeschichtungen	0.00
	2072	Kies 2/32	0.00
	2072	Massivholzparkett (Durchschnitt DE)	0.00
	2072	Universal-Spachtelmasse USP 32	0.00
	2072	Haustür, Passivhaus, Holz, U=0.8	0.00
	2072	Mineralwolle (Innenausbau-Dämmung)	0.00
	2072	Oriented Strand Board (Durchschnitt DE)	0.00
			Sum: 0.32

7. Life cycle cost analysis

7.1. Boundary conditions

Assessment period	50 Jahre
Gross Floor Area (GFA)	302.78999999999996 m²
Rate of Energy Price Increase	5 %/Jahr
Price Discount Rate	3 %/Jahr
Initial Price for Electricity	0,3 €/kWh
Price for [Electricity]	0,3

7.2. Overview of results

Investment costs				
KG 300 Building construction	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)
KG 400 Technical building equipment	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)
Operational costs				
Energy costs	2,957.13	€/m^2_{GFA}	59.14	€/(m^2_{GFA}*a)
CO_2 Cost	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)
Inspection & maintenance costs for KG 300	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)
Inspection & maintenance costs for KG 400	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)
Repair Cost				
Repair Cost for KG 300	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)
Repair Cost for KG 400	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)

7.3. Results by cost group 2nd level

	Construction	Maintenance & Replace	Repair
KG 300 - Building construction	0.00 €	0.00 €	0.00 €
KG 320 Foundation	0.00 €	0.00 €	0.00 €
KG 330 Exterior walls	0.00 €	0.00 €	0.00 €
KG 340 Interior walls	0.00 €	0.00 €	0.00 €
KG 350 Ceilings	0.00 €	0.00 €	0.00 €
KG 360 Roofs	0.00 €	0.00 €	0.00 €
KG 400 - Technical building equipment	0.00 €	0.00 €	0.00 €

7.4. Results by cost group 3rd level

	Construction	Maintenance & Replacement		Repair	
	Costs	Expenses per year	Costs	Expenses per year	Costs
300 - Building construction	0.00 €		0.00 €		0.00 €
322 Flat foundation	0.00 €	0.1%	0.00 €	0.35%	0.00 €
324 Base plate	0.00 €	0.1%	0.00 €	0.35%	0.00 €
325 Base flooring	0.00 €	0.1%	0.00 €	0.35%	0.00 €
326 Sealing	0.00 €	0.1%	0.00 €	0.35%	0.00 €
331 Load-bearing exterior wall	0.00 €	0.1%	0.00 €	0.35%	0.00 €
334 Exterior doors and windows	0.00 €	0.1%	0.00 €	0.35%	0.00 €
335 Exterior wall cladding outside	0.00 €	0.1%	0.00 €	0.35%	0.00 €
336 Exterior wall finishing inside	0.00 €	0.1%	0.00 €	0.35%	0.00 €
341 Load-bearing interior wall	0.00 €	0.1%	0.00 €	0.35%	0.00 €
342 Non-load-bearing interior wall	0.00 €	0.1%	0.00 €	0.35%	0.00 €
345 Interior wall finishing (outside)	0.00 €	0.1%	0.00 €	0.35%	0.00 €
345 Interior wall finishing (inside)	0.00 €	0.1%	0.00 €	0.35%	0.00 €
351 Ceiling strucutre	0.00 €	0.1%	0.00 €	0.35%	0.00 €
352 Ceiling flooring	0.00 €	0.1%	0.00 €	0.35%	0.00 €
353 Ceiling finishing	0.00 €	0.1%	0.00 €	0.35%	0.00 €
361 Roof structure	0.00 €	0.1%	0.00 €	0.35%	0.00 €
363 Roof covering	0.00 €	0.1%	0.00 €	0.35%	0.00 €
364 Roof finishing inside	0.00 €	0.1%	0.00 €	0.35%	0.00 €

8. Building envelope and building technology

8.1. Surfaces

Overview

	ID	Layer	Orientation	Net area	Gross area	Length	Angle (Azimut
▶	**CAALA_A01 Exterior wall load-bearing (Count: 25 , Net area: 174.36 m² , Gross area: 217.24 m² , Length: 0.00 m)**						
▶	**CAALA_A03 Roof (Count: 6 , Net area: 188.43 m² , Gross area: 188.43 m² , Length: 0.00 m)**						
▶	**CAALA_A11 Floor to ground (Count: 12 , Net area: 181.72 m² , Gross area: 181.72 m² , Length: 0.00 m)**						
▶	**CAALA_A12 Window (exterior wall) (Count: 18 , Net area: 39.64 m² , Gross area: 39.64 m² , Length: 0.00 m)**						
▶	**CAALA_A14 Door (Count: 2 , Net area: 4.20 m² , Gross area: 4.20 m² , Length: 0.00 m)**						
▶	**CAALA_B01 Ceiling (Count: 14 , Net area: 121.07 m² , Gross area: 121.07 m² , Length: 0.00 m)**						
▶	**CAALA_B02 Interior wall load-bearing (Count: 17 , Net area: 73.73 m² , Gross area: 73.73 m² , Length: 0.00 m)**						
▶	**CAALA_B03 Interior wall non-load-bearing (Count: 29 , Net area: 119.05 m² , Gross area: 119.05 m² , Length: 0.00 m)**						
▶	**CAALA_B07 Roof (unheated room) (Count: 8 , Net area: 24.96 m² , Gross area: 24.96 m² , Length: 0.00 m)**						

Detailed areas

	ID	Layer	Orientation	Net area	Gross area	Length	Angle (Azimu
◢	**CAALA_A01 Exterior wall load-bearing (Count: 25 , Net area: 174.36 m² , Gross area: 217.24 m² , Length: 0.00 m)**						
	28281	CAALA_A01 Exterior wall load-bearing	SE90	7.74	19.25	0	135
	84633	CAALA_A01 Exterior wall load-bearing	NW90	3.91	3.91	0	315
	73231	CAALA_A01 Exterior wall load-bearing	NW90	3.88	3.88	0	315
	28510	CAALA_A01 Exterior wall load-bearing	SW90	8.14	8.14	0	225
	28172	CAALA_A01 Exterior wall load-bearing	N90	8.92	8.92	0	0
	69012	CAALA_A01 Exterior wall load-bearing	E90	8.59	10.09	0	90
	27887	CAALA_A01 Exterior wall load-bearing	N90	5.47	7.57	0	0
	28682	CAALA_A01 Exterior wall load-bearing	SW90	3.56	3.56	0	225
	28508	CAALA_A01 Exterior wall load-bearing	NW90	10.18	10.18	0	315

	28108	CAALA_A01 Exterior wall load-bearing	SE90	4.08	4.08	0	135
	70209	CAALA_A01 Exterior wall load-bearing	N90	10.35	11.89	0	0
	77663	CAALA_A01 Exterior wall load-bearing	NW90	5.24	6.78	0	315
	99992	CAALA_A01 Exterior wall load-bearing	NW90	7.55	7.55	0	315
	52072	CAALA_A01 Exterior wall load-bearing	E90	9.07	13.47	0	90
	28144	CAALA_A01 Exterior wall load-bearing	E90	15.4	15.4	0	90
	50690	CAALA_A01 Exterior wall load-bearing	S90	2.26	2.26	0	180
	28479	CAALA_A01 Exterior wall load-bearing	S90	14.81	19.25	0	180
	51351	CAALA_A01 Exterior wall load-bearing	SW90	4.07	14.44	0	225
	28347	CAALA_A01 Exterior wall load-bearing	SW90	10.05	12.45	0	225
	27893	CAALA_A01 Exterior wall load-bearing	SE90	4.08	4.08	0	135
	52959	CAALA_A01 Exterior wall load-bearing	NW90	1.69	1.69	0	315
	50694	CAALA_A01 Exterior wall load-bearing	SE90	5.92	5.92	0	135
	84319	CAALA_A01 Exterior wall load-bearing	NW90	7.76	9.3	0	315
	123517	CAALA_A01 Exterior wall load-bearing	S90	3.66	3.66	0	180
	69481	CAALA_A01 Exterior wall load-bearing	N90	7.98	9.52	0	0
◢	**CAALA_A03 Roof (Count: 6 , Net area: 188.43 m² , Gross area: 188.43 m² , Length: 0.00 m)**						
	99967	CAALA_A03 Roof	NW30	32.99	32.99	0	315
	28232	CAALA_A03 Roof	S30	17.16	17.16	0	180
	28691	CAALA_A03 Roof	N30	48.58	48.58	0	0
	99968	CAALA_A03 Roof	NW30	28.63	28.63	0	315
	28681	CAALA_A03 Roof	NW30	38.77	38.77	0	315
	123601	CAALA_A03 Roof	S30	22.3	22.3	0	180
◢	**CAALA_A11 Floor to ground (Count: 12 , Net area: 181.72 m² , Gross area: 181.72 m² , Length: 0.00 m)**						
	66969	CAALA_A11 Floor to ground	HOR	2.76	2.76	0	5.93
	84007	CAALA_A11 Floor to ground	HOR	20.62	20.62	0	208.75

	78242	CAALA_A11 Floor to ground	HOR	12.64	12.64	0	209.91
	66523	CAALA_A11 Floor to ground	HOR	12.91	12.91	0	90
	80334	CAALA_A11 Floor to ground	HOR	2.04	2.04	0	93.11
	81842	CAALA_A11 Floor to ground	HOR	4.42	4.42	0	2.99
	66086	CAALA_A11 Floor to ground	HOR	11.3	11.3	0	90
	28165	CAALA_A11 Floor to ground	HOR	6.56	6.56	0	90
	83079	CAALA_A11 Floor to ground	HOR	86.24	86.24	0	116.14
	82458	CAALA_A11 Floor to ground	HOR	9.45	9.45	0	335
	27948	CAALA_A11 Floor to ground	HOR	12.52	12.52	0	90
	65657	CAALA_A11 Floor to ground	HOR	0.26	0.26	0	90
◢	**CAALA_A12 Window (exterior wall) (Count: 18 , Net area: 39.64 m² , Gross area: 39.64 m² , Length: 0.00 m)**						
	27898	CAALA_A12 Window (exterior wall)	S90	1.68	1.68	0	180
	28455	CAALA_A12 Window (exterior wall)	E90	1.5	1.5	0	90
	52783	CAALA_A12 Window (exterior wall)	NW90	0.96	0.96	0	315
	28415	CAALA_A12 Window (exterior wall)	E90	0.7	0.7	0	90
	28291	CAALA_A12 Window (exterior wall)	SE90	4.6	4.6	0	135
	28595	CAALA_A12 Window (exterior wall)	NW90	1.54	1.54	0	315
	28550	CAALA_A12 Window (exterior wall)	N90	1.54	1.54	0	0
	28329	CAALA_A12 Window (exterior wall)	SW90	4.6	4.6	0	225
	28357	CAALA_A12 Window (exterior wall)	SW90	1.2	1.2	0	225
	51337	CAALA_A12 Window (exterior wall)	SW90	3.46	3.46	0	225
	28264	CAALA_A12 Window (exterior wall)	SE90	2.31	2.31	0	135
	28432	CAALA_A12 Window (exterior wall)	E90	1.6	1.6	0	90
	27897	CAALA_A12 Window (exterior wall)	SE90	4.6	4.6	0	135
	27891	CAALA_A12 Window (exterior wall)	SW90	1.2	1.2	0	225
	28391	CAALA_A12 Window (exterior wall)	S90	2.76	2.76	0	180
	28568	CAALA_A12 Window (exterior wall)	N90	1.54	1.54	0	0
	28303	CAALA_A12 Window (exterior wall)	SW90	2.31	2.31	0	225
	28632	CAALA_A12 Window (exterior wall)	NW90	1.54	1.54	0	315
◢	**CAALA_A14 Door (Count: 2 , Net area: 4.20 m² , Gross area: 4.20 m² , Length: 0.00 m)**						
	28467	CAALA_A14 Door	N90	2.1	2.1	0	0
	28443	CAALA_A14 Door	E90	2.1	2.1	0	90
◢	**CAALA_B01 Ceiling (Count: 14 , Net area: 121.07 m² , Gross area: 121.07 m² , Length: 0.00 m)**						
	69722	CAALA_B01 Ceiling	HOR	12.91	12.91	0	90
	86852	CAALA_B01 Ceiling	HOR	4.42	4.42	0	90
	69241	CAALA_B01 Ceiling	HOR	11.3	11.3	0	90
	88175	CAALA_B01 Ceiling	HOR	20.62	20.62	0	90

	27991	CAALA_B01 Ceiling	HOR	23.7	23.7	0	90
	94983	CAALA_B01 Ceiling	HOR	2.04	2.04	0	90
	74314	CAALA_B01 Ceiling	HOR	12.52	12.52	0	90
	72192	CAALA_B01 Ceiling	HOR	0.26	0.26	0	90
	89193	CAALA_B01 Ceiling	HOR	2.76	2.76	0	90
	73497	CAALA_B01 Ceiling	HOR	3.92	3.92	0	90
	72964	CAALA_B01 Ceiling	HOR	2	2	0	90
	94985	CAALA_B01 Ceiling	HOR	2.53	2.53	0	90
	94986	CAALA_B01 Ceiling	HOR	9.45	9.45	0	90
	100000	CAALA_B01 Ceiling	HOR	12.64	12.64	0	90
◢	**CAALA_B02 Interior wall load-bearing (Count: 17 , Net area: 73.73 m² , Gross area: 73.73 m² , Length: 0.00 m)**						
	123431	CAALA_B02 Interior wall load-bearing	S90	3.79	3.79	0	180
	71200	CAALA_B02 Interior wall load-bearing	N90	0.25	0.25	0	0
	88853	CAALA_B02 Interior wall load-bearing	SE90	6.78	6.78	0	135
	56360	CAALA_B02 Interior wall load-bearing	N90	1.71	1.71	0	0
	28219	CAALA_B02 Interior wall load-bearing	SE90	7.09	7.09	0	135
	99678	CAALA_B02 Interior wall load-bearing	W90	1.69	1.69	0	270
	55082	CAALA_B02 Interior wall load-bearing	SE90	10.2	10.2	0	135
	57214	CAALA_B02 Interior wall load-bearing	N90	0.27	0.27	0	0
	28101	CAALA_B02 Interior wall load-bearing	N90	5.34	5.34	0	0
	57642	CAALA_B02 Interior wall load-bearing	N90	1.26	1.26	0	0
	58494	CAALA_B02 Interior wall load-bearing	SE90	10.74	10.74	0	135
	50686	CAALA_B02 Interior wall load-bearing	W90	4.89	4.89	0	270
	77376	CAALA_B02 Interior wall load-bearing	SE90	1.51	1.51	0	135
	87183	CAALA_B02 Interior wall load-bearing	SE90	3.06	3.06	0	135
	123283	CAALA_B02 Interior wall load-bearing	SE90	8.66	8.66	0	135
	123602	CAALA_B02 Interior wall load-bearing	W90	3.85	3.85	0	270

	28104	CAALA_B02 Interior wall load-bearing	S30	2.64	2.64	0	180
CAALA_B03 Interior wall non-load-bearing (Count: 29 , Net area: 119.05 m² , Gross area: 119.05 m² , Length: 0.00 m)							
	89194	CAALA_B03 Interior wall non-load-bearing	SW90	4.09	4.09	0	225
	86532	CAALA_B03 Interior wall non-load-bearing	SE90	1.5	1.5	0	135
	77950	CAALA_B03 Interior wall non-load-bearing	SW90	3.53	3.53	0	225
	72965	CAALA_B03 Interior wall non-load-bearing	S90	0.26	0.26	0	180
	79136	CAALA_B03 Interior wall non-load-bearing	NE90	3.5	3.5	0	44.62
	88510	CAALA_B03 Interior wall non-load-bearing	SE90	1.07	1.07	0	135
	69963	CAALA_B03 Interior wall non-load-bearing	N90	7.32	7.32	0	0
	73498	CAALA_B03 Interior wall non-load-bearing	NE90	0.48	0.48	0	44.62
	71943	CAALA_B03 Interior wall non-load-bearing	S90	5.2	5.2	0	180
	86853	CAALA_B03 Interior wall non-load-bearing	NE90	8.44	8.44	0	45
	85895	CAALA_B03 Interior wall non-load-bearing	S90	3.35	3.35	0	180
	81536	CAALA_B03 Interior wall non-load-bearing	NW90	3.93	3.93	0	315
	75430	CAALA_B03 Interior wall non-load-bearing	SE90	1.9	1.9	0	134.62
	75150	CAALA_B03 Interior wall non-load-bearing	NE90	3.87	3.87	0	44.62
	87840	CAALA_B03 Interior wall non-load-bearing	SE90	3.83	3.83	0	135
	69964	CAALA_B03 Interior wall non-load-bearing	E90	10.09	10.09	0	90
	80934	CAALA_B03 Interior wall non-load-bearing	NW90	3.91	3.91	0	315
	88511	CAALA_B03 Interior wall non-load-bearing	SW90	4.09	4.09	0	225
	94984	CAALA_B03 Interior wall non-load-bearing	SW90	4.32	4.32	0	225
	85262	CAALA_B03 Interior wall non-load-bearing	SW90	6.05	6.05	0	224.62

	68333	CAALA_B03 Interior wall non-load-bearing	N90	2.34	2.34	0	0
	72193	CAALA_B03 Interior wall non-load-bearing	W90	1.69	1.69	0	270
	78836	CAALA_B03 Interior wall non-load-bearing	NE90	4.81	4.81	0	44.62
	94981	CAALA_B03 Interior wall non-load-bearing	SW90	4.78	4.78	0	225
	99677	CAALA_B03 Interior wall non-load-bearing	S90	2.81	2.81	0	180
	90935	CAALA_B03 Interior wall non-load-bearing	SW90	2.35	2.35	0	225
	89890	CAALA_B03 Interior wall non-load-bearing	SE90	2.65	2.65	0	135
	100001	CAALA_B03 Interior wall non-load-bearing	SW90	8.49	8.49	0	225
	70700	CAALA_B03 Interior wall non-load-bearing	W90	8.4	8.4	0	270
◢	**CAALA_B07 Roof (unheated room) (Count: 8 , Net area: 24.96 m² , Gross area: 24.96 m² , Length: 0.00 m)**						
	99975	CAALA_B07 Roof (unheated room)	NW30	0.81	0.81	0	315
	99971	CAALA_B07 Roof (unheated room)	NW30	0.81	0.81	0	315
	28236	CAALA_B07 Roof (unheated room)	NW30	3.99	3.99	0	315
	99969	CAALA_B07 Roof (unheated room)	NW30	1.83	1.83	0	315
	28521	CAALA_B07 Roof (unheated room)	S30	3.72	3.72	0	180
	99962	CAALA_B07 Roof (unheated room)	NW30	1.92	1.92	0	315
	28531	CAALA_B07 Roof (unheated room)	N30	4.74	4.74	0	0
	28537	CAALA_B07 Roof (unheated room)	NW30	7.14	7.14	0	315

8.2. Building Construction

Layer Name	CAALA_A01 Exterior wall load-bearing
Area	174.36 m²
Thickness	32.41 cm
U-value	0.20 W/(m²*K)
Reference U-Value	0.28 W/(m²*K)
Cost group	331 Load-bearing exterior wall
Name	Vårgårda bärande yttervägg
Id	62e478bf-6f92-40c5-97ee-64bbbd18a3a3
Thickness	28.90 cm
Cost group	335 Exterior wall cladding outside
Name	Panel vårgårda
Id	71ebd6fd-62b1-4f66-be6f-fdd683e693f0
Thickness	2.20 cm
Cost group	336 Exterior wall finishing inside
Name	Gips och färg
Id	bc7fd0ab-45bb-4007-94bf-dab2a881aba6
Thickness	1.31 cm
Layer Name	CAALA_A03 Roof
Area	188.43 m²
Thickness	63.44 cm
U-value	0.09 W/(m²*K)
Reference U-Value	0.20 W/(m²*K)
Cost group	361 Roof structure
Name	Vårgårda isolerat tak
Id	a0fd139b-b1b1-4f88-9196-bc9d01e6dd35
Thickness	60.14 cm
Cost group	363 Roof covering

Name	vårgårda betongtakpannor
Id	670ea5a5-0800-4923-ba20-72a8e1770ef8
Thickness	2.00 cm
Cost group	364 Roof finishing inside
Name	Vårgårda innertaks beklädnad
Id	ba4678f6-338a-4f77-8645-931d166d0891
Thickness	1.30 cm
Layer Name	CAALA_A11 Floor to ground
Area	181.72 m²
Thickness	61.90 cm
U-value	0.14 W/(m²*K)
Reference U-Value	0.35 W/(m²*K)
Cost group	322 Flat foundation
Name	- empty -
Id	
Thickness	0.00 cm
Cost group	324 Base plate
Name	Vårgårda floor to ground
Id	19a4b374-9658-49a5-b075-808fea86a785
Thickness	60.20 cm
Cost group	325 Base flooring
Name	vårgårda parkett
Id	be5580ef-b14a-4495-86f0-bfc754eb4716
Thickness	1.70 cm
Cost group	326 Sealing
Name	- empty -
Id	
Thickness	0.00 cm
Layer Name	CAALA_A12 Window (exterior wall)

Area	39.64 m²
Thickness	0.00 cm
U-value	1.05 W/(m²*K)
Reference U-Value	1.30 W/(m²*K)
Cost group	334 Exterior doors and windows
Name	Fenster, Dreifach-Isolierverglasung, Holz-Alu-Rahmen, U=1,05, g=0,35
Id	79390d1b-10e3-484d-af56-963b2a42045a
Thickness	0.00 cm
Layer Name	CAALA_A14 Door
Area	4.20 m²
Thickness	0.00 cm
U-value	0.90 W/(m²*K)
Reference U-Value	1.80 W/(m²*K)
Cost group	334 Exterior doors and windows
Name	Eingangstür, Holz, U=0,9
Id	be65e629-5f13-49b6-8d17-3d7992f2d838
Thickness	0.00 cm
Layer Name	CAALA_B01 Ceiling
Area	121.07 m²
Thickness	29.00 cm
U-value	-
Reference U-Value	0.00 W/(m²*K)
Cost group	351 Ceiling strucutre
Name	vårgårda bjälklag
Id	104afeae-8f41-4777-a548-a1c8fd7c4c63
Thickness	29.00 cm
Cost group	352 Ceiling flooring
Name	- empty -

Id	
Thickness	0.00 cm
Cost group	353 Ceiling finishing
Name	- empty -
Id	
Thickness	0.00 cm
Layer Name	CAALA_B02 Interior wall load-bearing
Area	73.73 m²
Thickness	16.60 cm
U-value	-
Reference U-Value	0.00 W/(m²*K)
Cost group	341 Load-bearing interior wall
Name	Vårgårda bärande innervägg
Id	ec2971b7-6f8c-46a5-943b-fdc8a408afa1
Thickness	16.60 cm
Cost group	345 Interior wall finishing (outside)
Name	- empty -
Id	
Thickness	0.00 cm
Cost group	345 Interior wall finishing (inside)
Name	- empty -
Id	
Thickness	0.00 cm
Layer Name	CAALA_B03 Interior wall non-load-bearing
Area	119.05 m²
Thickness	9.10 cm
U-value	-
Reference U-Value	0.00 W/(m²*K)
Cost group	342 Non-load-bearing interior wall

Name	Vårgårda icke bärande innervägg
Id	d2f58772-7534-4404-9103-7536a0771203
Thickness	9.10 cm
Cost group	345 Interior wall finishing (outside)
Name	- empty -
Id	
Thickness	0.00 cm
Cost group	345 Interior wall finishing (inside)
Name	- empty -
Id	
Thickness	0.00 cm
Layer Name	CAALA_B07 Roof (unheated room)
Area	24.96 m²
Thickness	31.20 cm
U-value	-
Reference U-Value	0.00 W/(m²*K)
Cost group	361 Roof structure
Name	vårgårda oisolerattak
Id	05bfd895-c102-4a7c-b34a-646c61a3a3c0
Thickness	29.20 cm
Cost group	363 Roof covering
Name	vårgårda betongpannor
Id	0244e3bb-229a-41a2-9581-dbe6fdaa45e8
Thickness	2.00 cm
Cost group	364 Roof finishing inside
Name	- empty -
Id	
Thickness	0.00 cm

8.3. Building Technology

420 Heat generation equipment	Electric heat pump air-water
Producer effort figure e_e	1.00
Aux. energy requirement [kWh/m²]	1.50 kWh/m²
Primary energy factor heat	0.70
Primary energy factor electricity	1.80
Investment costs KG	-
Investment cost for ventilation system	-
Performance coefficiente$_p$	1.50
440 Photovoltaik 1	Not available
440 Photovoltaik 2	Not available

8.4. Other input values and boundary conditions

Thermal bridge surcharge	General 0,10 W/m²K
Air tightness	New construction - general: n50 = 4 h^{-1}

Caala Report

For Project: house djup

Table of Content

1. Object data

1.1. Object

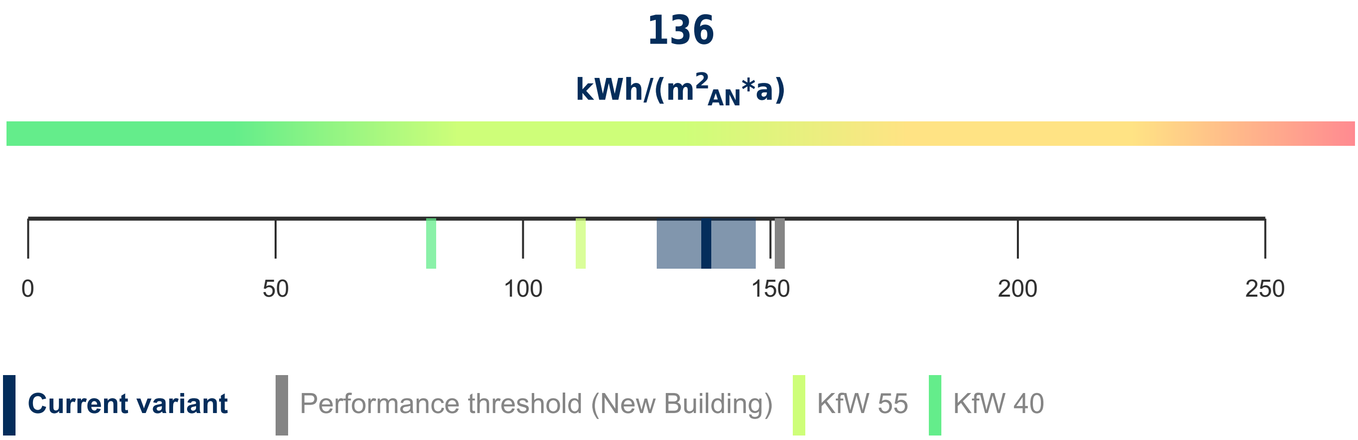
Model	VILLA DJUPVIK 2102
Scope of analysis	Full Life Cycle
Level of detail	Blueprint planning
Building type	Single family house
Energy standard	EnEV 2016
Reference study period	50 Jahre
Climate region - reference location	Region 10 - Hof

1.2. Geometry

Average floor height	2.70 m
V	817.53 m^3
GFA th.	302.79 m^2
NFA	242.23 m^2
Reference area	261.61 m^2

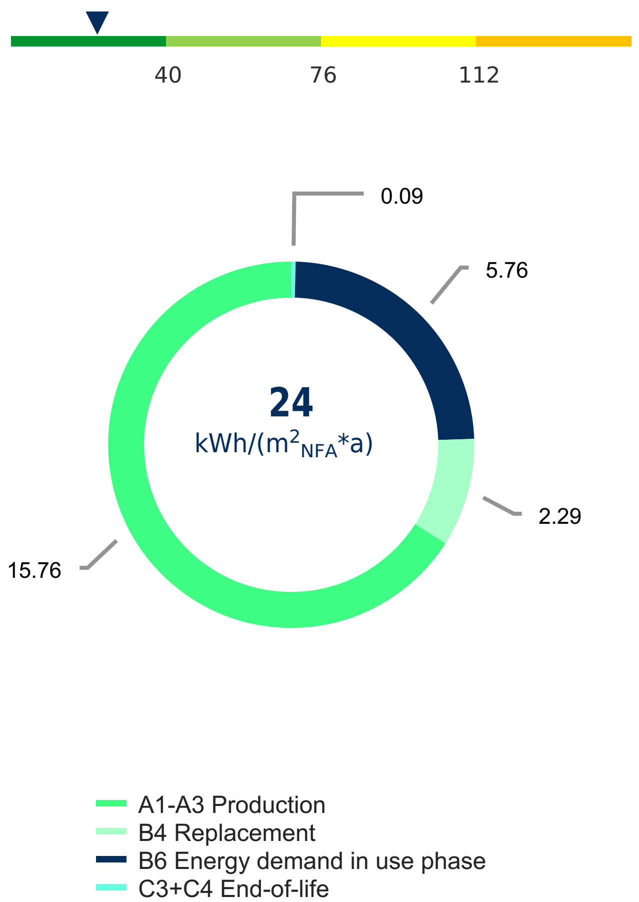
2. Overview

2.1. Primary energy demand

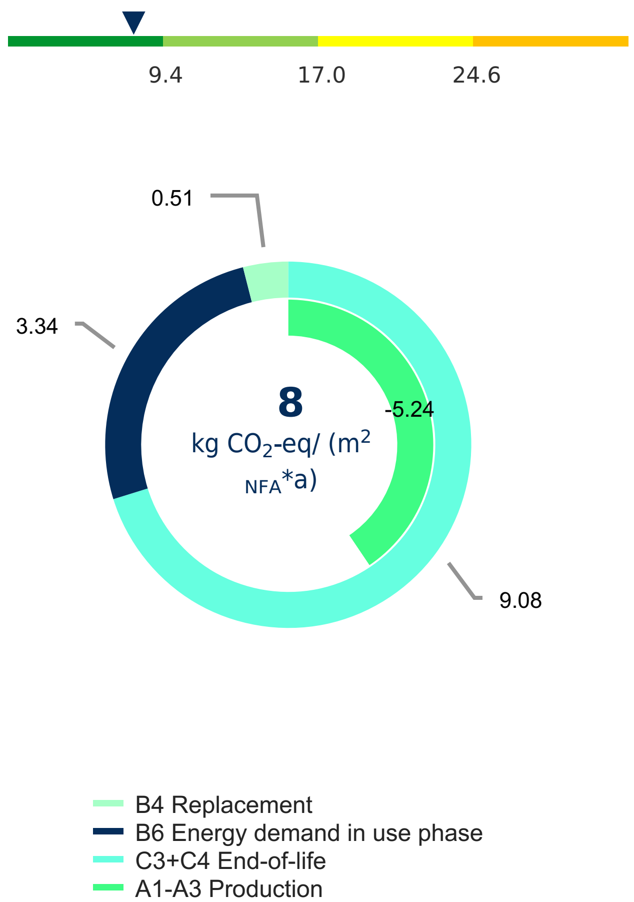


2.2. Life Cycle Assessment

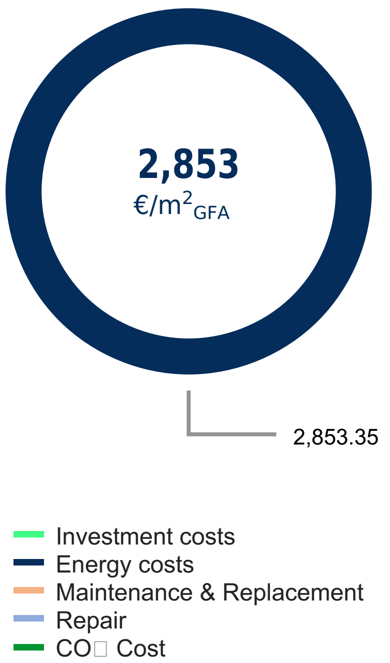
Primary energy non renewable (PENRT)



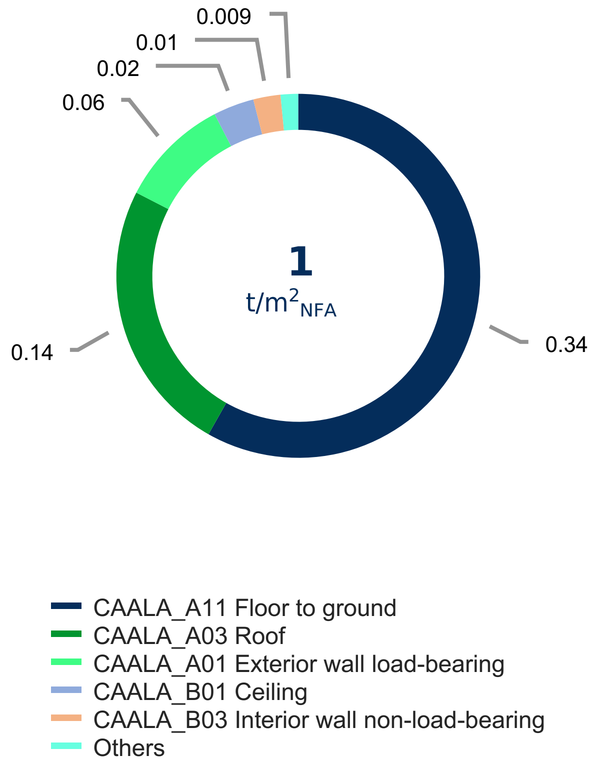
Global warming potential (GWP)



Life cycle costs



Mass Balance

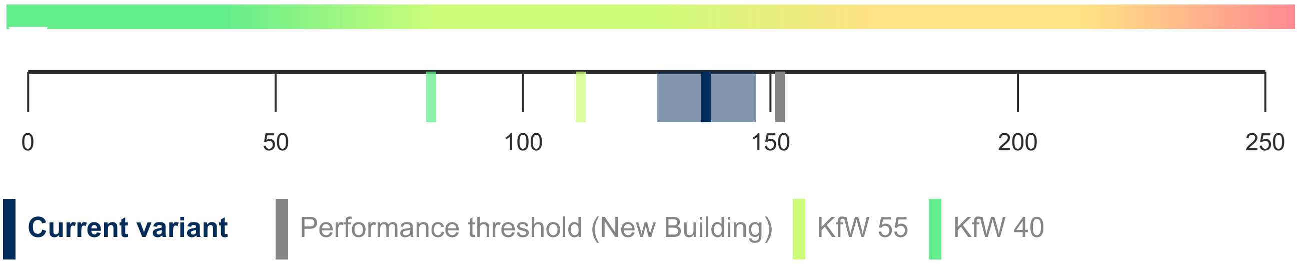


3. Operational energy demand

3.1. Overview

136

kWh/(m^2_{AN}*a)



Annual energy requirement operation

Primary energy demand		136 kWh/(m^2_{AN}*a)
End energy demand	Electric heat pump air-water	80 kWh/(m^2_{AN}*a)
	Hot water	9 kWh/(m^2_{AN}*a)
	Auxilary electricity	2 kWh/(m^2_{AN}*a)
	User Electricity	40 kWh/(m^2_{AN}*a)
Useful energy requirement	Space heating	80 kWh/(m^2_{AN}*a)
	Hot water	9 kWh/(m^2_{AN}*a)

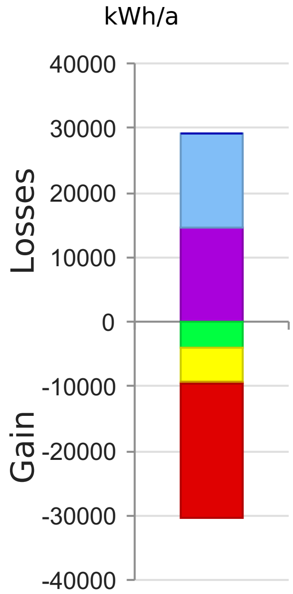
Energetic parameters

Energy reference area	261.61 m^2
Specific area-based transmission heat loss H'_T	**0.26 W/(m^2*K)**
Max. specific area-based transmission heat loss H'_T	0.35 W/(m^2*K)

3.2. Result per year

Legend

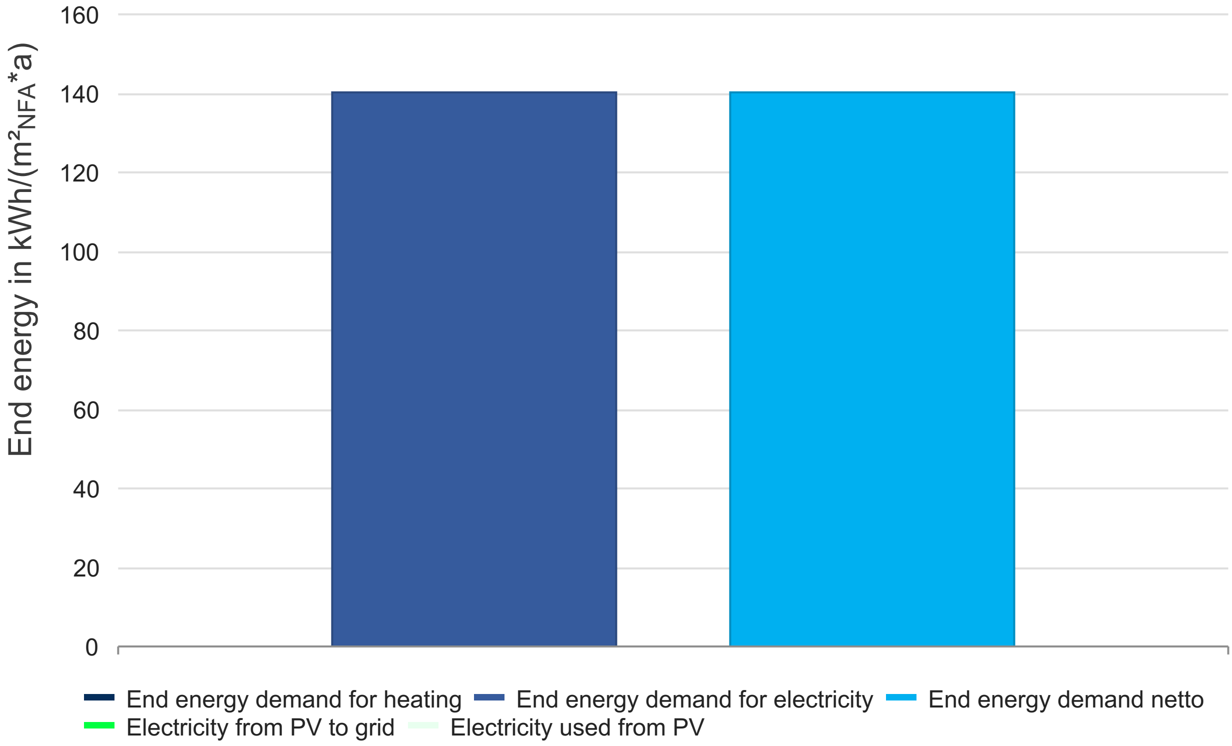
Losse	Solar losses opaque	86 kWh/a
	Ventilation heat losses	14,483 kWh/a
	Transmission heat losses	14,662 kWh/a
Gain	Internal gains	3,972 kWh/a
	Solar gains transparent	5,252 kWh/a
	Solar gains opaque	297 kWh/a
	Heating demand	**20,869 kWh/a**



Annual balance of energy generation on site (photovoltaics)

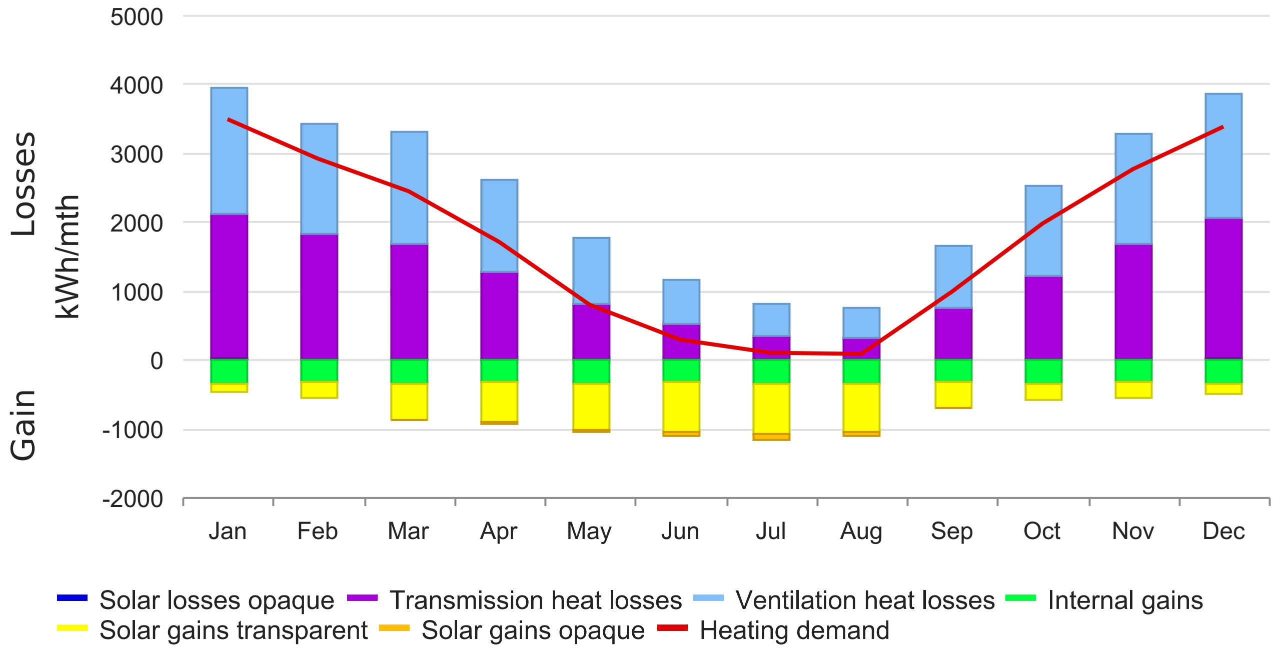
Electricity harvested	0 kWh/a
Electricity demand	33,949 kWh/a

Annual balance of end energy demand with potential for on-site energy generation (photovoltaics)

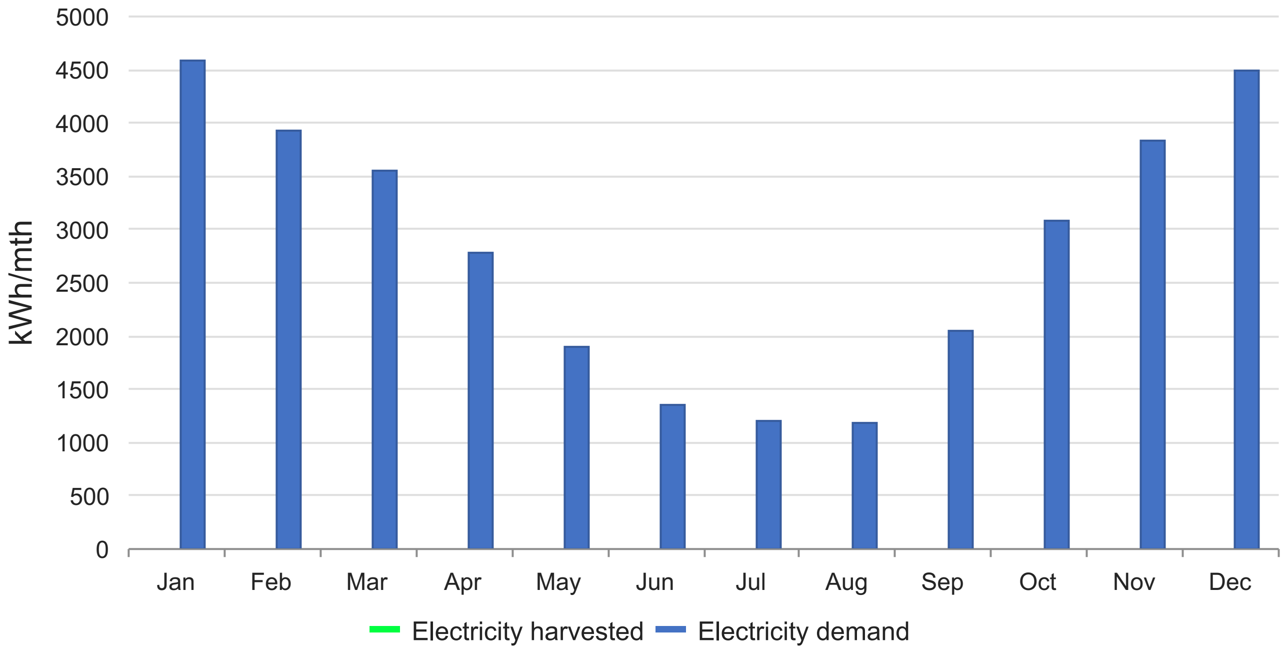


3.3. Result monthly per year sheet

Monthly energy balance



Monthly energy harvesting on site (photovoltaics)



Monthly values

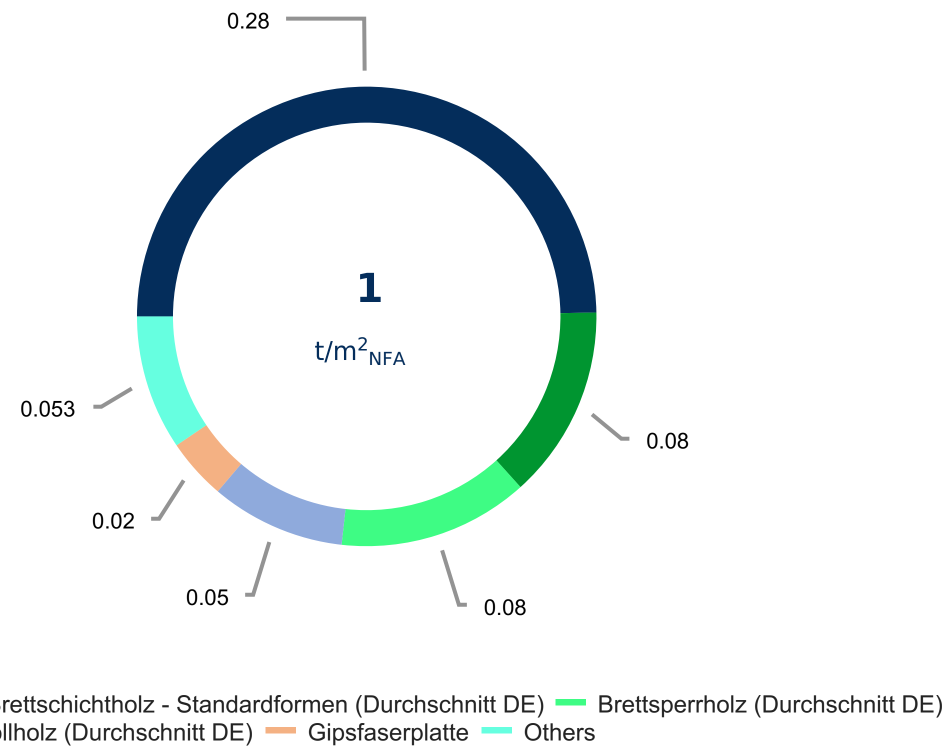
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Natural ventilation $H_{V, win, mth}$ (W / K)	66.1	68.9	80.1	93.5	111.4	121.3	127.6	128.7	112.5	97.0	78.4	67.8
Ref: Natural ventilation $H_{V, win, mth}$ (W / K)	72.8	75.9	88.2	102.9	122.7	133.5	140.5	141.6	123.8	106.8	86.3	74.7
Internal temperature balance(°C)	18.3	18.3	18.4	18.8	19.2	19.5	19.7	19.7	19.3	18.9	18.4	18.3
Ref: Internal temperature balance(°C)	18.2	18.2	18.4	18.7	19.2	19.5	19.6	19.7	19.2	18.8	18.3	18.2
Transmission heat sinks QT_{sink} (kWh)	2,107.3	1,827.4	1,693.0	1,276.4	817.0	523.9	364.2	334.7	762.1	1,220.6	1,686.0	2,054.7
Ref: Transmission heat sinks QT_{sink} (kWh)	2,867.8	2,486.8	2,301.3	1,735.1	1,110.5	712.1	495.1	454.9	1,035.9	1,659.1	2,291.8	2,796.2
Ventilation heat sinks QV_{sink} (kWh)	1,814.1	1,608.5	1,621.1	1,339.4	958.0	649.8	467.5	432.0	899.1	1,310.3	1,594.0	1,793.7
Ref: Ventilation heat sinks QV_{sink} (kWh)	1,477.4	1,319.9	1,364.9	1,157.5	851.2	584.7	423.8	392.1	800.0	1,139.2	1,337.0	1,467.7
Solar gains transparent $QS_{tr,source}$ (kWh)	123.9	230.0	525.1	567.6	666.7	713.6	747.7	716.8	361.7	236.4	211.1	157.8
Ref: Solar gains transparent $QS_{tr,source}$ (kWh)	123.9	230.0	525.1	567.6	666.7	713.6	747.7	716.8	361.7	236.4	211.1	157.8
Solar gains opaque $QS_{opaq,source}$ (kWh)	0.0	0.0	17.6	32.7	53.2	63.5	64.4	53.3	11.5	0.0	0.0	0.0
Ref: Solar gains opaque $QS_{opaq,source}$ (kWh)	0.0	0.0	33.2	64.3	106.5	127.7	129.2	106.0	22.2	0.0	0.0	0.0
Solar losses opaque $QS_{opaq,sink}$ (kWh)	25.3	10.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.1	17.1	24.2
Ref: Solar losses opaque $QS_{opaq,sink}$ (kWh)	25.3	10.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.1	17.1	24.2
Internal heat sources QI_{source} (kWh)	337.9	305.2	337.9	327.0	337.9	327.0	337.9	337.9	327.0	337.9	327.0	337.9
Ref: Internal heat sources QI_{source} (kWh)	337.9	305.2	337.9	327.0	337.9	327.0	337.9	337.9	327.0	337.9	327.0	337.9
Utilization factor η^M	1.0	1.0	1.0	1.0	0.9	0.8	0.6	0.6	1.0	1.0	1.0	1.0
Ref: Utilization factor η^M	1.0	1.0	1.0	1.0	0.9	0.8	0.7	0.6	1.0	1.0	1.0	1.0
Heat demand $Q_{h,b}$	3,485.2	2,911.3	2,439.0	1,703.2	790.7	284.5	93.0	77.3	979.5	1,968.8	2,759.8	3,377.2
Ref: Heat demand $Q_{h,b}$	3,936.0	3,294.0	2,776.3	1,950.0	930.0	353.5	126.0	107.7	1,143.7	2,247.9	3,127.7	3,819.0
Electricity demand (kWh)	4,592.4	3,929.3	3,546.4	2,780.8	1,898.1	1,362.2	1,200.4	1,184.7	2,057.1	3,076.1	3,837.3	4,484.4

Monthly energy harvesting on site (photovoltaics)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Electricity harvested plant 1 (kWh/mth)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electricity harvested plant 2 (kWh/mth)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

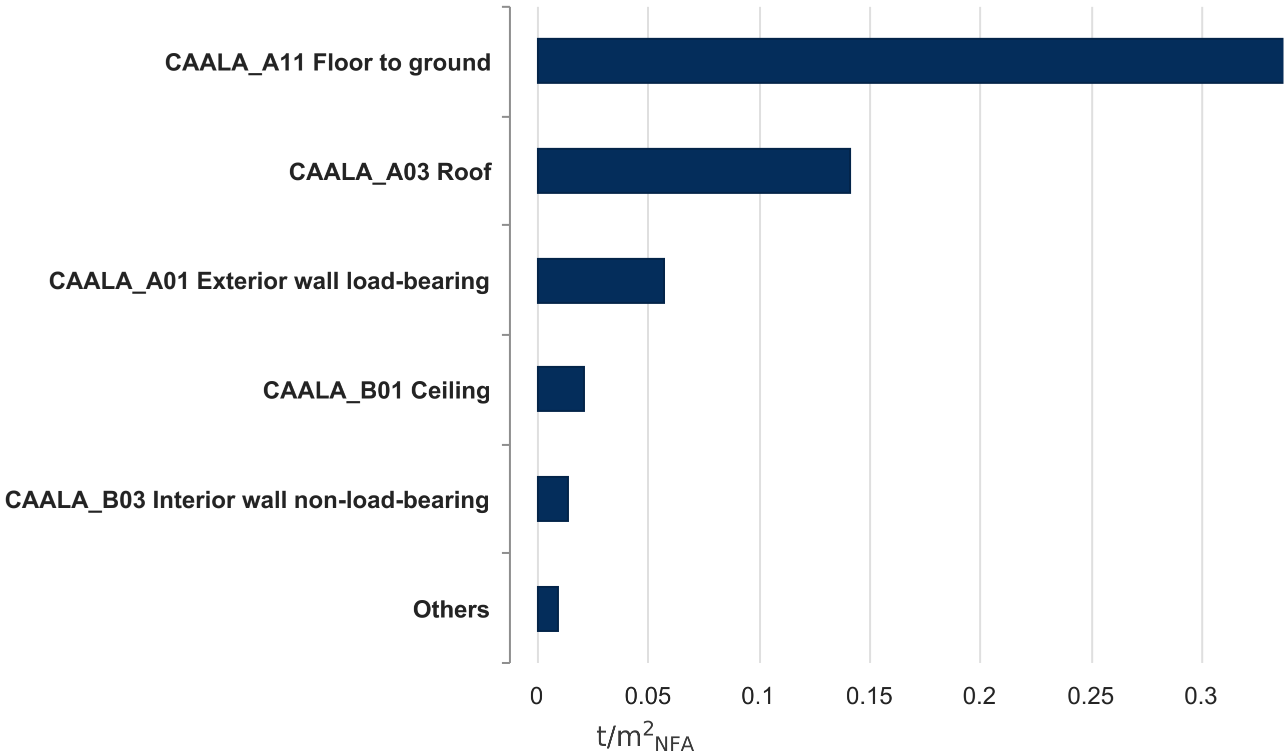
4. Mass Balance

4.1. Masses per material

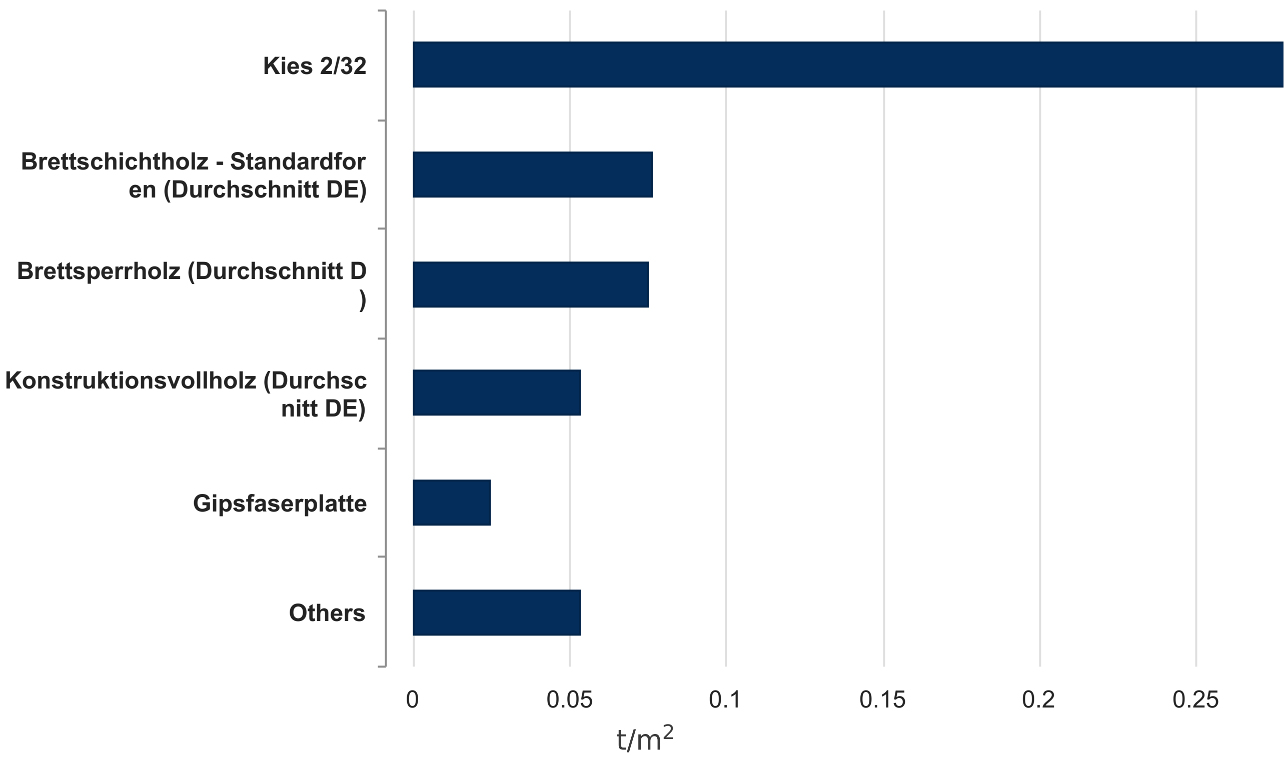


4.2. Masses per layer & Masses per material

Masses per layer



Masses per material



NFA

4.3. Detailed results

Masses per layer

Layer	SELECTED ELEMENT	AREA m²	WEIGHT t/m²NFA
Layer: CAALA_A01 Exterior wall load-bearing		**174.36**	**0.06**
CAALA_A01 Exterior wall load-bearing	Vårgårda bärande yttervägg KL-trä		
CAALA_A01 Exterior wall load-bearing	Panel vårgårda		
CAALA_A01 Exterior wall load-bearing	- empty -		
Layer: CAALA_A03 Roof		**188.43**	**0.14**
CAALA_A03 Roof	Vårgårda yttertak KL-trä		
CAALA_A03 Roof	- empty -		
CAALA_A03 Roof	Vårgårda innertaks beklädnad		
Layer: CAALA_A11 Floor to ground		**181.72**	**0.34**
CAALA_A11 Floor to ground	- empty -		
CAALA_A11 Floor to ground	Vårgårda floor to ground KL-TRÄ		
CAALA_A11 Floor to ground	vårgårda parkett		
CAALA_A11 Floor to ground	- empty -		
Layer: CAALA_A12 Window (exterior wall)		**39.64**	**0**
CAALA_A12 Window (exterior wall)	Fenster, Dreifach-Isolierverglasung, Holz-Alu-Rahmen, U=1,05, g=0,35		
Layer: CAALA_A14 Door		**4.2**	**0**
CAALA_A14 Door	Eingangstür, Holz, U=0,9		
Layer: CAALA_B01 Ceiling		**121.07**	**0.02**
CAALA_B01 Ceiling	vårgårda bjälklag		
CAALA_B01 Ceiling	- empty -		
CAALA_B01 Ceiling	- empty -		

◢ Layer: CAALA_B02 Interior wall load-bearing		**73.73**	**0.01**
CAALA_B02 Interior wall load-bearing	Vårgårda bärande innervägg		
CAALA_B02 Interior wall load-bearing	- empty -		
CAALA_B02 Interior wall load-bearing	- empty -		
◢ Layer: CAALA_B03 Interior wall non-load-bearing		**119.05**	**0.01**
CAALA_B03 Interior wall non-load-bearing	Vårgårda icke bärande innervägg		
CAALA_B03 Interior wall non-load-bearing	- empty -		
CAALA_B03 Interior wall non-load-bearing	- empty -		
◢ Layer: CAALA_B07 Roof (unheated room)		**24.96**	**0**
CAALA_B07 Roof (unheated room)	vårgårda oisolerattak		
CAALA_B07 Roof (unheated room)	- empty -		
CAALA_B07 Roof (unheated room)	- empty -		

Masses per material

Material	Weight t/m²$_{NFA}$
Kies 2/32	0.28
Brettschichtholz - Standardformen (Durchschnitt DE)	0.08
Brettsperrholz (Durchschnitt DE)	0.08
Konstruktionsvollholz (Durchschnitt DE)	0.05
Gipsfaserplatte	0.02
Holzfaserdämmstoff	0.02
Massivholzparkett (Durchschnitt DE)	0.02
Nadelschnittholz - getrocknet (Durchschnitt DE)	0.01
EpS-Hartschaum (Styropor ®) für Decken/Böden und als Perimeterdämmung B/P-035	0.01

5. Life cycle assessment

5.1. Boundary conditions

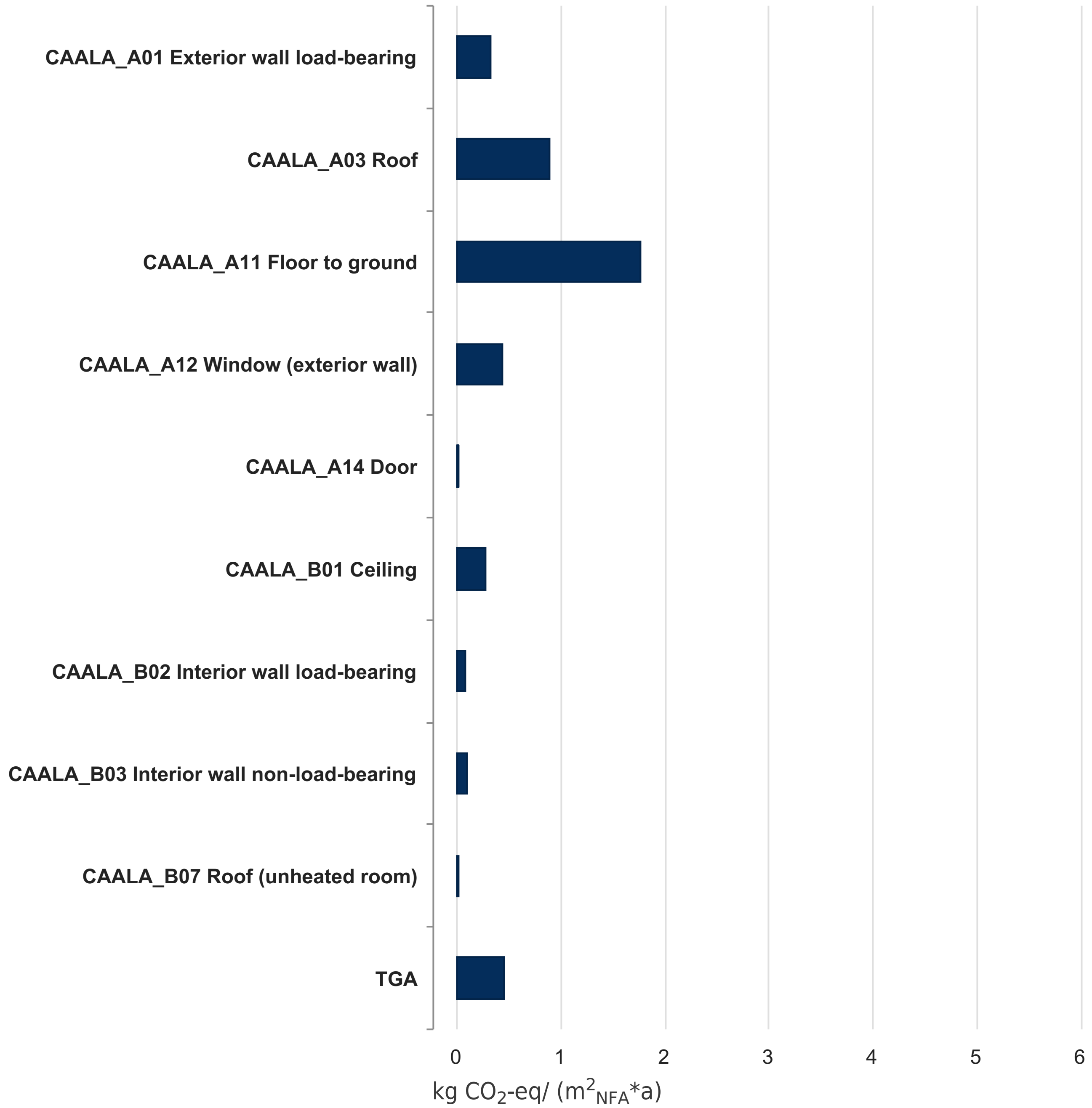
Assessment period	50 Jahre
Net floor area (NFA)	242.23 m²
Database	Ökobau.dat 2016
Assessed life cycle modules	A1-A3, B4, B6, C3+C4

5.2. Overview of the results

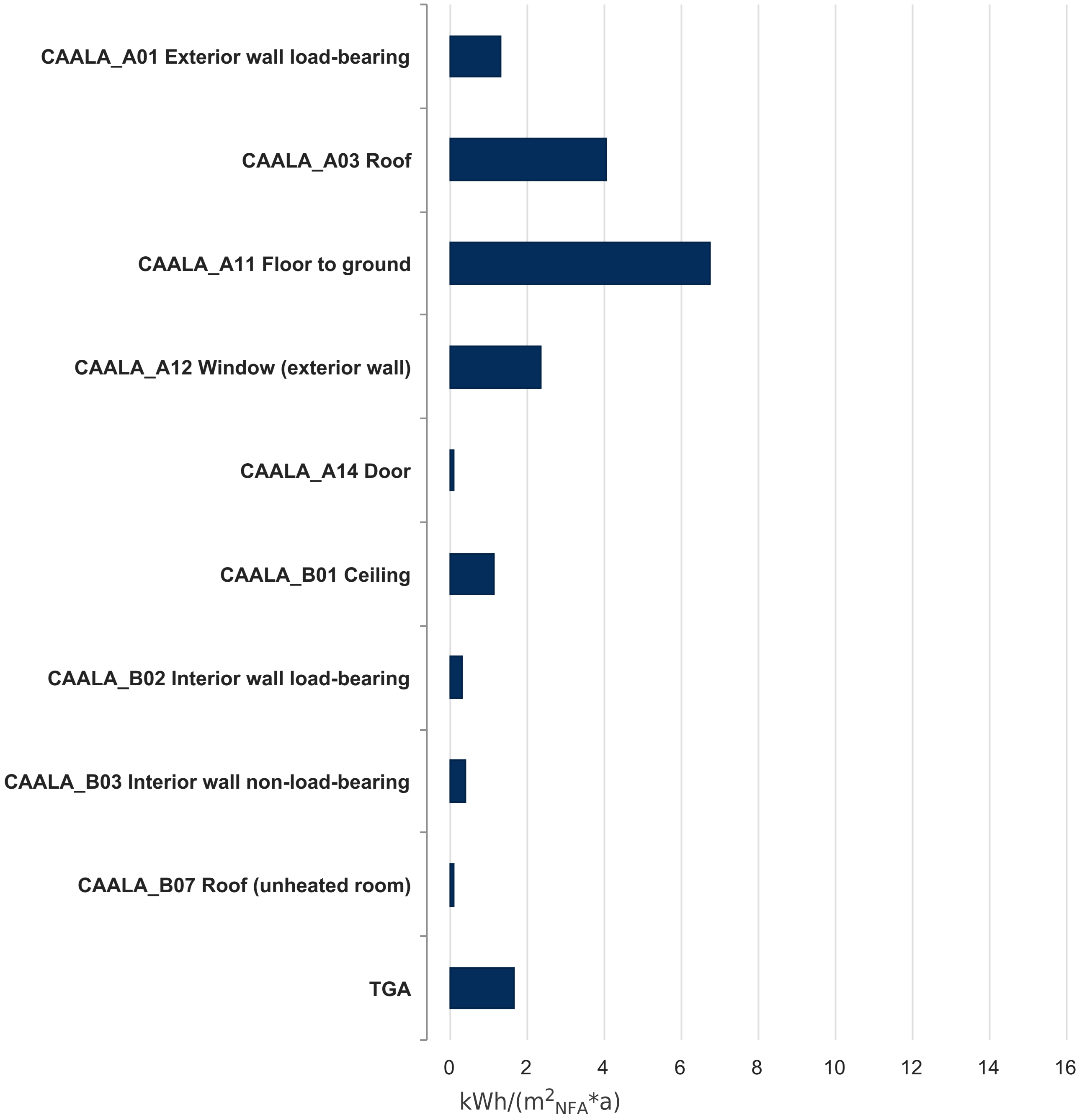
	MODULE	GWP	ODP	POCP	AP	EP	PENRT	PERT
Embodied	A1-A3, B4, B6, C3+C4	4.35	7,431e-7	5,788e-3	1,460e-2	2,708e-3	18.14	13.98
Operational	B6	3.34	1,042e-10	3,856e-4	4,675e-3	5,269e-4	5.76	350.86
Total		7.69	7,432e-7	6,173e-3	1,927e-2	3,235e-3	23.89	364.84

5.3. Results for integrated environmental impacts

Global warming potential (GWP)



Primary energy non renewable (PENRT)

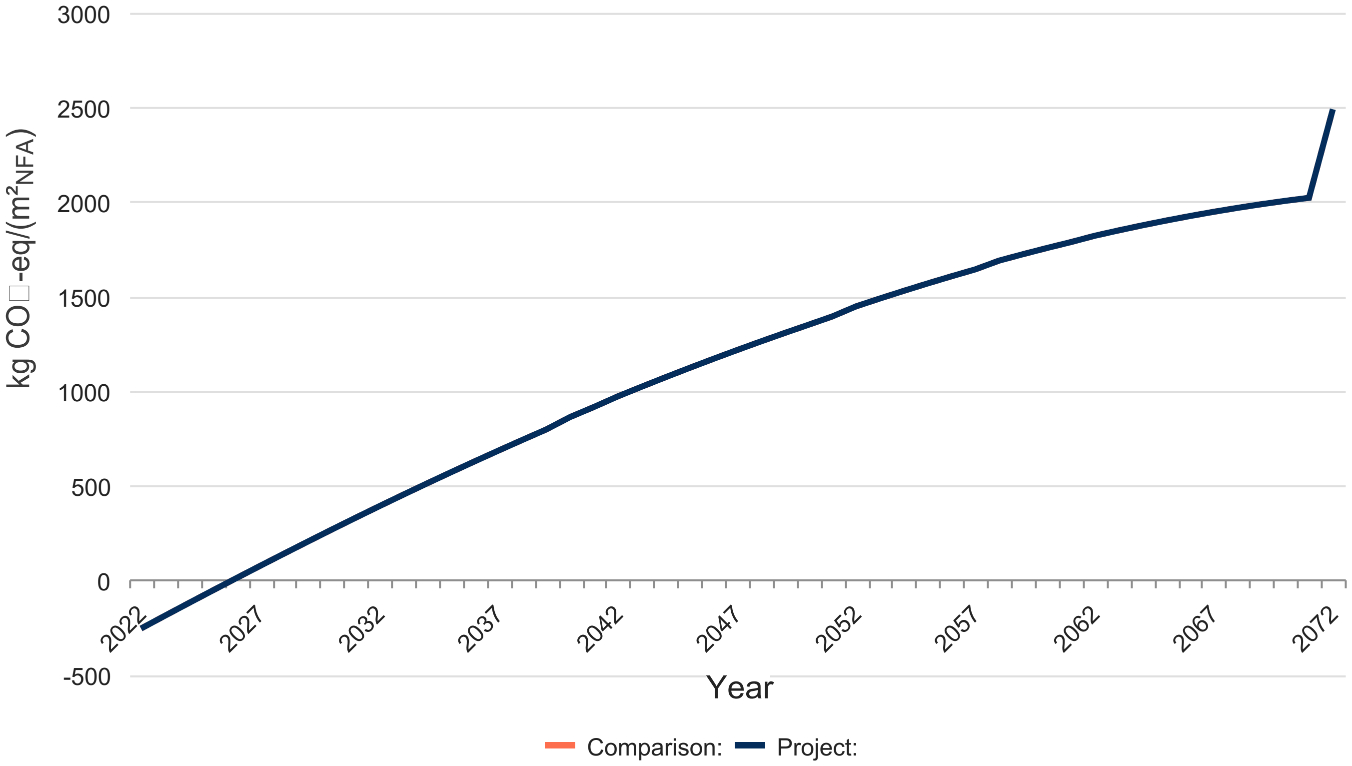


5.4. Results for integrated environmental impacts per layer

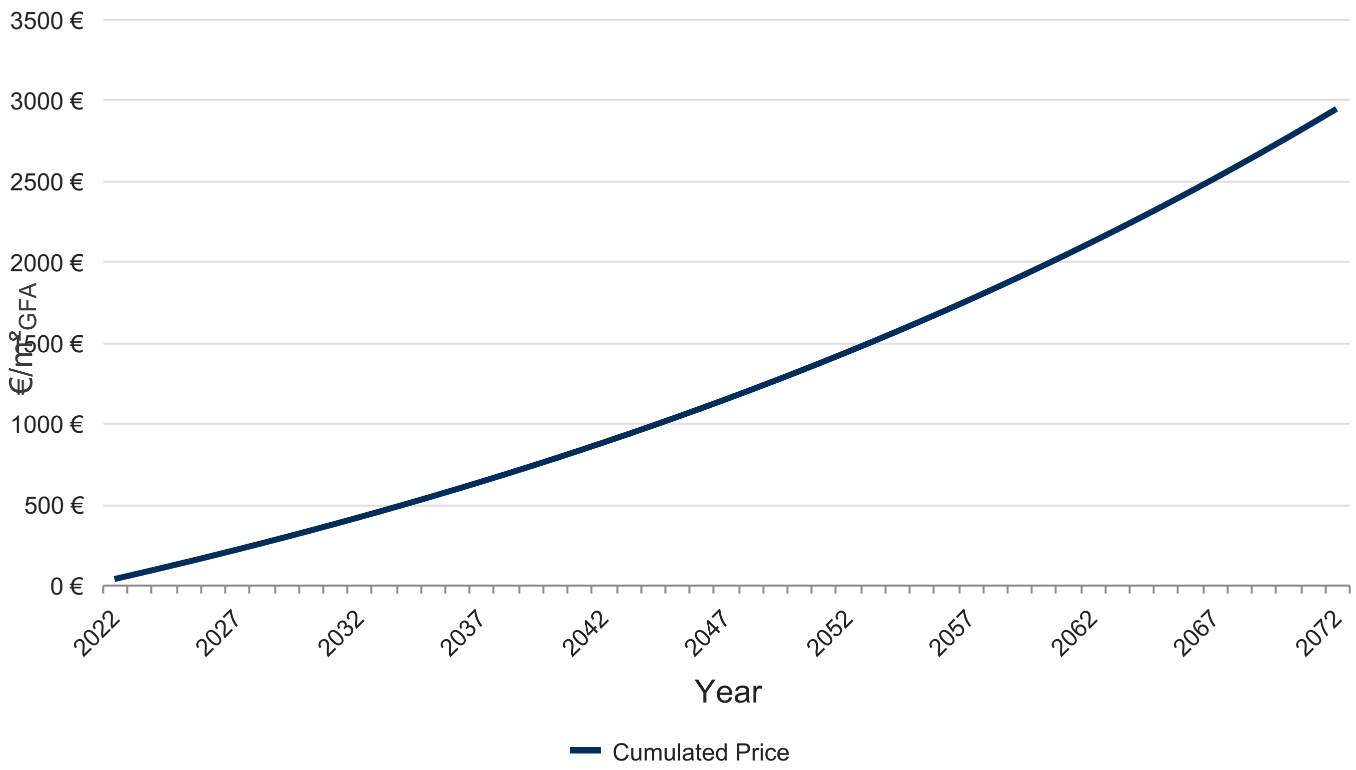
	m^2	GWP	ODP	POCP	AP	EP	PENRT	PERT
CAALA_A01 Exterior wall load-bearing	174.36	3	3,658e-10	2,849e-4	1,471e-3	3,329e-4	1.31	1.82
CAALA_A03 Roof	188.43	8	2,281e-9	7,476e-4	3,624e-3	7,725e-4	4.06	3.73
CAALA_A11 Floor to ground	181.72	1	2,878e-7	3,751e-3	3,694e-3	5,844e-4	6.75	3.23
CAALA_A12 Window (exterior wall)	39.64	4	5,046e-11	5,159e-4	2,247e-3	3,553e-4	2.37	2.86
CAALA_A14 Door	4.2	1	3,297e-9	2,426e-5	6,497e-5	8,503e-6	0.09	0.15
CAALA_B01 Ceiling	121.07	2	1,611e-10	2,393e-4	1,282e-3	2,307e-4	1.12	1.73
CAALA_B02 Interior wall load-bearing	73.73	8	2,256e-12	2,704e-5	2,504e-4	4,112e-5	0.32	0.07
CAALA_B03 Interior wall non-load-bearing	119.05	9	2,761e-12	3,033e-5	2,343e-4	4,237e-5	0.39	0.1
CAALA_B07 Roof (unheated room)	24.96	1	1,330e-12	2,098e-5	9,396e-5	2,022e-5	0.07	0.11
TGA	0	4	4,492e-7	1,468e-4	1,638e-3	3,196e-4	1.65	0.18

6. Cumulative emissions & costs

6.1. Cumulative emissions



6.2. Cumulative costs



Cumulative emissions & costs

Year	Ref. Factor kg CO_2-eq/kWh	Ref. Emission kg CO_2-eq/(m^2_{NFA})	Cur. Factor kg CO_2-eq/kWh	Cur. Emission kg CO_2-eq/(m^2_{NFA})	Cost €/m^2_{GFA}
2022	0.05	-255.29	0.05	-255.29	34.29€
2023	0.49	-187.79	0.49	-187.79	69.24€
2024	0.49	-120.89	0.49	-120.89	104.88€
2025	0.48	-54.59	0.48	-54.59	141.20€
2026	0.48	11.10	0.48	11.10	178.24€
2027	0.48	76.19	0.48	76.19	215.99€
2028	0.47	140.67	0.47	140.67	254.47€
2029	0.47	204.54	0.47	204.54	293.70€
2030	0.46	267.82	0.46	267.82	333.69€
2031	0.46	330.20	0.46	330.20	374.46€
2032	0.45	391.69	0.45	391.69	416.02€
2033	0.44	452.29	0.44	452.29	458.39€
2034	0.44	512.00	0.44	512.00	501.58€
2035	0.43	570.82	0.43	570.82	545.61€
2036	0.42	628.75	0.42	628.75	590.49€
2037	0.42	685.79	0.42	685.79	636.25€
2038	0.41	741.94	0.41	741.94	682.89€
2039	0.40	797.20	0.40	797.20	730.44€
2040	0.40	862.77	0.40	862.77	778.92€
2041	0.39	916.06	0.39	916.06	828.33€
2042	0.38	971.98	0.38	971.98	878.70€
2043	0.37	1,023.10	0.37	1,023.10	930.05€
2044	0.37	1,073.14	0.37	1,073.14	982.40€
2045	0.36	1,122.10	0.36	1,122.10	1,035.77€
2046	0.35	1,169.98	0.35	1,169.98	1,090.17€
2047	0.34	1,216.78	0.34	1,216.78	1,145.63€

2048	0.33	1,262.49	0.33	1,262.49	1,202.16€
2049	0.33	1,307.13	0.33	1,307.13	1,259.80€
2050	0.32	1,350.68	0.32	1,350.68	1,318.55€
2051	0.32	1,394.64	0.32	1,394.64	1,378.44€
2052	0.31	1,448.20	0.31	1,448.20	1,439.49€
2053	0.30	1,489.78	0.30	1,489.78	1,501.74€
2054	0.29	1,530.13	0.29	1,530.13	1,565.19€
2055	0.29	1,569.23	0.29	1,569.23	1,629.87€
2056	0.28	1,607.06	0.28	1,607.06	1,695.80€
2057	0.27	1,643.59	0.27	1,643.59	1,763.02€
2058	0.26	1,690.01	0.26	1,690.01	1,831.54€
2059	0.25	1,723.90	0.25	1,723.90	1,901.40€
2060	0.24	1,756.42	0.24	1,756.42	1,972.61€
2061	0.23	1,787.57	0.23	1,787.57	2,045.20€
2062	0.22	1,821.02	0.22	1,821.02	2,119.20€
2063	0.21	1,849.34	0.21	1,849.34	2,194.64€
2064	0.20	1,876.22	0.20	1,876.22	2,271.55€
2065	0.19	1,901.62	0.19	1,901.62	2,349.94€
2066	0.17	1,925.53	0.17	1,925.53	2,429.86€
2067	0.16	1,947.94	0.16	1,947.94	2,511.33€
2068	0.15	1,968.81	0.15	1,968.81	2,594.39€
2069	0.14	1,988.12	0.14	1,988.12	2,679.05€
2070	0.13	2,005.85	0.13	2,005.85	2,765.36€
2071	0.12	2,021.99	0.12	2,021.99	2,853.35€
2072	0.11	2,490.36	0.11	2,490.36	2,943.04€

B4 Replacement

	Replacement Year	Name	GWP kg CO_2-eq/(m^2_{NFA})
◢ Replacement Year: 2040			

	2040	Strom Wärmepumpe (Luft-Wasser) 14kW	11.20
			Sum: 11.20
Replacement Year: 2042			
	2042	Pufferspeicher (Edelstahl)	3.71
			Sum: 3.71
Replacement Year: 2052			
	2052	Fenster, Dreifach-Isolierverglasung, Holz	10.78
			Sum: 10.78
Replacement Year: 2058			
	2058	Strom Wärmepumpe (Luft-Wasser) 14kW	11.20
			Sum: 11.20
Replacement Year: 2062			
	2062	Pufferspeicher (Edelstahl)	3.71
			Sum: 3.71
Replacement Year: 2072			
	2072	Konstruktionsvollholz (Durchschnitt DE)	0.00
	2072	Luft	0.00
	2072	Holzfaserdämmplatten	0.00
	2072	ISOCELL-Einblasdämmstoff aus Zellulosefasern frei aufliegend 28 kg/m³	0.00
	2072	Dampfbremse PE	0.00
	2072	Brettschichtholz - Standardformen (Durchschnitt DE)	0.00
	2072	Kraftpapier	0.00
	2072	Bewehrungsstahl	0.00

	2072	Holzfaserdämmstoff	0.00
	2072	Brettsperrholz (Durchschnitt DE)	0.00
	2072	Nadelschnittholz - getrocknet (Durchschnitt DE)	0.00
	2072	Gipsfaserplatte	0.00
	2072	EPS-Hartschaum (Styropor ®) für Decken/Böden und als Perimeterdämmung B/P-035	0.00
	2072	PU-Dämmplatten mit Mineralvlies-Deckschicht	0.00
	2072	Massivholzparkett (Durchschnitt DE)	0.00
	2072	Universal-Spachtelmasse USP 32	0.00
	2072	Haustür, Passivhaus, Holz, U=0.8	0.00
	2072	Mineralwolle (Innenausbau-Dämmung)	0.00
	2072	Oriented Strand Board (Durchschnitt DE)	0.00
			Sum: 0.00

7. Life cycle cost analysis

7.1. Boundary conditions

Assessment period	50 Jahre
Gross Floor Area (GFA)	302.78999999999996 m²
Rate of Energy Price Increase	5 %/Jahr
Price Discount Rate	3 %/Jahr
Initial Price for Electricity	0,3 €/kWh
Price for [Electricity]	0,3

7.2. Overview of results

Investment costs				
KG 300 Building construction	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)
KG 400 Technical building equipment	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)
Operational costs				
Energy costs	2,853.35	€/m^2_{GFA}	57.07	€/(m^2_{GFA}*a)
CO_2 Cost	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)
Inspection & maintenance costs for KG 300	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)
Inspection & maintenance costs for KG 400	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)
Repair Cost				
Repair Cost for KG 300	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)
Repair Cost for KG 400	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)

7.3. Results by cost group 2nd level

	Construction	Maintenance & Replace	Repair
KG 300 - Building construction	0.00 €	0.00 €	0.00 €
KG 320 Foundation	0.00 €	0.00 €	0.00 €
KG 330 Exterior walls	0.00 €	0.00 €	0.00 €
KG 340 Interior walls	0.00 €	0.00 €	0.00 €
KG 350 Ceilings	0.00 €	0.00 €	0.00 €
KG 360 Roofs	0.00 €	0.00 €	0.00 €
KG 400 - Technical building equipment	0.00 €	0.00 €	0.00 €

7.4. Results by cost group 3rd level

	Construction	Maintenance & Replacement		Repair	
	Costs	Expenses per year	Costs	Expenses per year	Costs
300 - Building construction	0.00 €		0.00 €		0.00 €
322 Flat foundation	0.00 €	0.1%	0.00 €	0.35%	0.00 €
324 Base plate	0.00 €	0.1%	0.00 €	0.35%	0.00 €
325 Base flooring	0.00 €	0.1%	0.00 €	0.35%	0.00 €
326 Sealing	0.00 €	0.1%	0.00 €	0.35%	0.00 €
331 Load-bearing exterior wall	0.00 €	0.1%	0.00 €	0.35%	0.00 €
334 Exterior doors and windows	0.00 €	0.1%	0.00 €	0.35%	0.00 €
335 Exterior wall cladding outside	0.00 €	0.1%	0.00 €	0.35%	0.00 €
336 Exterior wall finishing inside	0.00 €	0.1%	0.00 €	0.35%	0.00 €
341 Load-bearing interior wall	0.00 €	0.1%	0.00 €	0.35%	0.00 €
342 Non-load-bearing interior wall	0.00 €	0.1%	0.00 €	0.35%	0.00 €
345 Interior wall finishing (outside)	0.00 €	0.1%	0.00 €	0.35%	0.00 €
345 Interior wall finishing (inside)	0.00 €	0.1%	0.00 €	0.35%	0.00 €
351 Ceiling strucutre	0.00 €	0.1%	0.00 €	0.35%	0.00 €
352 Ceiling flooring	0.00 €	0.1%	0.00 €	0.35%	0.00 €
353 Ceiling finishing	0.00 €	0.1%	0.00 €	0.35%	0.00 €
361 Roof structure	0.00 €	0.1%	0.00 €	0.35%	0.00 €
363 Roof covering	0.00 €	0.1%	0.00 €	0.35%	0.00 €
364 Roof finishing inside	0.00 €	0.1%	0.00 €	0.35%	0.00 €

8. Building envelope and building technology

8.1. Surfaces

Overview

	ID	Layer	Orientation	Net area	Gross area	Length	Angle (Azimut
▶	**CAALA_A01 Exterior wall load-bearing (Count: 25 , Net area: 174.36 m² , Gross area: 217.24 m² , Length: 0.00 m)**						
▶	**CAALA_A03 Roof (Count: 6 , Net area: 188.43 m² , Gross area: 188.43 m² , Length: 0.00 m)**						
▶	**CAALA_A11 Floor to ground (Count: 12 , Net area: 181.72 m² , Gross area: 181.72 m² , Length: 0.00 m)**						
▶	**CAALA_A12 Window (exterior wall) (Count: 18 , Net area: 39.64 m² , Gross area: 39.64 m² , Length: 0.00 m)**						
▶	**CAALA_A14 Door (Count: 2 , Net area: 4.20 m² , Gross area: 4.20 m² , Length: 0.00 m)**						
▶	**CAALA_B01 Ceiling (Count: 14 , Net area: 121.07 m² , Gross area: 121.07 m² , Length: 0.00 m)**						
▶	**CAALA_B02 Interior wall load-bearing (Count: 17 , Net area: 73.73 m² , Gross area: 73.73 m² , Length: 0.00 m)**						
▶	**CAALA_B03 Interior wall non-load-bearing (Count: 29 , Net area: 119.05 m² , Gross area: 119.05 m² , Length: 0.00 m)**						
▶	**CAALA_B07 Roof (unheated room) (Count: 8 , Net area: 24.96 m² , Gross area: 24.96 m² , Length: 0.00 m)**						

Detailed areas

	ID	Layer	Orientation	Net area	Gross area	Length	Angle (Azimu
◢	**CAALA_A01 Exterior wall load-bearing (Count: 25 , Net area: 174.36 m² , Gross area: 217.24 m² , Length: 0.00 m)**						
	28281	CAALA_A01 Exterior wall load-bearing	SE90	7.74	19.25	0	135
	84633	CAALA_A01 Exterior wall load-bearing	NW90	3.91	3.91	0	315
	73231	CAALA_A01 Exterior wall load-bearing	NW90	3.88	3.88	0	315
	28510	CAALA_A01 Exterior wall load-bearing	SW90	8.14	8.14	0	225
	28172	CAALA_A01 Exterior wall load-bearing	N90	8.92	8.92	0	0
	69012	CAALA_A01 Exterior wall load-bearing	E90	8.59	10.09	0	90
	27887	CAALA_A01 Exterior wall load-bearing	N90	5.47	7.57	0	0
	28682	CAALA_A01 Exterior wall load-bearing	SW90	3.56	3.56	0	225
	28508	CAALA_A01 Exterior wall load-bearing	NW90	10.18	10.18	0	315

	28108	CAALA_A01 Exterior wall load-bearing	SE90	4.08	4.08	0	135
	70209	CAALA_A01 Exterior wall load-bearing	N90	10.35	11.89	0	0
	77663	CAALA_A01 Exterior wall load-bearing	NW90	5.24	6.78	0	315
	99992	CAALA_A01 Exterior wall load-bearing	NW90	7.55	7.55	0	315
	52072	CAALA_A01 Exterior wall load-bearing	E90	9.07	13.47	0	90
	28144	CAALA_A01 Exterior wall load-bearing	E90	15.4	15.4	0	90
	50690	CAALA_A01 Exterior wall load-bearing	S90	2.26	2.26	0	180
	28479	CAALA_A01 Exterior wall load-bearing	S90	14.81	19.25	0	180
	51351	CAALA_A01 Exterior wall load-bearing	SW90	4.07	14.44	0	225
	28347	CAALA_A01 Exterior wall load-bearing	SW90	10.05	12.45	0	225
	27893	CAALA_A01 Exterior wall load-bearing	SE90	4.08	4.08	0	135
	52959	CAALA_A01 Exterior wall load-bearing	NW90	1.69	1.69	0	315
	50694	CAALA_A01 Exterior wall load-bearing	SE90	5.92	5.92	0	135
	84319	CAALA_A01 Exterior wall load-bearing	NW90	7.76	9.3	0	315
	123517	CAALA_A01 Exterior wall load-bearing	S90	3.66	3.66	0	180
	69481	CAALA_A01 Exterior wall load-bearing	N90	7.98	9.52	0	0
◢	**CAALA_A03 Roof (Count: 6 , Net area: 188.43 m² , Gross area: 188.43 m² , Length: 0.00 m)**						
	99967	CAALA_A03 Roof	NW30	32.99	32.99	0	315
	28232	CAALA_A03 Roof	S30	17.16	17.16	0	180
	28691	CAALA_A03 Roof	N30	48.58	48.58	0	0
	99968	CAALA_A03 Roof	NW30	28.63	28.63	0	315
	28681	CAALA_A03 Roof	NW30	38.77	38.77	0	315
	123601	CAALA_A03 Roof	S30	22.3	22.3	0	180
◢	**CAALA_A11 Floor to ground (Count: 12 , Net area: 181.72 m² , Gross area: 181.72 m² , Length: 0.00 m)**						
	66969	CAALA_A11 Floor to ground	HOR	2.76	2.76	0	5.93
	84007	CAALA_A11 Floor to ground	HOR	20.62	20.62	0	208.75

	78242	CAALA_A11 Floor to ground	HOR	12.64	12.64	0	209.91
	66523	CAALA_A11 Floor to ground	HOR	12.91	12.91	0	90
	80334	CAALA_A11 Floor to ground	HOR	2.04	2.04	0	93.11
	81842	CAALA_A11 Floor to ground	HOR	4.42	4.42	0	2.99
	66086	CAALA_A11 Floor to ground	HOR	11.3	11.3	0	90
	28165	CAALA_A11 Floor to ground	HOR	6.56	6.56	0	90
	83079	CAALA_A11 Floor to ground	HOR	86.24	86.24	0	116.14
	82458	CAALA_A11 Floor to ground	HOR	9.45	9.45	0	335
	27948	CAALA_A11 Floor to ground	HOR	12.52	12.52	0	90
	65657	CAALA_A11 Floor to ground	HOR	0.26	0.26	0	90
◢	**CAALA_A12 Window (exterior wall) (Count: 18 , Net area: 39.64 m² , Gross area: 39.64 m² , Length: 0.00 m)**						
	27898	CAALA_A12 Window (exterior wall)	S90	1.68	1.68	0	180
	28455	CAALA_A12 Window (exterior wall)	E90	1.5	1.5	0	90
	52783	CAALA_A12 Window (exterior wall)	NW90	0.96	0.96	0	315
	28415	CAALA_A12 Window (exterior wall)	E90	0.7	0.7	0	90
	28291	CAALA_A12 Window (exterior wall)	SE90	4.6	4.6	0	135
	28595	CAALA_A12 Window (exterior wall)	NW90	1.54	1.54	0	315
	28550	CAALA_A12 Window (exterior wall)	N90	1.54	1.54	0	0
	28329	CAALA_A12 Window (exterior wall)	SW90	4.6	4.6	0	225
	28357	CAALA_A12 Window (exterior wall)	SW90	1.2	1.2	0	225
	51337	CAALA_A12 Window (exterior wall)	SW90	3.46	3.46	0	225
	28264	CAALA_A12 Window (exterior wall)	SE90	2.31	2.31	0	135
	28432	CAALA_A12 Window (exterior wall)	E90	1.6	1.6	0	90
	27897	CAALA_A12 Window (exterior wall)	SE90	4.6	4.6	0	135
	27891	CAALA_A12 Window (exterior wall)	SW90	1.2	1.2	0	225
	28391	CAALA_A12 Window (exterior wall)	S90	2.76	2.76	0	180
	28568	CAALA_A12 Window (exterior wall)	N90	1.54	1.54	0	0
	28303	CAALA_A12 Window (exterior wall)	SW90	2.31	2.31	0	225
	28632	CAALA_A12 Window (exterior wall)	NW90	1.54	1.54	0	315
◢	**CAALA_A14 Door (Count: 2 , Net area: 4.20 m² , Gross area: 4.20 m² , Length: 0.00 m)**						
	28467	CAALA_A14 Door	N90	2.1	2.1	0	0
	28443	CAALA_A14 Door	E90	2.1	2.1	0	90
◢	**CAALA_B01 Ceiling (Count: 14 , Net area: 121.07 m² , Gross area: 121.07 m² , Length: 0.00 m)**						
	69722	CAALA_B01 Ceiling	HOR	12.91	12.91	0	90
	86852	CAALA_B01 Ceiling	HOR	4.42	4.42	0	90
	69241	CAALA_B01 Ceiling	HOR	11.3	11.3	0	90
	88175	CAALA_B01 Ceiling	HOR	20.62	20.62	0	90

27991	CAALA_B01 Ceiling	HOR	23.7	23.7	0	90
94983	CAALA_B01 Ceiling	HOR	2.04	2.04	0	90
74314	CAALA_B01 Ceiling	HOR	12.52	12.52	0	90
72192	CAALA_B01 Ceiling	HOR	0.26	0.26	0	90
89193	CAALA_B01 Ceiling	HOR	2.76	2.76	0	90
73497	CAALA_B01 Ceiling	HOR	3.92	3.92	0	90
72964	CAALA_B01 Ceiling	HOR	2	2	0	90
94985	CAALA_B01 Ceiling	HOR	2.53	2.53	0	90
94986	CAALA_B01 Ceiling	HOR	9.45	9.45	0	90
100000	CAALA_B01 Ceiling	HOR	12.64	12.64	0	90
CAALA_B02 Interior wall load-bearing (Count: 17 , Net area: 73.73 m² , Gross area: 73.73 m² , Length: 0.00 m)						
123431	CAALA_B02 Interior wall load-bearing	S90	3.79	3.79	0	180
71200	CAALA_B02 Interior wall load-bearing	N90	0.25	0.25	0	0
88853	CAALA_B02 Interior wall load-bearing	SE90	6.78	6.78	0	135
56360	CAALA_B02 Interior wall load-bearing	N90	1.71	1.71	0	0
28219	CAALA_B02 Interior wall load-bearing	SE90	7.09	7.09	0	135
99678	CAALA_B02 Interior wall load-bearing	W90	1.69	1.69	0	270
55082	CAALA_B02 Interior wall load-bearing	SE90	10.2	10.2	0	135
57214	CAALA_B02 Interior wall load-bearing	N90	0.27	0.27	0	0
28101	CAALA_B02 Interior wall load-bearing	N90	5.34	5.34	0	0
57642	CAALA_B02 Interior wall load-bearing	N90	1.26	1.26	0	0
58494	CAALA_B02 Interior wall load-bearing	SE90	10.74	10.74	0	135
50686	CAALA_B02 Interior wall load-bearing	W90	4.89	4.89	0	270
77376	CAALA_B02 Interior wall load-bearing	SE90	1.51	1.51	0	135
87183	CAALA_B02 Interior wall load-bearing	SE90	3.06	3.06	0	135
123283	CAALA_B02 Interior wall load-bearing	SE90	8.66	8.66	0	135
123602	CAALA_B02 Interior wall load-bearing	W90	3.85	3.85	0	270

	28104	CAALA_B02 Interior wall load-bearing	S30	2.64	2.64	0	180
CAALA_B03 Interior wall non-load-bearing (Count: 29 , Net area: 119.05 m² , Gross area: 119.05 m² , Length: 0.00 m)							
	89194	CAALA_B03 Interior wall non-load-bearing	SW90	4.09	4.09	0	225
	86532	CAALA_B03 Interior wall non-load-bearing	SE90	1.5	1.5	0	135
	77950	CAALA_B03 Interior wall non-load-bearing	SW90	3.53	3.53	0	225
	72965	CAALA_B03 Interior wall non-load-bearing	S90	0.26	0.26	0	180
	79136	CAALA_B03 Interior wall non-load-bearing	NE90	3.5	3.5	0	44.62
	88510	CAALA_B03 Interior wall non-load-bearing	SE90	1.07	1.07	0	135
	69963	CAALA_B03 Interior wall non-load-bearing	N90	7.32	7.32	0	0
	73498	CAALA_B03 Interior wall non-load-bearing	NE90	0.48	0.48	0	44.62
	71943	CAALA_B03 Interior wall non-load-bearing	S90	5.2	5.2	0	180
	86853	CAALA_B03 Interior wall non-load-bearing	NE90	8.44	8.44	0	45
	85895	CAALA_B03 Interior wall non-load-bearing	S90	3.35	3.35	0	180
	81536	CAALA_B03 Interior wall non-load-bearing	NW90	3.93	3.93	0	315
	75430	CAALA_B03 Interior wall non-load-bearing	SE90	1.9	1.9	0	134.62
	75150	CAALA_B03 Interior wall non-load-bearing	NE90	3.87	3.87	0	44.62
	87840	CAALA_B03 Interior wall non-load-bearing	SE90	3.83	3.83	0	135
	69964	CAALA_B03 Interior wall non-load-bearing	E90	10.09	10.09	0	90
	80934	CAALA_B03 Interior wall non-load-bearing	NW90	3.91	3.91	0	315
	88511	CAALA_B03 Interior wall non-load-bearing	SW90	4.09	4.09	0	225
	94984	CAALA_B03 Interior wall non-load-bearing	SW90	4.32	4.32	0	225
	85262	CAALA_B03 Interior wall non-load-bearing	SW90	6.05	6.05	0	224.62

	68333	CAALA_B03 Interior wall non-load-bearing	N90	2.34	2.34	0	0
	72193	CAALA_B03 Interior wall non-load-bearing	W90	1.69	1.69	0	270
	78836	CAALA_B03 Interior wall non-load-bearing	NE90	4.81	4.81	0	44.62
	94981	CAALA_B03 Interior wall non-load-bearing	SW90	4.78	4.78	0	225
	99677	CAALA_B03 Interior wall non-load-bearing	S90	2.81	2.81	0	180
	90935	CAALA_B03 Interior wall non-load-bearing	SW90	2.35	2.35	0	225
	89890	CAALA_B03 Interior wall non-load-bearing	SE90	2.65	2.65	0	135
	100001	CAALA_B03 Interior wall non-load-bearing	SW90	8.49	8.49	0	225
	70700	CAALA_B03 Interior wall non-load-bearing	W90	8.4	8.4	0	270
◢	**CAALA_B07 Roof (unheated room) (Count: 8 , Net area: 24.96 m² , Gross area: 24.96 m² , Length: 0.00 m)**						
	99975	CAALA_B07 Roof (unheated room)	NW30	0.81	0.81	0	315
	99971	CAALA_B07 Roof (unheated room)	NW30	0.81	0.81	0	315
	28236	CAALA_B07 Roof (unheated room)	NW30	3.99	3.99	0	315
	99969	CAALA_B07 Roof (unheated room)	NW30	1.83	1.83	0	315
	28521	CAALA_B07 Roof (unheated room)	S30	3.72	3.72	0	180
	99962	CAALA_B07 Roof (unheated room)	NW30	1.92	1.92	0	315
	28531	CAALA_B07 Roof (unheated room)	N30	4.74	4.74	0	0
	28537	CAALA_B07 Roof (unheated room)	NW30	7.14	7.14	0	315

8.2. Building Construction

Layer Name	CAALA_A01 Exterior wall load-bearing
Area	174.36 m²
Thickness	33.70 cm
U-value	0.16 W/(m²*K)
Reference U-Value	0.28 W/(m²*K)
Cost group	331 Load-bearing exterior wall
Name	Vårgårda bärande yttervägg KL-trä
Id	7b9fa05a-adfa-478d-8718-875952565215
Thickness	31.50 cm
Cost group	335 Exterior wall cladding outside
Name	Panel vårgårda
Id	71ebd6fd-62b1-4f66-be6f-fdd683e693f0
Thickness	2.20 cm
Cost group	336 Exterior wall finishing inside
Name	- empty -
Id	
Thickness	0.00 cm
Layer Name	CAALA_A03 Roof
Area	188.43 m²
Thickness	56.90 cm
U-value	0.09 W/(m²*K)
Reference U-Value	0.20 W/(m²*K)
Cost group	361 Roof structure
Name	Vårgårda yttertak KL-trä
Id	8d6c5f05-278c-4b3c-b027-c61d19ab358d
Thickness	55.60 cm
Cost group	363 Roof covering

Name	- empty -
Id	
Thickness	0.00 cm
Cost group	364 Roof finishing inside
Name	Vårgårda innertaks beklädnad
Id	ba4678f6-338a-4f77-8645-931d166d0891
Thickness	1.30 cm
Layer Name	CAALA_A11 Floor to ground
Area	181.72 m²
Thickness	72.30 cm
U-value	0.09 W/(m²*K)
Reference U-Value	0.35 W/(m²*K)
Cost group	322 Flat foundation
Name	- empty -
Id	
Thickness	0.00 cm
Cost group	324 Base plate
Name	Vårgårda floor to ground KL-TRÄ
Id	267f6ad3-386a-4d70-88cf-a4e7e83aacb0
Thickness	70.60 cm
Cost group	325 Base flooring
Name	vårgårda parkett
Id	be5580ef-b14a-4495-86f0-bfc754eb4716
Thickness	1.70 cm
Cost group	326 Sealing
Name	- empty -
Id	
Thickness	0.00 cm
Layer Name	CAALA_A12 Window (exterior wall)

Area	39.64 m²
Thickness	0.00 cm
U-value	1.05 W/(m²*K)
Reference U-Value	1.30 W/(m²*K)
Cost group	334 Exterior doors and windows
Name	Fenster, Dreifach-Isolierverglasung, Holz-Alu-Rahmen, U=1,05, g=0,35
Id	79390d1b-10e3-484d-af56-963b2a42045a
Thickness	0.00 cm
Layer Name	CAALA_A14 Door
Area	4.20 m²
Thickness	0.00 cm
U-value	0.90 W/(m²*K)
Reference U-Value	1.80 W/(m²*K)
Cost group	334 Exterior doors and windows
Name	Eingangstür, Holz, U=0,9
Id	be65e629-5f13-49b6-8d17-3d7992f2d838
Thickness	0.00 cm
Layer Name	CAALA_B01 Ceiling
Area	121.07 m²
Thickness	29.00 cm
U-value	-
Reference U-Value	0.00 W/(m²*K)
Cost group	351 Ceiling strucutre
Name	vårgårda bjälklag
Id	104afeae-8f41-4777-a548-a1c8fd7c4c63
Thickness	29.00 cm
Cost group	352 Ceiling flooring
Name	- empty -

Id	
Thickness	0.00 cm
Cost group	353 Ceiling finishing
Name	- empty -
Id	
Thickness	0.00 cm
Layer Name	CAALA_B02 Interior wall load-bearing
Area	73.73 m²
Thickness	16.60 cm
U-value	-
Reference U-Value	0.00 W/(m²*K)
Cost group	341 Load-bearing interior wall
Name	Vårgårda bärande innervägg
Id	ec2971b7-6f8c-46a5-943b-fdc8a408afa1
Thickness	16.60 cm
Cost group	345 Interior wall finishing (outside)
Name	- empty -
Id	
Thickness	0.00 cm
Cost group	345 Interior wall finishing (inside)
Name	- empty -
Id	
Thickness	0.00 cm
Layer Name	CAALA_B03 Interior wall non-load-bearing
Area	119.05 m²
Thickness	9.10 cm
U-value	-
Reference U-Value	0.00 W/(m²*K)
Cost group	342 Non-load-bearing interior wall

Name	Vårgårda icke bärande innervägg
Id	d2f58772-7534-4404-9103-7536a0771203
Thickness	9.10 cm
Cost group	345 Interior wall finishing (outside)
Name	- empty -
Id	
Thickness	0.00 cm
Cost group	345 Interior wall finishing (inside)
Name	- empty -
Id	
Thickness	0.00 cm
Layer Name	CAALA_B07 Roof (unheated room)
Area	24.96 m²
Thickness	29.20 cm
U-value	-
Reference U-Value	0.00 W/(m²*K)
Cost group	361 Roof structure
Name	vårgårda oisolerattak
Id	05bfd895-c102-4a7c-b34a-646c61a3a3c0
Thickness	29.20 cm
Cost group	363 Roof covering
Name	- empty -
Id	
Thickness	0.00 cm
Cost group	364 Roof finishing inside
Name	- empty -
Id	
Thickness	0.00 cm

8.3. Building Technology

420 Heat generation equipment	Electric heat pump air-water
Producer effort figure e_e	1.00
Aux. energy requirement [kWh/m²]	1.50 kWh/m²
Primary energy factor heat	0.70
Primary energy factor electricity	1.80
Investment costs KG	-
Investment cost for ventilation system	-
Performance coefficiente$_p$	1.55
440 Photovoltaik 1	Not available
440 Photovoltaik 2	Not available

8.4. Other input values and boundary conditions

Thermal bridge surcharge	General 0,10 W/m²K
Air tightness	New construction - general: n50 = 4 h^{-1}

Caala Report

For Project: house djup

Table of Content

1. Object data

1.1. Object

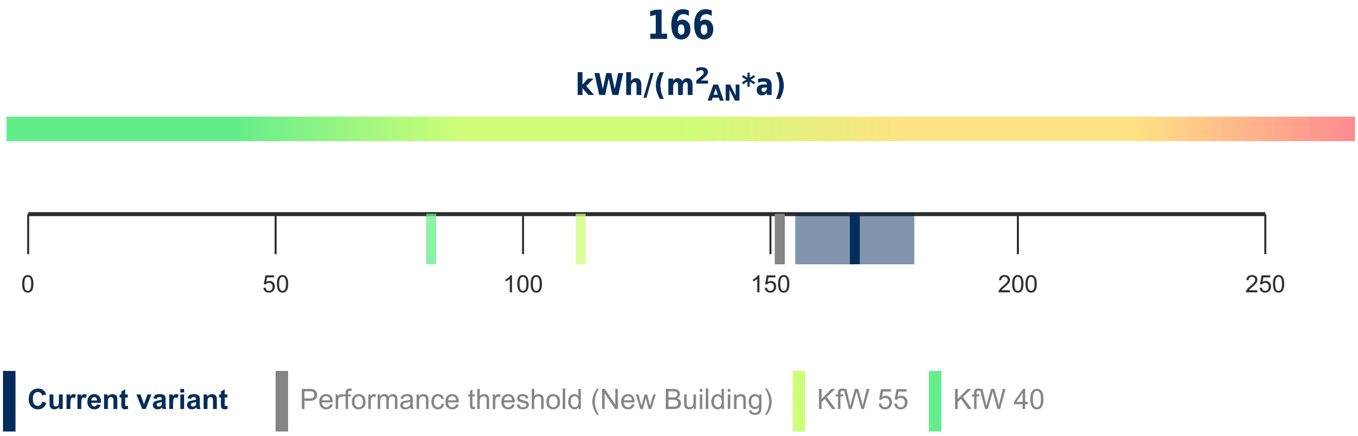
Model	VILLA DJUPVIK 2102
Scope of analysis	Full Life Cycle
Level of detail	Blueprint planning
Building type	Single family house
Energy standard	EnEV 2016
Reference study period	50 Jahre
Climate region - reference location	Region 10 - Hof

1.2. Geometry

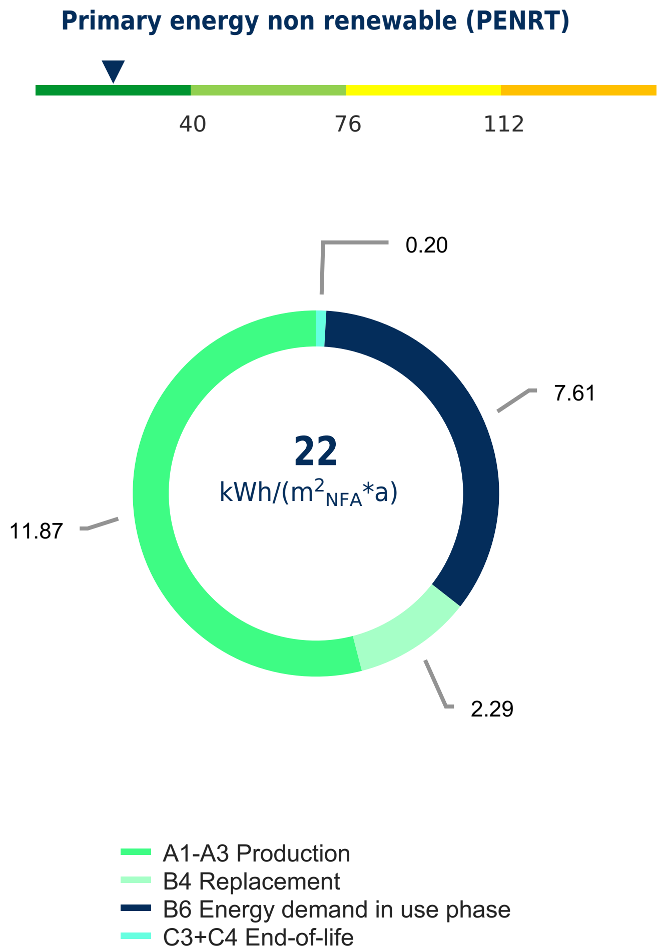
Average floor height	2.70 m
V	817.53 m^3
GFA th.	302.79 m^2
NFA	242.23 m^2
Reference area	261.61 m^2

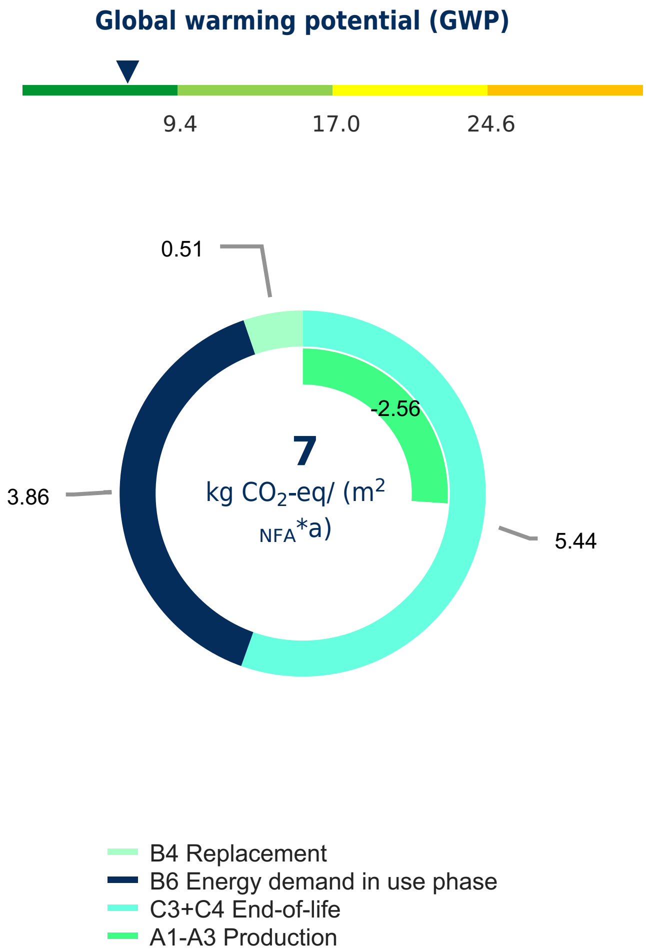
2. Overview

2.1. Primary energy demand

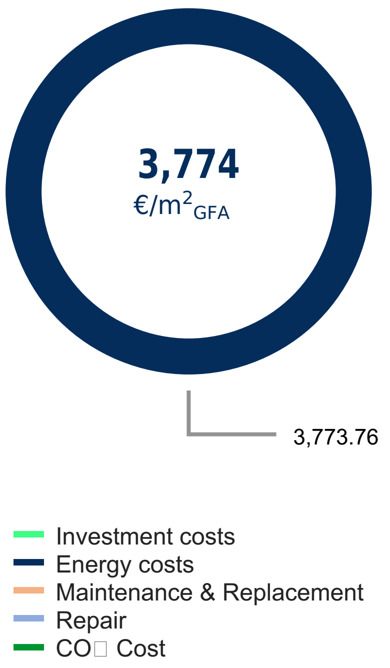


2.2. Life Cycle Assessment

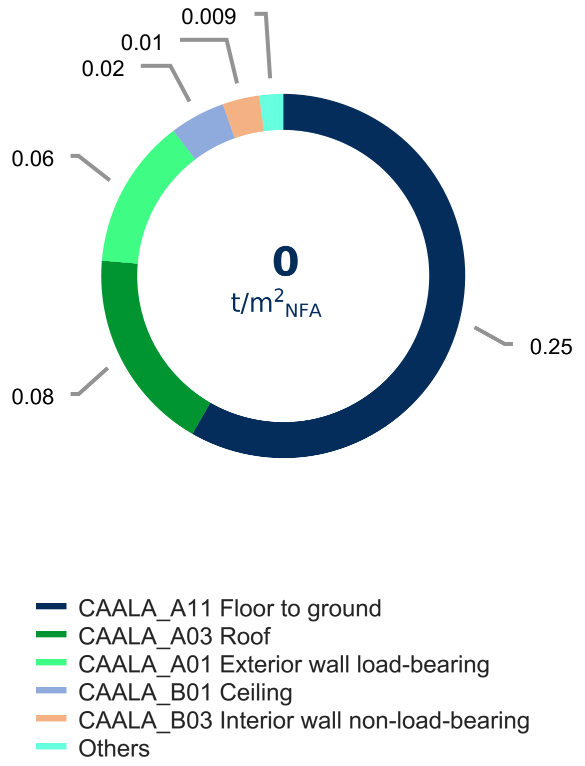




Life cycle costs



Mass Balance

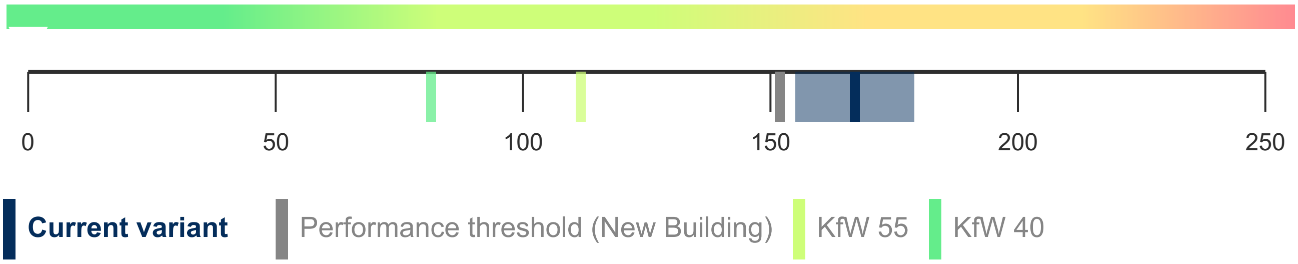


3. Operational energy demand

3.1. Overview

166

kWh/(m^2_{AN}*a)



Annual energy requirement operation

Primary energy demand		166 kWh/(m^2_{AN}*a)
End energy demand	Electric heat pump air-water	122 kWh/(m^2_{AN}*a)
	Hot water	9 kWh/(m^2_{AN}*a)
	Auxilary electricity	2 kWh/(m^2_{AN}*a)
	User Electricity	40 kWh/(m^2_{AN}*a)
Useful energy requirement	Space heating	122 kWh/(m^2_{AN}*a)
	Hot water	9 kWh/(m^2_{AN}*a)

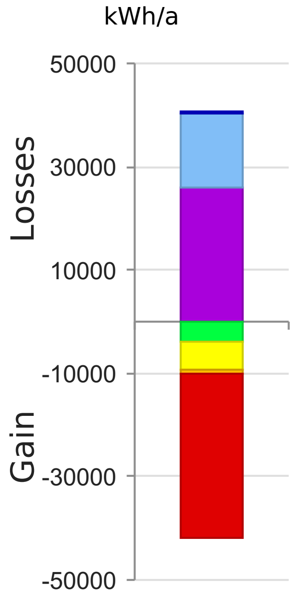
Energetic parameters

Energy reference area	261.61 m^2
Specific area-based transmission heat loss H'_T	**0.46 W/(m^2*K)**
Max. specific area-based transmission heat loss H'_T	0.35 W/(m^2*K)

3.2. Result per year

Legend

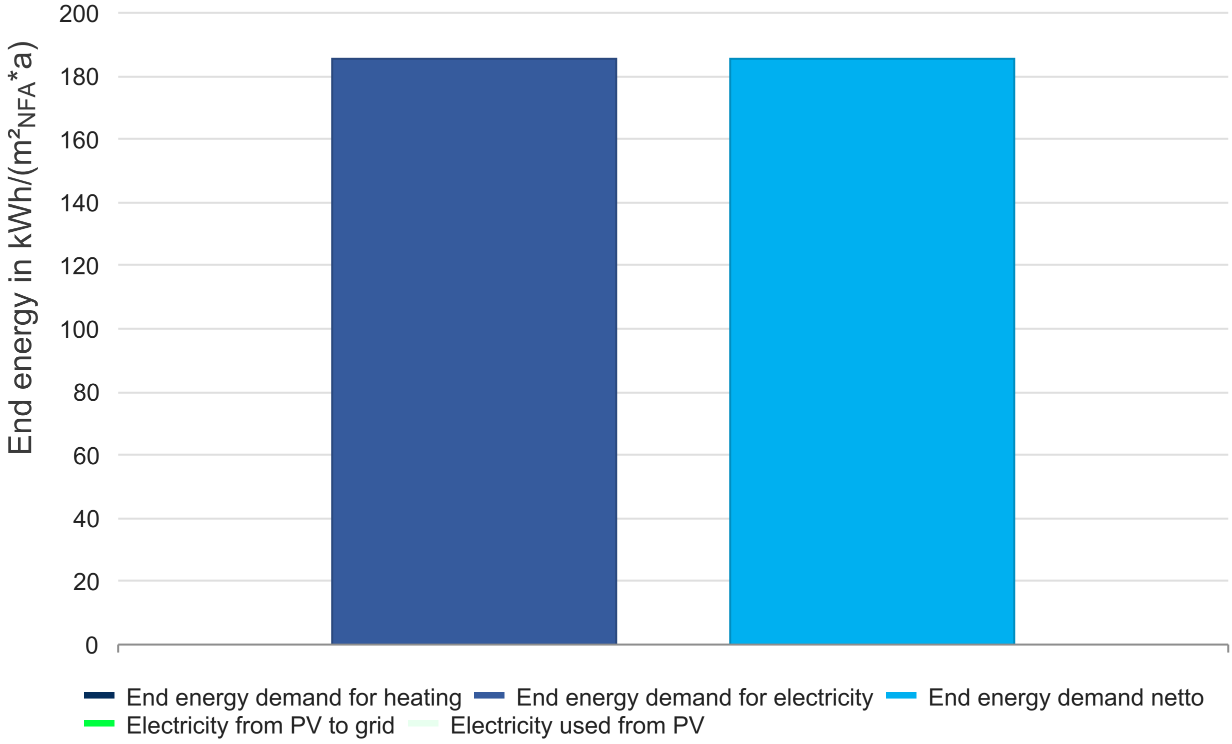
Losse	Solar losses opaque	439 kWh/a
	Ventilation heat losses	14,338 kWh/a
	Transmission heat losses	26,051 kWh/a
Gain	Internal gains	3,972 kWh/a
	Solar gains transparent	5,252 kWh/a
	Solar gains opaque	1,006 kWh/a
	Heating demand	**31,820 kWh/a**



Annual balance of energy generation on site (photovoltaics)

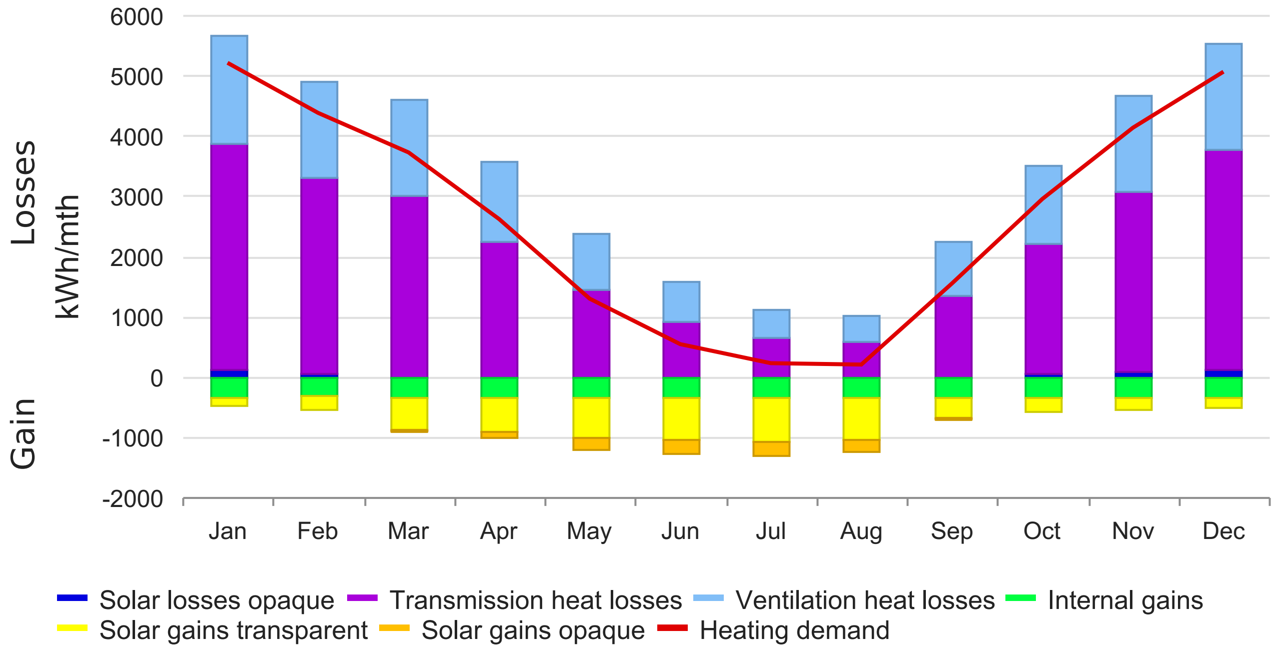
Electricity harvested	0 kWh/a
Electricity demand	44,900 kWh/a

Annual balance of end energy demand with potential for on-site energy generation (photovoltaics)

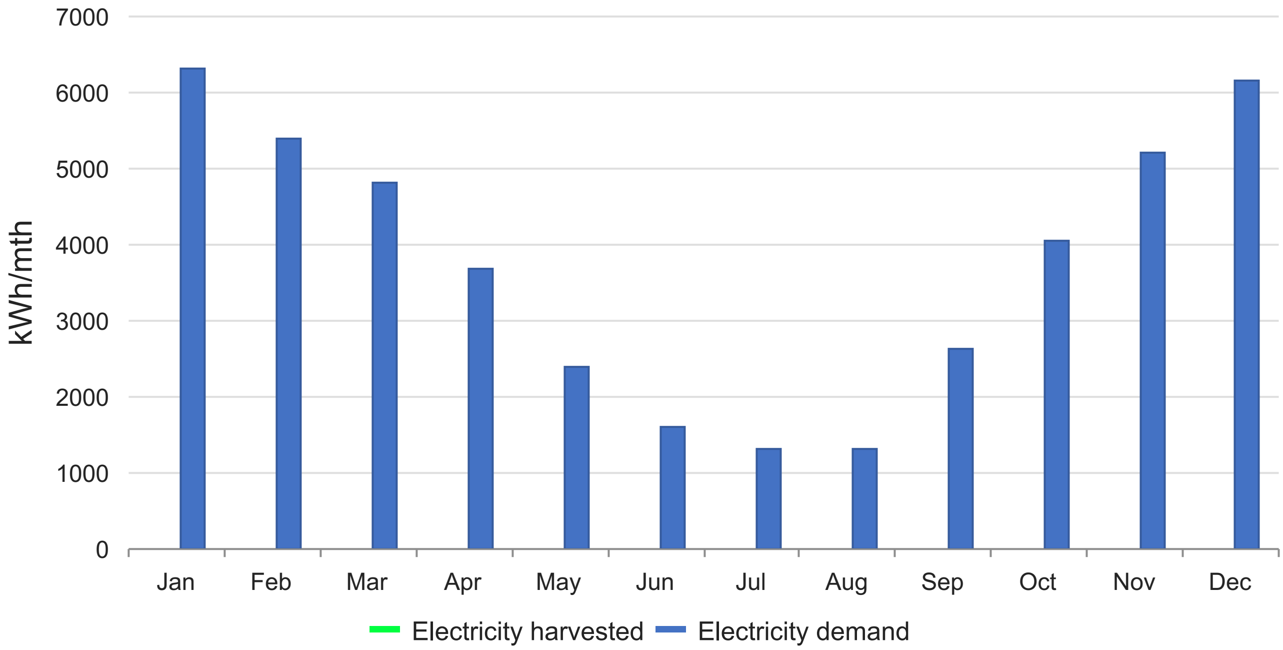


3.3. Result monthly per year sheet

Monthly energy balance



Monthly energy harvesting on site (photovoltaics)



Monthly values

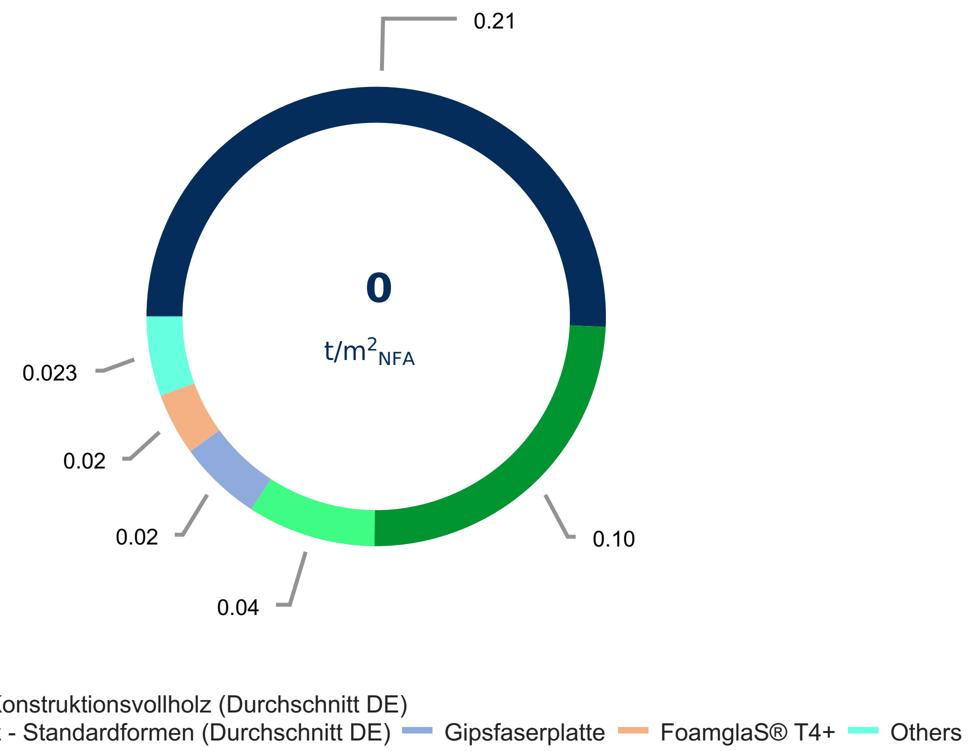
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Natural ventilation $H_{V, win, mth}$ (W / K)	66.1	68.9	80.1	93.5	111.4	121.3	127.6	128.7	112.5	97.0	78.4	67.8
Ref: Natural ventilation $H_{V, win, mth}$ (W / K)	72.8	75.9	88.2	102.9	122.7	133.5	140.5	141.6	123.8	106.8	86.3	74.7
Internal temperature balance(°C)	18.1	18.1	18.3	18.6	19.2	19.4	19.6	19.7	19.2	18.8	18.2	18.1
Ref: Internal temperature balance(°C)	18.2	18.2	18.4	18.7	19.2	19.5	19.6	19.7	19.2	18.8	18.3	18.2
Transmission heat sinks QT_{sink} (kWh)	3,750.2	3,252.0	3,003.0	2,264.1	1,449.1	929.3	646.0	593.6	1,351.7	2,165.0	2,995.2	3,656.6
Ref: Transmission heat sinks QT_{sink} (kWh)	2,867.8	2,486.8	2,301.3	1,735.1	1,110.5	712.1	495.1	454.9	1,035.9	1,659.1	2,291.8	2,796.2
Ventilation heat sinks QV_{sink} (kWh)	1,799.7	1,595.7	1,602.9	1,324.4	947.2	642.5	462.3	427.2	889.0	1,295.6	1,578.6	1,779.4
Ref: Ventilation heat sinks QV_{sink} (kWh)	1,477.4	1,319.9	1,364.9	1,157.5	851.2	584.7	423.8	392.1	800.0	1,139.2	1,337.0	1,467.7
Solar gains transparent $QS_{tr,source}$ (kWh)	123.9	230.0	525.1	567.6	666.7	713.6	747.7	716.8	361.7	236.4	211.1	157.8
Ref: Solar gains transparent $QS_{tr,source}$ (kWh)	123.9	230.0	525.1	567.6	666.7	713.6	747.7	716.8	361.7	236.4	211.1	157.8
Solar gains opaque $QS_{opaq,source}$ (kWh)	0.0	0.0	32.8	101.6	189.3	234.7	234.9	182.0	29.6	0.0	0.0	0.0
Ref: Solar gains opaque $QS_{opaq,source}$ (kWh)	0.0	0.0	33.2	64.3	106.5	127.7	129.2	106.0	22.2	0.0	0.0	0.0
Solar losses opaque $QS_{opaq,sink}$ (kWh)	115.9	60.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.7	90.5	115.9
Ref: Solar losses opaque $QS_{opaq,sink}$ (kWh)	115.9	60.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.7	90.5	115.9
Internal heat sources QI_{source} (kWh)	337.9	305.2	337.9	327.0	337.9	327.0	337.9	337.9	327.0	337.9	327.0	337.9
Ref: Internal heat sources QI_{source} (kWh)	337.9	305.2	337.9	327.0	337.9	327.0	337.9	337.9	327.0	337.9	327.0	337.9
Utilization factor η^M	1.0	1.0	1.0	1.0	0.9	0.8	0.7	0.7	1.0	1.0	1.0	1.0
Ref: Utilization factor η^M	1.0	1.0	1.0	1.0	0.9	0.8	0.7	0.6	1.0	1.0	1.0	1.0
Heat demand $Q_{h,b}$	5,204.3	4,373.6	3,716.8	2,610.9	1,290.3	535.8	219.9	197.1	1,541.5	2,945.7	4,127.2	5,056.7
Ref: Heat demand $Q_{h,b}$	3,936.0	3,294.0	2,776.3	1,950.0	930.0	353.5	126.0	107.7	1,143.7	2,247.9	3,127.7	3,819.0
Electricity demand (kWh)	6,311.7	5,391.7	4,824.2	3,688.5	2,397.7	1,613.4	1,327.3	1,304.5	2,619.1	4,053.1	5,204.8	6,164.1

Monthly energy harvesting on site (photovoltaics)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Electricity harvested plant 1 (kWh/mth)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Electricity harvested plant 2 (kWh/mth)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

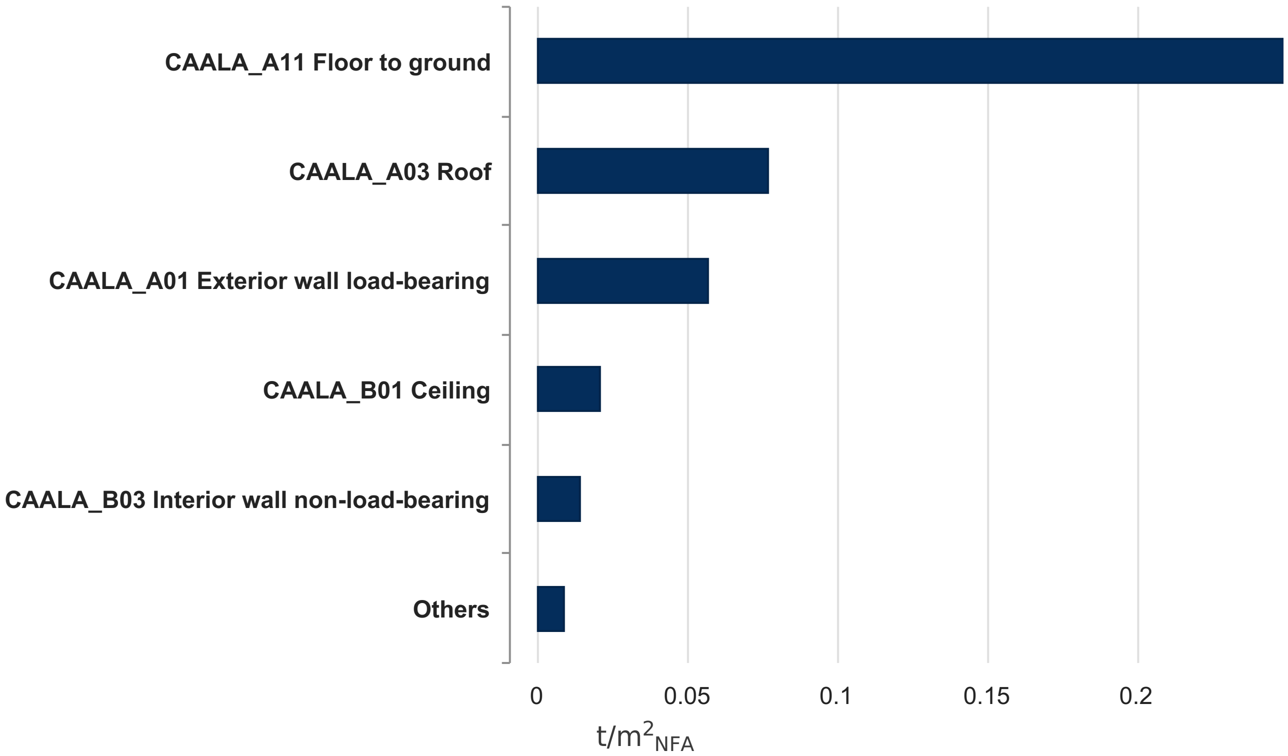
4. Mass Balance

4.1. Masses per material

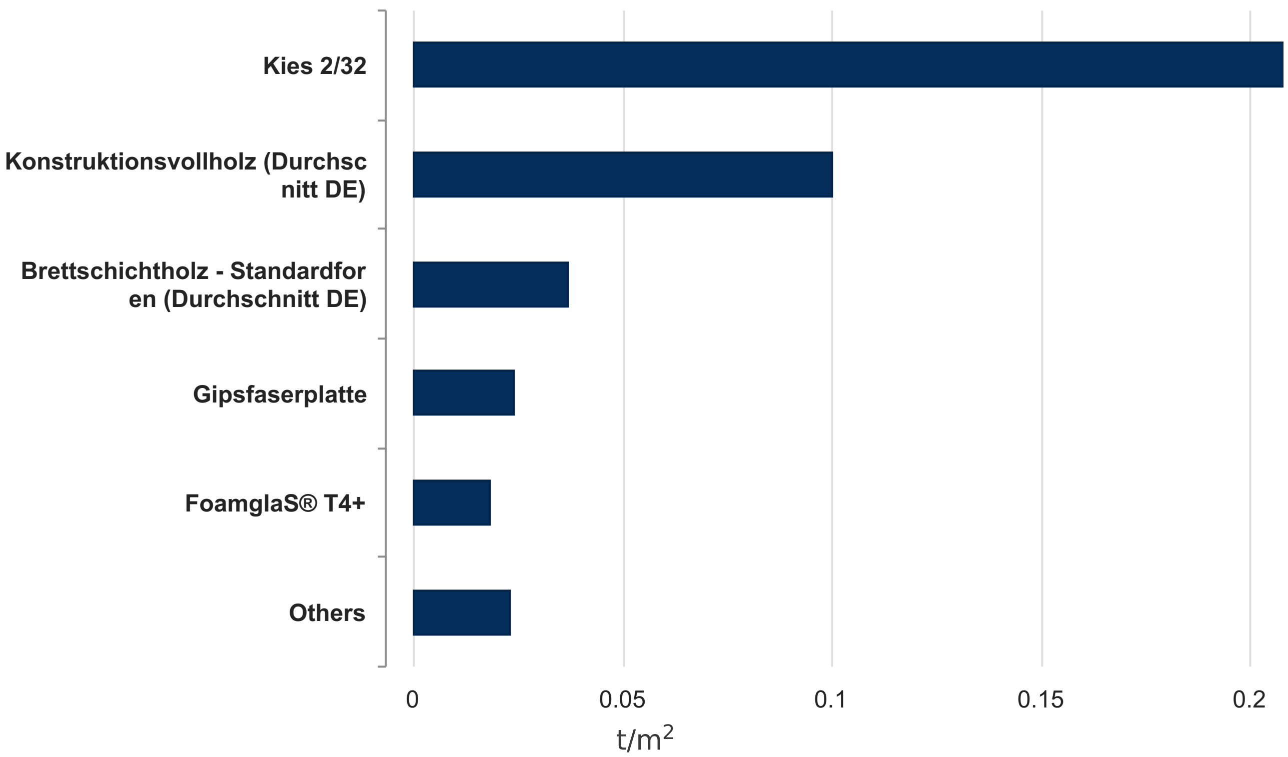


4.2. Masses per layer & Masses per material

Masses per layer



Masses per material



NFA

4.3. Detailed results

Masses per layer

Layer	SELECTED ELEMENT	AREA m²	WEIGHT t/m²NFA
Layer: CAALA_A01 Exterior wall load-bearing		**174.36**	**0.06**
CAALA_A01 Exterior wall load-bearing	Vårgårda bärande yttervägg KL-trä		
CAALA_A01 Exterior wall load-bearing	Panel vårgårda		
CAALA_A01 Exterior wall load-bearing	- empty -		
Layer: CAALA_A03 Roof		**188.43**	**0.08**
CAALA_A03 Roof	Massivholzdecke (18 cm)		
CAALA_A03 Roof	- empty -		
CAALA_A03 Roof	Vårgårda innertaks beklädnad		
Layer: CAALA_A11 Floor to ground		**181.72**	**0.25**
CAALA_A11 Floor to ground	- empty -		
CAALA_A11 Floor to ground	Vårgårda floor to ground FOAMGLASS		
CAALA_A11 Floor to ground	vårgårda parkett		
CAALA_A11 Floor to ground	- empty -		
Layer: CAALA_A12 Window (exterior wall)		**39.64**	**0**
CAALA_A12 Window (exterior wall)	Fenster, Dreifach-Isolierverglasung, Holz-Alu-Rahmen, U=1,05, g=0,35		
Layer: CAALA_A14 Door		**4.2**	**0**
CAALA_A14 Door	Eingangstür, Holz, U=0,9		
Layer: CAALA_B01 Ceiling		**121.07**	**0.02**
CAALA_B01 Ceiling	vårgårda bjälklag		
CAALA_B01 Ceiling	- empty -		
CAALA_B01 Ceiling	- empty -		

Layer: CAALA_B02 Interior wall load-bearing		**73.73**	**0.01**
CAALA_B02 Interior wall load-bearing	Vårgårda bärande innervägg		
CAALA_B02 Interior wall load-bearing	- empty -		
CAALA_B02 Interior wall load-bearing	- empty -		
Layer: CAALA_B03 Interior wall non-load-bearing		**119.05**	**0.01**
CAALA_B03 Interior wall non-load-bearing	Vårgårda icke bärande innervägg		
CAALA_B03 Interior wall non-load-bearing	- empty -		
CAALA_B03 Interior wall non-load-bearing	- empty -		
Layer: CAALA_B07 Roof (unheated room)		**24.96**	**0**
CAALA_B07 Roof (unheated room)	vårgårda oisolerattak		
CAALA_B07 Roof (unheated room)	- empty -		
CAALA_B07 Roof (unheated room)	- empty -		

Masses per material

Material	Weight t/m^2_{NFA}
Kies 2/32	0.21
Konstruktionsvollholz (Durchschnitt DE)	0.10
Brettschichtholz - Standardformen (Durchschnitt DE)	0.04
Gipsfaserplatte	0.02
FoamglaS® T4+	0.02
Massivholzparkett (Durchschnitt DE)	0.02
FoamglaS® W+F und FOAMGLAS® T3+	0.01

5. Life cycle assessment

5.1. Boundary conditions

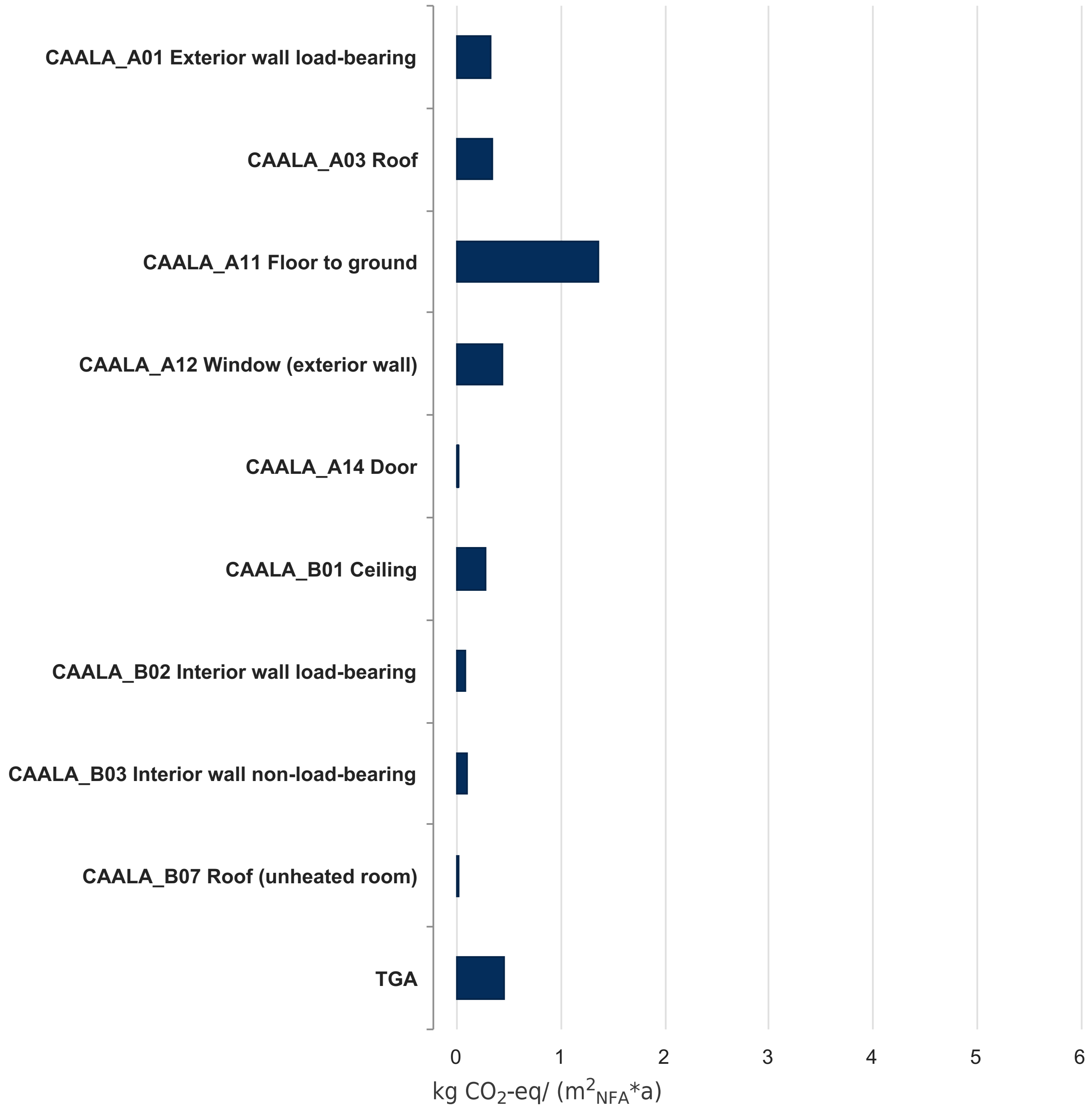
Assessment period	50 Jahre
Net floor area (NFA)	242.23 m²
Database	Ökobau.dat 2016
Assessed life cycle modules	A1-A3, B4, B6, C3+C4

5.2. Overview of the results

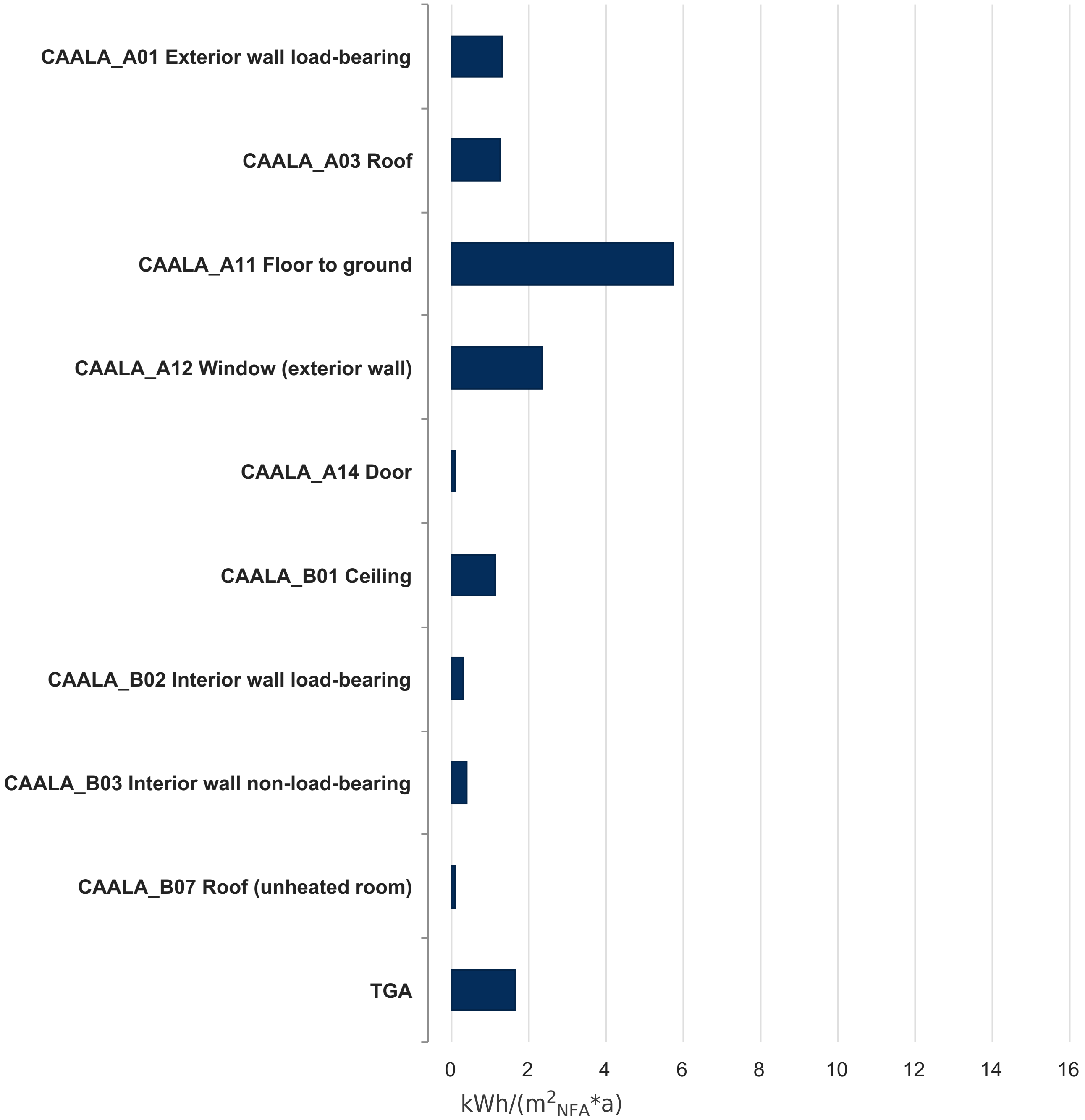
	MODULE	GWP	ODP	POCP	AP	EP	PENRT	PERT
Embodied	A1-A3, B4, B6, C3+C4	3.4	7,385e-7	2,053e-3	1,262e-2	2,183e-3	14.35	12.36
Operational	B6	3.86	1,379e-10	5,100e-4	6,183e-3	6,969e-4	7.61	464.03
Total		7.25	7,386e-7	2,563e-3	1,880e-2	2,880e-3	21.97	476.39

5.3. Results for integrated environmental impacts

Global warming potential (GWP)



Primary energy non renewable (PENRT)

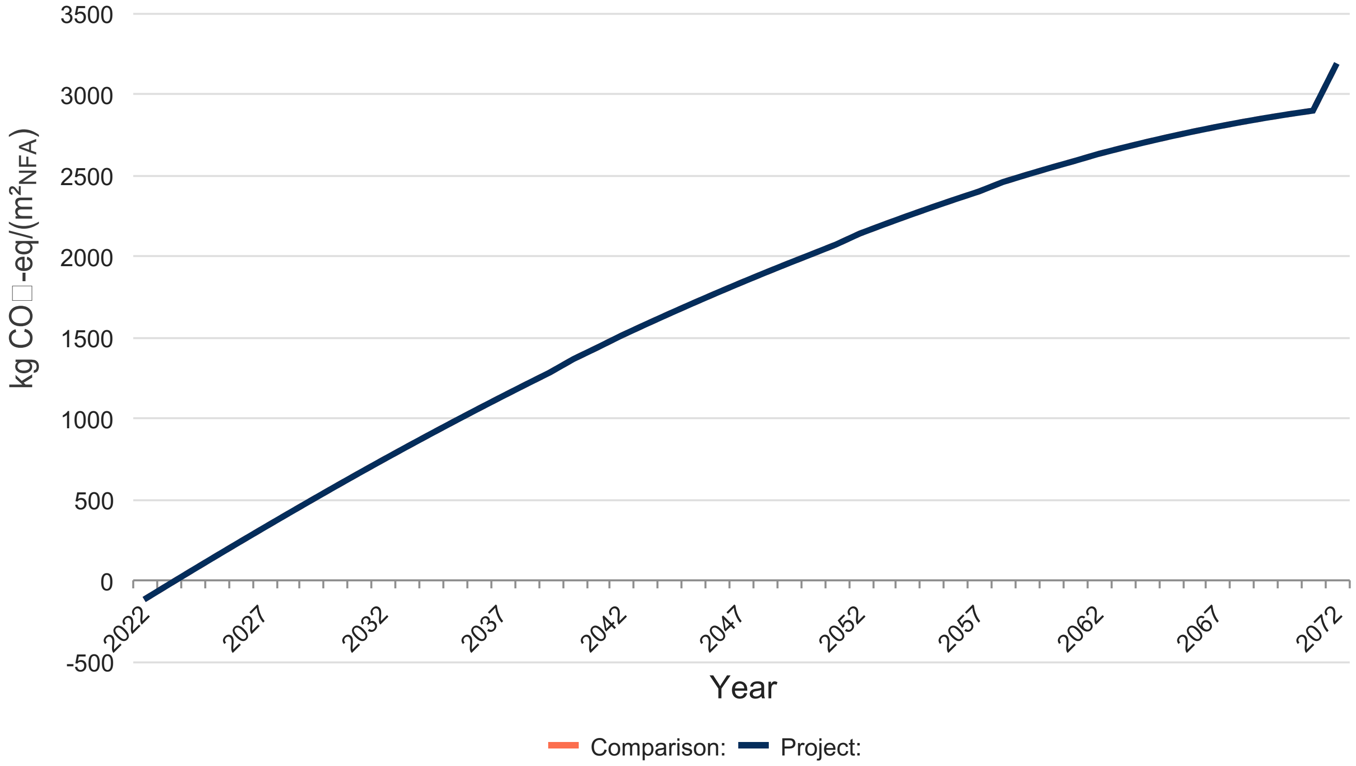


5.4. Results for integrated environmental impacts per layer

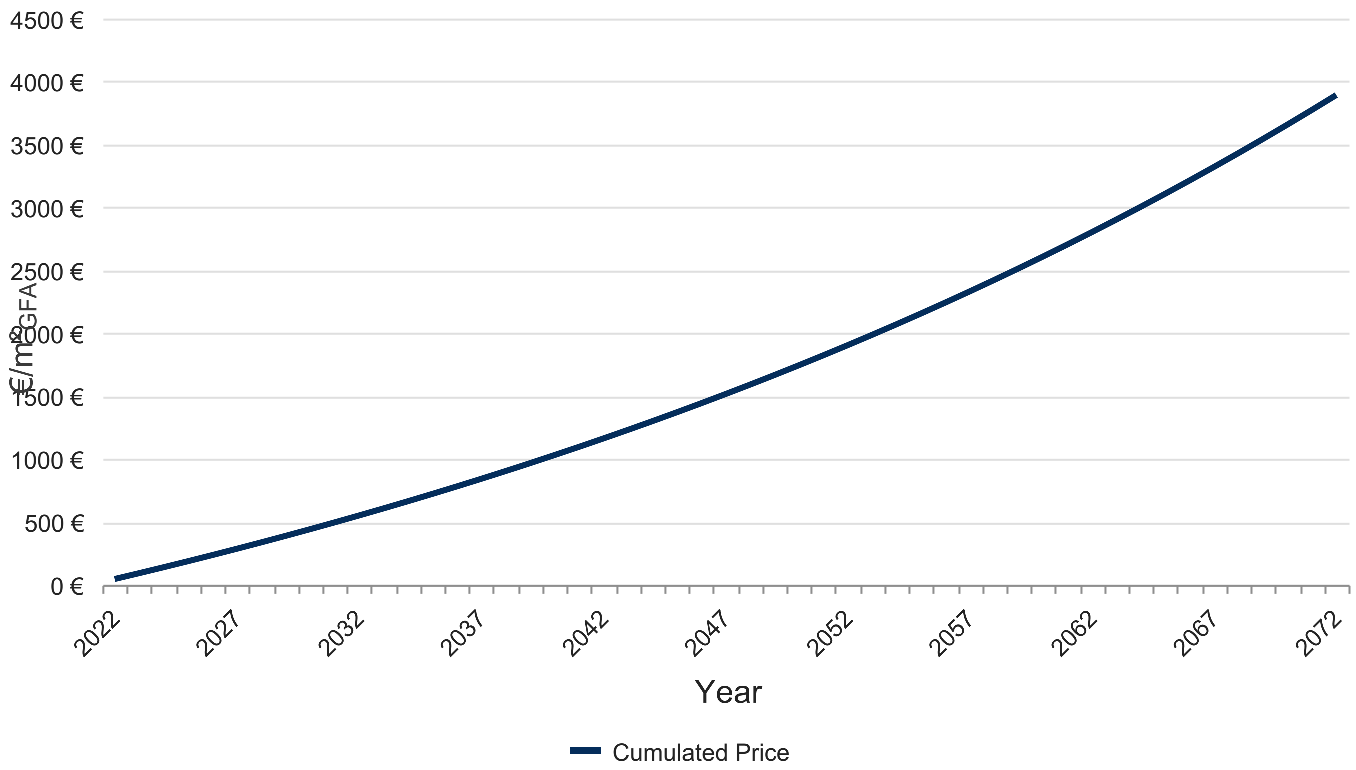
	m^2	GWP	ODP	POCP	AP	EP	PENRT	PERT
CAALA_A01 Exterior wall load-bearing	174.36	3	3,658e-10	2,849e-4	1,471e-3	3,329e-4	1.31	1.82
CAALA_A03 Roof	188.43	3	2,059e-11	3,163e-4	1,453e-3	3,101e-4	1.27	1.6
CAALA_A11 Floor to ground	181.72	1	2,854e-7	4,475e-4	3,887e-3	5,220e-4	5.76	3.74
CAALA_A12 Window (exterior wall)	39.64	4	5,046e-11	5,159e-4	2,247e-3	3,553e-4	2.37	2.86
CAALA_A14 Door	4.2	1	3,297e-9	2,426e-5	6,497e-5	8,503e-6	0.09	0.15
CAALA_B01 Ceiling	121.07	2	1,611e-10	2,393e-4	1,282e-3	2,307e-4	1.12	1.73
CAALA_B02 Interior wall load-bearing	73.73	8	2,256e-12	2,704e-5	2,504e-4	4,112e-5	0.32	0.07
CAALA_B03 Interior wall non-load-bearing	119.05	9	2,761e-12	3,033e-5	2,343e-4	4,237e-5	0.39	0.1
CAALA_B07 Roof (unheated room)	24.96	1	1,330e-12	2,098e-5	9,396e-5	2,022e-5	0.07	0.11
TGA	0	4	4,492e-7	1,468e-4	1,638e-3	3,196e-4	1.65	0.18

6. Cumulative emissions & costs

6.1. Cumulative emissions



6.2. Cumulative costs



Cumulative emissions & costs

Year	Ref. Factor kg CO_2-eq/kWh	Ref. Emission kg CO_2-eq/(m^2_{NFA})	Cur. Factor kg CO_2-eq/kWh	Cur. Emission kg CO_2-eq/(m^2_{NFA})	Cost €/m^2_{GFA}
2022	0.05	-118.92	0.05	-118.92	45.35€
2023	0.49	-29.13	0.49	-29.13	91.58€
2024	0.49	59.85	0.49	59.85	138.71€
2025	0.48	148.03	0.48	148.03	186.75€
2026	0.48	235.41	0.48	235.41	235.73€
2027	0.48	321.98	0.48	321.98	285.66€
2028	0.47	407.75	0.47	407.75	336.55€
2029	0.47	492.71	0.47	492.71	388.44€
2030	0.46	576.87	0.46	576.87	441.33€
2031	0.46	659.84	0.46	659.84	495.25€
2032	0.45	741.63	0.45	741.63	550.22€
2033	0.44	822.24	0.44	822.24	606.25€
2034	0.44	901.66	0.44	901.66	663.38€
2035	0.43	979.90	0.43	979.90	721.61€
2036	0.42	1,056.95	0.42	1,056.95	780.97€
2037	0.42	1,132.82	0.42	1,132.82	841.48€
2038	0.41	1,207.51	0.41	1,207.51	903.17€
2039	0.40	1,281.01	0.40	1,281.01	966.06€
2040	0.40	1,364.53	0.40	1,364.53	1,030.17€
2041	0.39	1,435.41	0.39	1,435.41	1,095.52€
2042	0.38	1,508.56	0.38	1,508.56	1,162.15€
2043	0.37	1,576.56	0.37	1,576.56	1,230.06€
2044	0.37	1,643.12	0.37	1,643.12	1,299.30€
2045	0.36	1,708.24	0.36	1,708.24	1,369.88€
2046	0.35	1,771.93	0.35	1,771.93	1,441.83€
2047	0.34	1,834.17	0.34	1,834.17	1,515.17€

2048	0.33	1,894.98	0.33	1,894.98	1,589.95€
2049	0.33	1,954.34	0.33	1,954.34	1,666.17€
2050	0.32	2,012.27	0.32	2,012.27	1,743.87€
2051	0.32	2,070.75	0.32	2,070.75	1,823.08€
2052	0.31	2,138.43	0.31	2,138.43	1,903.83€
2053	0.30	2,193.73	0.30	2,193.73	1,986.15€
2054	0.29	2,247.40	0.29	2,247.40	2,070.07€
2055	0.29	2,299.41	0.29	2,299.41	2,155.61€
2056	0.28	2,349.72	0.28	2,349.72	2,242.82€
2057	0.27	2,398.32	0.27	2,398.32	2,331.72€
2058	0.26	2,456.37	0.26	2,456.37	2,422.35€
2059	0.25	2,501.44	0.25	2,501.44	2,514.73€
2060	0.24	2,544.70	0.24	2,544.70	2,608.91€
2061	0.23	2,586.13	0.23	2,586.13	2,704.92€
2062	0.22	2,629.40	0.22	2,629.40	2,802.80€
2063	0.21	2,667.07	0.21	2,667.07	2,902.57€
2064	0.20	2,702.81	0.20	2,702.81	3,004.28€
2065	0.19	2,736.60	0.19	2,736.60	3,107.97€
2066	0.17	2,768.41	0.17	2,768.41	3,213.66€
2067	0.16	2,798.21	0.16	2,798.21	3,321.42€
2068	0.15	2,825.97	0.15	2,825.97	3,431.26€
2069	0.14	2,851.65	0.14	2,851.65	3,543.24€
2070	0.13	2,875.24	0.13	2,875.24	3,657.39€
2071	0.12	2,896.71	0.12	2,896.71	3,773.76€
2072	0.11	3,188.16	0.11	3,188.16	3,892.38€

B4 Replacement

	Replacement Year	Name	GWP kg CO_2-eq/(m^2_{NFA})
◢ **Replacement Year: 2040**			

	2040	Strom Wärmepumpe (Luft-Wasser) 14kW	11.20
			Sum: 11.20
Replacement Year: 2042			
	2042	Pufferspeicher (Edelstahl)	3.71
			Sum: 3.71
Replacement Year: 2052			
	2052	Fenster, Dreifach-Isolierverglasung, Holz	10.78
			Sum: 10.78
Replacement Year: 2058			
	2058	Strom Wärmepumpe (Luft-Wasser) 14kW	11.20
			Sum: 11.20
Replacement Year: 2062			
	2062	Pufferspeicher (Edelstahl)	3.71
			Sum: 3.71
Replacement Year: 2072			
	2072	Konstruktionsvollholz (Durchschnitt DE)	0.00
	2072	Luft	0.00
	2072	Holzfaserdämmplatten	0.00
	2072	ISOCELL-Einblasdämmstoff aus Zellulosefasern frei aufliegend 28 kg/m³	0.00
	2072	Dampfbremse PE	0.00
	2072	Brettschichtholz - Standardformen (Durchschnitt DE)	0.00
	2072	Gipsfaserplatte	0.00
	2072	FOAMGLAS® T4+	0.00

	2072	FOAMGLAS® W+F und FOAMGLAS® T3+	0.00
	2072	PU-Dämmplatten mit Aluminium-Mehrlagen-Deckschicht	0.00
	2072	Kunststoffmodifizierte Bitumendickbeschichtungen	0.00
	2072	Aluminium Profil (2005)	0.00
	2072	Massivholzparkett (Durchschnitt DE)	0.00
	2072	Universal-Spachtelmasse USP 32	0.00
	2072	Haustür, Passivhaus, Holz, U=0.8	0.00
	2072	Mineralwolle (Innenausbau-Dämmung)	0.00
	2072	Oriented Strand Board (Durchschnitt DE)	0.00
	2072	Kraftpapier	0.00
			Sum: 0.00

7. Life cycle cost analysis

7.1. Boundary conditions

Assessment period	50 Jahre
Gross Floor Area (GFA)	302.78999999999996 m²
Rate of Energy Price Increase	5 %/Jahr
Price Discount Rate	3 %/Jahr
Initial Price for Electricity	0,3 €/kWh
Price for [Electricity]	0,3

7.2. Overview of results

Investment costs				
KG 300 Building construction	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)
KG 400 Technical building equipment	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)
Operational costs				
Energy costs	3,773.76	€/m^2_{GFA}	75.48	€/(m^2_{GFA}*a)
CO_2 Cost	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)
Inspection & maintenance costs for KG 300	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)
Inspection & maintenance costs for KG 400	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)
Repair Cost				
Repair Cost for KG 300	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)
Repair Cost for KG 400	0.00	€/m^2_{GFA}	0.00	€/(m^2_{GFA}*a)

7.3. Results by cost group 2nd level

	Construction	Maintenance & Replace	Repair
KG 300 - Building construction	0.00 €	0.00 €	0.00 €
KG 320 Foundation	0.00 €	0.00 €	0.00 €
KG 330 Exterior walls	0.00 €	0.00 €	0.00 €
KG 340 Interior walls	0.00 €	0.00 €	0.00 €
KG 350 Ceilings	0.00 €	0.00 €	0.00 €
KG 360 Roofs	0.00 €	0.00 €	0.00 €
KG 400 - Technical building equipment	0.00 €	0.00 €	0.00 €

7.4. Results by cost group 3rd level

	Construction	Maintenance & Replacement		Repair	
	Costs	Expenses per year	Costs	Expenses per year	Costs
300 - Building construction	0.00 €		0.00 €		0.00 €
322 Flat foundation	0.00 €	0.1%	0.00 €	0.35%	0.00 €
324 Base plate	0.00 €	0.1%	0.00 €	0.35%	0.00 €
325 Base flooring	0.00 €	0.1%	0.00 €	0.35%	0.00 €
326 Sealing	0.00 €	0.1%	0.00 €	0.35%	0.00 €
331 Load-bearing exterior wall	0.00 €	0.1%	0.00 €	0.35%	0.00 €
334 Exterior doors and windows	0.00 €	0.1%	0.00 €	0.35%	0.00 €
335 Exterior wall cladding outside	0.00 €	0.1%	0.00 €	0.35%	0.00 €
336 Exterior wall finishing inside	0.00 €	0.1%	0.00 €	0.35%	0.00 €
341 Load-bearing interior wall	0.00 €	0.1%	0.00 €	0.35%	0.00 €
342 Non-load-bearing interior wall	0.00 €	0.1%	0.00 €	0.35%	0.00 €
345 Interior wall finishing (outside)	0.00 €	0.1%	0.00 €	0.35%	0.00 €
345 Interior wall finishing (inside)	0.00 €	0.1%	0.00 €	0.35%	0.00 €
351 Ceiling strucutre	0.00 €	0.1%	0.00 €	0.35%	0.00 €
352 Ceiling flooring	0.00 €	0.1%	0.00 €	0.35%	0.00 €
353 Ceiling finishing	0.00 €	0.1%	0.00 €	0.35%	0.00 €
361 Roof structure	0.00 €	0.1%	0.00 €	0.35%	0.00 €
363 Roof covering	0.00 €	0.1%	0.00 €	0.35%	0.00 €
364 Roof finishing inside	0.00 €	0.1%	0.00 €	0.35%	0.00 €

8. Building envelope and building technology

8.1. Surfaces

Overview

ID	Layer	Orientation	Net area	Gross area	Length	Angle (Azimut
CAALA_A01 Exterior wall load-bearing (Count: 25 , Net area: 174.36 m² , Gross area: 217.24 m² , Length: 0.00 m)						
CAALA_A03 Roof (Count: 6 , Net area: 188.43 m² , Gross area: 188.43 m² , Length: 0.00 m)						
CAALA_A11 Floor to ground (Count: 12 , Net area: 181.72 m² , Gross area: 181.72 m² , Length: 0.00 m)						
CAALA_A12 Window (exterior wall) (Count: 18 , Net area: 39.64 m² , Gross area: 39.64 m² , Length: 0.00 m)						
CAALA_A14 Door (Count: 2 , Net area: 4.20 m² , Gross area: 4.20 m² , Length: 0.00 m)						
CAALA_B01 Ceiling (Count: 14 , Net area: 121.07 m² , Gross area: 121.07 m² , Length: 0.00 m)						
CAALA_B02 Interior wall load-bearing (Count: 17 , Net area: 73.73 m² , Gross area: 73.73 m² , Length: 0.00 m)						
CAALA_B03 Interior wall non-load-bearing (Count: 29 , Net area: 119.05 m² , Gross area: 119.05 m² , Length: 0.00 m)						
CAALA_B07 Roof (unheated room) (Count: 8 , Net area: 24.96 m² , Gross area: 24.96 m² , Length: 0.00 m)						

Detailed areas

ID	Layer	Orientation	Net area	Gross area	Length	Angle (Azimu
CAALA_A01 Exterior wall load-bearing (Count: 25 , Net area: 174.36 m² , Gross area: 217.24 m² , Length: 0.00 m)						
28281	CAALA_A01 Exterior wall load-bearing	SE90	7.74	19.25	0	135
84633	CAALA_A01 Exterior wall load-bearing	NW90	3.91	3.91	0	315
73231	CAALA_A01 Exterior wall load-bearing	NW90	3.88	3.88	0	315
28510	CAALA_A01 Exterior wall load-bearing	SW90	8.14	8.14	0	225
28172	CAALA_A01 Exterior wall load-bearing	N90	8.92	8.92	0	0
69012	CAALA_A01 Exterior wall load-bearing	E90	8.59	10.09	0	90
27887	CAALA_A01 Exterior wall load-bearing	N90	5.47	7.57	0	0
28682	CAALA_A01 Exterior wall load-bearing	SW90	3.56	3.56	0	225
28508	CAALA_A01 Exterior wall load-bearing	NW90	10.18	10.18	0	315

	28108	CAALA_A01 Exterior wall load-bearing	SE90	4.08	4.08	0	135
	70209	CAALA_A01 Exterior wall load-bearing	N90	10.35	11.89	0	0
	77663	CAALA_A01 Exterior wall load-bearing	NW90	5.24	6.78	0	315
	99992	CAALA_A01 Exterior wall load-bearing	NW90	7.55	7.55	0	315
	52072	CAALA_A01 Exterior wall load-bearing	E90	9.07	13.47	0	90
	28144	CAALA_A01 Exterior wall load-bearing	E90	15.4	15.4	0	90
	50690	CAALA_A01 Exterior wall load-bearing	S90	2.26	2.26	0	180
	28479	CAALA_A01 Exterior wall load-bearing	S90	14.81	19.25	0	180
	51351	CAALA_A01 Exterior wall load-bearing	SW90	4.07	14.44	0	225
	28347	CAALA_A01 Exterior wall load-bearing	SW90	10.05	12.45	0	225
	27893	CAALA_A01 Exterior wall load-bearing	SE90	4.08	4.08	0	135
	52959	CAALA_A01 Exterior wall load-bearing	NW90	1.69	1.69	0	315
	50694	CAALA_A01 Exterior wall load-bearing	SE90	5.92	5.92	0	135
	84319	CAALA_A01 Exterior wall load-bearing	NW90	7.76	9.3	0	315
	123517	CAALA_A01 Exterior wall load-bearing	S90	3.66	3.66	0	180
	69481	CAALA_A01 Exterior wall load-bearing	N90	7.98	9.52	0	0
◢	**CAALA_A03 Roof (Count: 6 , Net area: 188.43 m² , Gross area: 188.43 m² , Length: 0.00 m)**						
	99967	CAALA_A03 Roof	NW30	32.99	32.99	0	315
	28232	CAALA_A03 Roof	S30	17.16	17.16	0	180
	28691	CAALA_A03 Roof	N30	48.58	48.58	0	0
	99968	CAALA_A03 Roof	NW30	28.63	28.63	0	315
	28681	CAALA_A03 Roof	NW30	38.77	38.77	0	315
	123601	CAALA_A03 Roof	S30	22.3	22.3	0	180
◢	**CAALA_A11 Floor to ground (Count: 12 , Net area: 181.72 m² , Gross area: 181.72 m² , Length: 0.00 m)**						
	66969	CAALA_A11 Floor to ground	HOR	2.76	2.76	0	5.93
	84007	CAALA_A11 Floor to ground	HOR	20.62	20.62	0	208.75

	78242	CAALA_A11 Floor to ground	HOR	12.64	12.64	0	209.91
	66523	CAALA_A11 Floor to ground	HOR	12.91	12.91	0	90
	80334	CAALA_A11 Floor to ground	HOR	2.04	2.04	0	93.11
	81842	CAALA_A11 Floor to ground	HOR	4.42	4.42	0	2.99
	66086	CAALA_A11 Floor to ground	HOR	11.3	11.3	0	90
	28165	CAALA_A11 Floor to ground	HOR	6.56	6.56	0	90
	83079	CAALA_A11 Floor to ground	HOR	86.24	86.24	0	116.14
	82458	CAALA_A11 Floor to ground	HOR	9.45	9.45	0	335
	27948	CAALA_A11 Floor to ground	HOR	12.52	12.52	0	90
	65657	CAALA_A11 Floor to ground	HOR	0.26	0.26	0	90
◢	**CAALA_A12 Window (exterior wall) (Count: 18 , Net area: 39.64 m² , Gross area: 39.64 m² , Length: 0.00 m)**						
	27898	CAALA_A12 Window (exterior wall)	S90	1.68	1.68	0	180
	28455	CAALA_A12 Window (exterior wall)	E90	1.5	1.5	0	90
	52783	CAALA_A12 Window (exterior wall)	NW90	0.96	0.96	0	315
	28415	CAALA_A12 Window (exterior wall)	E90	0.7	0.7	0	90
	28291	CAALA_A12 Window (exterior wall)	SE90	4.6	4.6	0	135
	28595	CAALA_A12 Window (exterior wall)	NW90	1.54	1.54	0	315
	28550	CAALA_A12 Window (exterior wall)	N90	1.54	1.54	0	0
	28329	CAALA_A12 Window (exterior wall)	SW90	4.6	4.6	0	225
	28357	CAALA_A12 Window (exterior wall)	SW90	1.2	1.2	0	225
	51337	CAALA_A12 Window (exterior wall)	SW90	3.46	3.46	0	225
	28264	CAALA_A12 Window (exterior wall)	SE90	2.31	2.31	0	135
	28432	CAALA_A12 Window (exterior wall)	E90	1.6	1.6	0	90
	27897	CAALA_A12 Window (exterior wall)	SE90	4.6	4.6	0	135
	27891	CAALA_A12 Window (exterior wall)	SW90	1.2	1.2	0	225
	28391	CAALA_A12 Window (exterior wall)	S90	2.76	2.76	0	180
	28568	CAALA_A12 Window (exterior wall)	N90	1.54	1.54	0	0
	28303	CAALA_A12 Window (exterior wall)	SW90	2.31	2.31	0	225
	28632	CAALA_A12 Window (exterior wall)	NW90	1.54	1.54	0	315
◢	**CAALA_A14 Door (Count: 2 , Net area: 4.20 m² , Gross area: 4.20 m² , Length: 0.00 m)**						
	28467	CAALA_A14 Door	N90	2.1	2.1	0	0
	28443	CAALA_A14 Door	E90	2.1	2.1	0	90
◢	**CAALA_B01 Ceiling (Count: 14 , Net area: 121.07 m² , Gross area: 121.07 m² , Length: 0.00 m)**						
	69722	CAALA_B01 Ceiling	HOR	12.91	12.91	0	90
	86852	CAALA_B01 Ceiling	HOR	4.42	4.42	0	90
	69241	CAALA_B01 Ceiling	HOR	11.3	11.3	0	90
	88175	CAALA_B01 Ceiling	HOR	20.62	20.62	0	90

	27991	CAALA_B01 Ceiling	HOR	23.7	23.7	0	90
	94983	CAALA_B01 Ceiling	HOR	2.04	2.04	0	90
	74314	CAALA_B01 Ceiling	HOR	12.52	12.52	0	90
	72192	CAALA_B01 Ceiling	HOR	0.26	0.26	0	90
	89193	CAALA_B01 Ceiling	HOR	2.76	2.76	0	90
	73497	CAALA_B01 Ceiling	HOR	3.92	3.92	0	90
	72964	CAALA_B01 Ceiling	HOR	2	2	0	90
	94985	CAALA_B01 Ceiling	HOR	2.53	2.53	0	90
	94986	CAALA_B01 Ceiling	HOR	9.45	9.45	0	90
	100000	CAALA_B01 Ceiling	HOR	12.64	12.64	0	90
◢	**CAALA_B02 Interior wall load-bearing (Count: 17 , Net area: 73.73 m² , Gross area: 73.73 m² , Length: 0.00 m)**						
	123431	CAALA_B02 Interior wall load-bearing	S90	3.79	3.79	0	180
	71200	CAALA_B02 Interior wall load-bearing	N90	0.25	0.25	0	0
	88853	CAALA_B02 Interior wall load-bearing	SE90	6.78	6.78	0	135
	56360	CAALA_B02 Interior wall load-bearing	N90	1.71	1.71	0	0
	28219	CAALA_B02 Interior wall load-bearing	SE90	7.09	7.09	0	135
	99678	CAALA_B02 Interior wall load-bearing	W90	1.69	1.69	0	270
	55082	CAALA_B02 Interior wall load-bearing	SE90	10.2	10.2	0	135
	57214	CAALA_B02 Interior wall load-bearing	N90	0.27	0.27	0	0
	28101	CAALA_B02 Interior wall load-bearing	N90	5.34	5.34	0	0
	57642	CAALA_B02 Interior wall load-bearing	N90	1.26	1.26	0	0
	58494	CAALA_B02 Interior wall load-bearing	SE90	10.74	10.74	0	135
	50686	CAALA_B02 Interior wall load-bearing	W90	4.89	4.89	0	270
	77376	CAALA_B02 Interior wall load-bearing	SE90	1.51	1.51	0	135
	87183	CAALA_B02 Interior wall load-bearing	SE90	3.06	3.06	0	135
	123283	CAALA_B02 Interior wall load-bearing	SE90	8.66	8.66	0	135
	123602	CAALA_B02 Interior wall load-bearing	W90	3.85	3.85	0	270

	28104	CAALA_B02 Interior wall load-bearing	S30	2.64	2.64	0	180
CAALA_B03 Interior wall non-load-bearing (Count: 29 , Net area: 119.05 m² , Gross area: 119.05 m² , Length: 0.00 m)							
	89194	CAALA_B03 Interior wall non-load-bearing	SW90	4.09	4.09	0	225
	86532	CAALA_B03 Interior wall non-load-bearing	SE90	1.5	1.5	0	135
	77950	CAALA_B03 Interior wall non-load-bearing	SW90	3.53	3.53	0	225
	72965	CAALA_B03 Interior wall non-load-bearing	S90	0.26	0.26	0	180
	79136	CAALA_B03 Interior wall non-load-bearing	NE90	3.5	3.5	0	44.62
	88510	CAALA_B03 Interior wall non-load-bearing	SE90	1.07	1.07	0	135
	69963	CAALA_B03 Interior wall non-load-bearing	N90	7.32	7.32	0	0
	73498	CAALA_B03 Interior wall non-load-bearing	NE90	0.48	0.48	0	44.62
	71943	CAALA_B03 Interior wall non-load-bearing	S90	5.2	5.2	0	180
	86853	CAALA_B03 Interior wall non-load-bearing	NE90	8.44	8.44	0	45
	85895	CAALA_B03 Interior wall non-load-bearing	S90	3.35	3.35	0	180
	81536	CAALA_B03 Interior wall non-load-bearing	NW90	3.93	3.93	0	315
	75430	CAALA_B03 Interior wall non-load-bearing	SE90	1.9	1.9	0	134.62
	75150	CAALA_B03 Interior wall non-load-bearing	NE90	3.87	3.87	0	44.62
	87840	CAALA_B03 Interior wall non-load-bearing	SE90	3.83	3.83	0	135
	69964	CAALA_B03 Interior wall non-load-bearing	E90	10.09	10.09	0	90
	80934	CAALA_B03 Interior wall non-load-bearing	NW90	3.91	3.91	0	315
	88511	CAALA_B03 Interior wall non-load-bearing	SW90	4.09	4.09	0	225
	94984	CAALA_B03 Interior wall non-load-bearing	SW90	4.32	4.32	0	225
	85262	CAALA_B03 Interior wall non-load-bearing	SW90	6.05	6.05	0	224.62

	68333	CAALA_B03 Interior wall non-load-bearing	N90	2.34	2.34	0	0
	72193	CAALA_B03 Interior wall non-load-bearing	W90	1.69	1.69	0	270
	78836	CAALA_B03 Interior wall non-load-bearing	NE90	4.81	4.81	0	44.62
	94981	CAALA_B03 Interior wall non-load-bearing	SW90	4.78	4.78	0	225
	99677	CAALA_B03 Interior wall non-load-bearing	S90	2.81	2.81	0	180
	90935	CAALA_B03 Interior wall non-load-bearing	SW90	2.35	2.35	0	225
	89890	CAALA_B03 Interior wall non-load-bearing	SE90	2.65	2.65	0	135
	100001	CAALA_B03 Interior wall non-load-bearing	SW90	8.49	8.49	0	225
	70700	CAALA_B03 Interior wall non-load-bearing	W90	8.4	8.4	0	270
◢	**CAALA_B07 Roof (unheated room) (Count: 8 , Net area: 24.96 m² , Gross area: 24.96 m² , Length: 0.00 m)**						
	99975	CAALA_B07 Roof (unheated room)	NW30	0.81	0.81	0	315
	99971	CAALA_B07 Roof (unheated room)	NW30	0.81	0.81	0	315
	28236	CAALA_B07 Roof (unheated room)	NW30	3.99	3.99	0	315
	99969	CAALA_B07 Roof (unheated room)	NW30	1.83	1.83	0	315
	28521	CAALA_B07 Roof (unheated room)	S30	3.72	3.72	0	180
	99962	CAALA_B07 Roof (unheated room)	NW30	1.92	1.92	0	315
	28531	CAALA_B07 Roof (unheated room)	N30	4.74	4.74	0	0
	28537	CAALA_B07 Roof (unheated room)	NW30	7.14	7.14	0	315

8.2. Building Construction

Layer Name	CAALA_A01 Exterior wall load-bearing
Area	174.36 m²
Thickness	33.70 cm
U-value	0.16 W/(m²*K)
Reference U-Value	0.28 W/(m²*K)
Cost group	331 Load-bearing exterior wall
Name	Vårgårda bärande yttervägg KL-trä
Id	7b9fa05a-adfa-478d-8718-875952565215
Thickness	31.50 cm
Cost group	335 Exterior wall cladding outside
Name	Panel vårgårda
Id	71ebd6fd-62b1-4f66-be6f-fdd683e693f0
Thickness	2.20 cm
Cost group	336 Exterior wall finishing inside
Name	- empty -
Id	
Thickness	0.00 cm
Layer Name	CAALA_A03 Roof
Area	188.43 m²
Thickness	19.30 cm
U-value	0.63 W/(m²*K)
Reference U-Value	0.20 W/(m²*K)
Cost group	361 Roof structure
Name	Massivholzdecke (18 cm)
Id	c42f78b6-8abf-4cb4-b109-f8ed26f7be74
Thickness	18.00 cm
Cost group	363 Roof covering

Name	- empty -
Id	
Thickness	0.00 cm
Cost group	364 Roof finishing inside
Name	Vårgårda innertaks beklädnad
Id	ba4678f6-338a-4f77-8645-931d166d0891
Thickness	1.30 cm
Layer Name	CAALA_A11 Floor to ground
Area	181.72 m²
Thickness	47.90 cm
U-value	0.25 W/(m²*K)
Reference U-Value	0.35 W/(m²*K)
Cost group	322 Flat foundation
Name	- empty -
Id	
Thickness	0.00 cm
Cost group	324 Base plate
Name	Vårgårda floor to ground FOAMGLASS
Id	ef71d329-11e7-4eae-81e1-9b2ece38a502
Thickness	46.20 cm
Cost group	325 Base flooring
Name	vårgårda parkett
Id	be5580ef-b14a-4495-86f0-bfc754eb4716
Thickness	1.70 cm
Cost group	326 Sealing
Name	- empty -
Id	
Thickness	0.00 cm
Layer Name	CAALA_A12 Window (exterior wall)

Area	39.64 m²
Thickness	0.00 cm
U-value	1.05 W/(m²*K)
Reference U-Value	1.30 W/(m²*K)
Cost group	334 Exterior doors and windows
Name	Fenster, Dreifach-Isolierverglasung, Holz-Alu-Rahmen, U=1,05, g=0,35
Id	79390d1b-10e3-484d-af56-963b2a42045a
Thickness	0.00 cm
Layer Name	CAALA_A14 Door
Area	4.20 m²
Thickness	0.00 cm
U-value	0.90 W/(m²*K)
Reference U-Value	1.80 W/(m²*K)
Cost group	334 Exterior doors and windows
Name	Eingangstür, Holz, U=0,9
Id	be65e629-5f13-49b6-8d17-3d7992f2d838
Thickness	0.00 cm
Layer Name	CAALA_B01 Ceiling
Area	121.07 m²
Thickness	29.00 cm
U-value	-
Reference U-Value	0.00 W/(m²*K)
Cost group	351 Ceiling strucutre
Name	vårgårda bjälklag
Id	104afeae-8f41-4777-a548-a1c8fd7c4c63
Thickness	29.00 cm
Cost group	352 Ceiling flooring
Name	- empty -

Id	
Thickness	0.00 cm
Cost group	353 Ceiling finishing
Name	- empty -
Id	
Thickness	0.00 cm
Layer Name	CAALA_B02 Interior wall load-bearing
Area	73.73 m²
Thickness	16.60 cm
U-value	-
Reference U-Value	0.00 W/(m²*K)
Cost group	341 Load-bearing interior wall
Name	Vårgårda bärande innervägg
Id	ec2971b7-6f8c-46a5-943b-fdc8a408afa1
Thickness	16.60 cm
Cost group	345 Interior wall finishing (outside)
Name	- empty -
Id	
Thickness	0.00 cm
Cost group	345 Interior wall finishing (inside)
Name	- empty -
Id	
Thickness	0.00 cm
Layer Name	CAALA_B03 Interior wall non-load-bearing
Area	119.05 m²
Thickness	9.10 cm
U-value	-
Reference U-Value	0.00 W/(m²*K)
Cost group	342 Non-load-bearing interior wall

Name	Vårgårda icke bärande innervägg
Id	d2f58772-7534-4404-9103-7536a0771203
Thickness	9.10 cm
Cost group	345 Interior wall finishing (outside)
Name	- empty -
Id	
Thickness	0.00 cm
Cost group	345 Interior wall finishing (inside)
Name	- empty -
Id	
Thickness	0.00 cm
Layer Name	CAALA_B07 Roof (unheated room)
Area	24.96 m²
Thickness	29.20 cm
U-value	-
Reference U-Value	0.00 W/(m²*K)
Cost group	361 Roof structure
Name	vårgårda oisolerattak
Id	05bfd895-c102-4a7c-b34a-646c61a3a3c0
Thickness	29.20 cm
Cost group	363 Roof covering
Name	- empty -
Id	
Thickness	0.00 cm
Cost group	364 Roof finishing inside
Name	- empty -
Id	
Thickness	0.00 cm

8.3. Building Technology

420 Heat generation equipment	Electric heat pump air-water
Producer effort figure e_e	1.00
Aux. energy requirement [kWh/m²]	1.50 kWh/m²
Primary energy factor heat	0.70
Primary energy factor electricity	1.80
Investment costs KG	-
Investment cost for ventilation system	-
Performance coefficiente$_p$	1.27
440 Photovoltaik 1	Not available
440 Photovoltaik 2	Not available

8.4. Other input values and boundary conditions

Thermal bridge surcharge	General 0,10 W/m²K
Air tightness	New construction - general: $n50 = 4\ h^{-1}$