CHALMERS
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The Environmental Potential of Hybrid Load Bearing Systems

A Life Cycle Assessment of a Skanska Residential Reference House

Master's Thesis in the Master's Programmes Structural Engineering and Building Technology & Design and Construction Project Management

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Cover:
Illustration of the Timber Tower research project by SOM, utilising a timber and concrete hybrid load bearing system for a 42 storey building

Department of Architecture and Civil Engineering, Göteborg, Sweden 2017

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ABSTRACT

Emissions from production activities in the Swedish construction industry accounts for 17 % of national greenhouse gas emissions, making reduction possibilities of large interest and importance. Concerning construction of new buildings large improvements have been made regarding energy efficiency, putting further emphasizes on the production phase. Construction of timber residential buildings is growing internationally and in Sweden. The environmental potential of structural systems in timber is promising, although associated with certain design and production challenges. Therefore, a life cycle assessment looking into the potential of timber and concrete hybrid systems is of interest. The aim of the thesis is to identify viable hybrid solutions and map their environmental potential regarding climate change.

A literature review covering relevant LCA methodology and scientific literature was carried out to form a theoretical base for the report. Findings strengthen the case of timber products emitting less greenhouse gases compared to concrete. However, both systems show large future reduction potential.

A case study on a concrete reference house was carried out, substituting incrementally more concrete to CLT through five scenarios. A sensitivity analysis covering the potential of downcycling CLT, using cement replacing materials and the impact of different input data and transport distances for CLT was added to the case study.

The discussion of the report mainly covers the result and its sensitivity. Further, the relevance of producing residential buildings with very long life spans, challenges constructing hybrid structural systems and important but omitted impact categories are discussed. Suggestion for key success factors going ahead with CLT and hybrid residential buildings are lastly given.

The result from the case study show a clear correlation reduced concrete use and GWP reduction. A majority of the total buildings' weight and emissions can be correlated to eleven material categories. Product development should be focused on these categories.

Downcycling of CLT and using cement replacing materials show large potential for both timber and concrete system. Using both approaches for a hybrid structure yield the largest GWP reductions.

Keywords: LCA, Life Cycle Assessment, GWP, Global Warming Potential, construction industry, residential building, CLT, concrete, hybrid structures

Den miljömässiga potentialen för hybridstommar i flerbostadshus

En livscykelanalys av ett referenshus från Skanska

Examensarbete inom mastersprogrammen Konstruktionsteknik och byggnadsteknologi & Organisering och ledning i bygg- och fastighetssektorn

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SAMMANFATTNING

Utsläpp av växthusgaser från produktion i byggsektorn star för 17 % av Sveriges totala utsläpp av koldioxidekvivalenter. Stora energieffektiviseringar på nybyggda hus har på senare år gjort att utsläpp från produktionsfasen har blivit av större vikt. Detta kan vara en av anledningarna till att produktion av flestbostadshus av trä växer i popularitet, både utomlands och i Sverige. Det finns en stor miljömässig potential för stommar i trä, men metoden dras med vissa utmaningar gällande projektering och produktion. En livscykelanalys som studerar den miljömässiga potentialen av hybridstommar av trä och betong är därför av intresse. Syftet med denna rapport är att identifiera möjliga hybridsystem och kartlägga deras miljömässiga potential gällande klimatförändringar.

Som teoretisk grund för rapporten utfördes en litteraturstudie över relevant LCA metodik och vetenskapliga artiklar samt tidigare studier inom samma område. Sammanfattningsvis stärkes tron på den miljömässiga vinsten att använda trämaterial över betong genom studien, men båda systemen påvisade stora möjligheter till minskning av utsläpp genom teknikutveckling och regelförändringar.

I rapporten utfördes en fallstudie på ett fiktivt referenshus i betong, där betongelement stegvis byttes ut mot KL-element i fem scenarier. Fallstudien följdes upp av en känslighetsanalys där återvinning av KL-trä, miljöbetong och varierande indata för emissionsfaktorer och transportavstånd för KL-trä testades.

Rapportens diskussion fokuserar främst på resultaten från fallstudien och känslighetsanalysen. Men även relevansen av att konstruera flerbostadshus med väldigt lång livslängd, utmaningar med hybrid- och träbyggnation samt viktiga men förbisedda påverkanskategorier behandlas. Slutligen ges förslag på viktiga aspekter att hantera för att vidareutveckla hybrid- och träbyggnadssystem av bostadshus på större skala.

Resultatet från studien visar ett tydligt samband en reducerad mängd betong och en minskad miljöpåverkan. En övergripande majoritet av byggnadens vikt och miljöpåverkan kan härledas till en materielgrupp om elva material och produkter. Det på dessa som produktutveckling med mål att minska klimatpåverkan bör fokuseras framöver.

Återvinning av KL-trä och miljöbetong påvisar stor potential för trä- och betongstommar. När båda metoderna används på en hybridstomme fås störst reduktion av klimatpåverkan.

Nyckelord: LCA, livscykelanalys, koldioxidekvivalenter, byggbranschen, flerbostadshus, KL-trä, betong, hybridstommar

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PREFACE

In this master's thesis, an LCA case study has been carried through a collaboration between Skanska and the Division of Building Technology at Chalmers University of Technology in Gothenburg, from January 2017 to June 2017.

We would like thank our supervisor Sjouke Beemsterboer for much appreciated support and feedback throughout the thesis work. Further, we would like to thank our examiner Holger Wallbaum for his valuable input.

We very much appreciate the provided help to initiate the thesis at Skanska from Charlotte Svensson Tengberg, Peter Samuelsson and Ingemar Andersson. Through the project we have continuously been supported by Jeanette Sveder Lundin and Martin Andersson, without your guidance and interest the project would have been difficult carrying through. Finally, we would like to thank Henrik Söderlund for his help with the software SPIK.

Göteborg, June 2017

Arvid Brandt Henrik Sonesson

DEFINITONS AND ABBREVATIONS

BBR	Boverket's Building Regulations (Boverket Byggregler)
BIM	Building Information Modeling
Biogenic carbon	The carbon bound in wood materials during its life cycle
BoR	Bill of Resources
CED	Cumulative Energy Demand
CLT	Cross Laminated Timber
CO_2 eq.	Carbon dioxide equivalents
EPD	Environmental Product Declaration
EU	European Union
GHG	Green House Gases
GWP	Global Warming Potential
ISO	International Organisation of Standardisation
IVL	Swedish Environmental Research Institute
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory Analysis
LCIA	Life Cycle Inventory Assessment
RISE	Research Institutes of Sweden
SP	Prior name of RISE before the merge with Inventia and Swedish ICT
SPIK	Skanska's in-house cost calculation software
Wood frame	Conventional construction technique using frames of wood studs

1 INTRODUCTION TO THE PROJECT

The construction industry's contribution to climate changes is substantial. Although varying between countries it is non-negligible across the world. According to Sveriges Byggindustrier and IVA (2014) 17 % of Sweden's CO_2-emission could be derived from the construction industry's production activities. The impact is approximately equally shared between infrastructure and construction activities. As such, reductions of the environmental impact in the sector have a large impact for national and global emissions.

Traditionally, the use phase of a building has accounted for most of the buildings environmental impact (up to 85%), regarding Global Warming Potential (GWP) and energy usage (Sveriges Byggindustrier & IVA 2014). This could mostly be derived to the heating, cooling and electricity use. However, due to more energy efficient buildings and cleaner energy mix, the focus has shifted to the environmental impact from the production phase. New data state that the impact from production and use phase is often shared equally. This trend is particularly true for countries with a lower dependency on fossil fuels, such as the Nordic countries. An increase in clients' awareness of the construction sector's effect on the environment is increasing the demand for more environmentally friendly buildings further.

In the production phase, the material production of load bearing system is often pointed out as the main contributor to environmental impact (Larsson et al. 2016b). Several studies have shown that the environmental impact of structural system of timber in multi-residential houses is smaller compared to concrete solutions (Lucon et al. 2014; Dodoo & Gustavsson 2013; Upton et al. 2008). However, results from these studies show large variations. There are also examples of concrete system with a high level of cement replacing materials that produce smaller GHG emissions when compared to a timber system (Kurkinen et al. 2017).

Large variations in results point to the complex nature of carrying out a Life Cycle Assessment (LCA), especially on buildings. Building systems and the structural systems within contain a large amount of different materials and variables that incur uncertainties in an LCA. Different materials are not obviously comparable in a completely fair view from a LCA perspective and depending on assumptions and chosen system boundaries, a comparison of two materials can produce very different outcomes. It is therefore of importance to identify the potential and drawbacks of compared materials and evaluate these in order to make an as fair comparison as possible. To further strengthen the robustness of such an LCA, a comprehensive sensitivity analysis of the result of an LCA should be carried out.

It could be argued that the approach of many LCA studies comparing wood and concrete alternatives are one-sided as the materials inherently hold different qualities and functions. While, comparing structural building systems of wood and concrete is interesting enough, exploring the potential of hybrid structural building systems combining the strengths of the materials can possibly open up for a more pragmatic approach.

Therefore, it is of large interest to further investigate which building elements that are most suitable to replace in a conventional concrete structural building systems. Both from an environmental and economic point of view. By keeping some elements in concrete, there is a possibility to maintain certain qualitative functions of concrete structures. Structural system that use a combination of timber and concrete elements, using each material to its best suit, are the main focus of this study. Cross Laminated Timber (CLT) elements were choosen to be used as structural members for the cases, due to its believed future potential and similarities with prefabricated concrete.

1.1 Project aim and purpose

The project aims to identify possible hybrid solutions for structural building systems including both CLT elements and concrete elements, for an existing reference house. Developed hybrid scenarios will be compared with existing concrete building from a life cycle perspective, where the different scenarios' emission of greenhouse gases is studied. An important aspect in the development process of the scenarios will be to evaluate the qualitative aspects of each scenario.

The purpose of the project is to provide new insights in order to facilitate a discussion regarding decision making of future design of residential buildings, with the aim of avoiding idealising and optimising for a single concept. Further, suggestions to implement construction of hybrid and CLT buildings within a project development and construction company's organisation will be proposed.

1.2 Problem statement

Based on the aim of the project the report should answer the following questions:

- How large is the GWP for the identified solutions?
- How large are the potential improvement possibilities with regards to GWP for each solution?

1.3 Limitations

Only GWP will be covered in the life cycle assessment. The production phase of the life cycle will primarily be studied. Options for the end-of-life stages will be covered through a sensitivity analysis. Although the use phase will be included in the case study it will not be looked further into in the assessment and discussion. The case study is carried out on a residential building located in Gothenburg.

1.4 Disposition of the report

The report starts with a description of the methodology used for the work flow during the thesis. It is followed up with a general description of LCA methodology with regards to buildings. To lay a solid theoretical foundation, a scientific literature review was carried out identifying the most important aspects of timber and concrete systems throughout the life cycle.

Following the theoretical chapters, the case study is presented, firstly the reference house and its scenarios followed up by the LCA of the case study. A separate chapter is given for post processing the result through a sensitivity analysis.

Lastly, the thesis is finished with a discussion of the results and its impacts, before providing the final conclusions.

2 METHODOLOGY

The following chapter describes the methodology applied throughout the thesis. Initially, LCA methodology regarding buildings together with a literature review was carried out to provide a theoretical context and to further justify the aim of the report. Hybrid scenarios was then developed for the case study. This was followed by introducing necessary CLT elements in Skanska's cost calculation software SPIK, in order to be able to create the scenarios for the case study. Inventory lists from the cost calculations was then exported to the LCA software Anavitor.

An LCA have been carried out comparing the hybrid scenarios with Skanska's reference house already in place. Following the analysis, a sensitivity analysis was carried out in order to illuminate the uncertainty of the result and future potential of the scenarios. Lastly, the results are assessed in a general discussion before conclusions are drawn.

The applied methodology for the LCA in the case study is described in Chapter 6.

2.1 Literature study

To provide a theoretical background regarding general LCA methodology and its specificities in regards to analysing buildings, an overview of relevant literature is given in Chapter 3.

This is followed by a review of relevant scientific literature in regards to LCAs of wood and concrete building systems. Critical aspects and implications regarding system boundaries are reviewed in a manner that follow the defined stages in ISO 14044, SS EN 15804 and SS EN 15978. Hence, the literature review is divided into the product stage (A1-A3), construction stage (A4-A5), use stage (B1-B7), the end-of-life stage (C1-C4) and the stage considering supplementary information beyond the life cycle (D). The literature study will result in a summary of critical aspects to consider when comparing wood and concrete structural building systems from a life cycle perspective. Findings from the study will primarily be adapted to the production and end-of-life stages of the case study, since it is main focus.

Used literature stem from published scientific articles and report, and from books within the subject. Examples of used key words during searches are: LCA, CLT, concrete, building systems and secondary effects. Using a so-called snow ball method, key studies on the subjects were found and from these studies further important references were identified. Some key studies topical for Sweden were provided by supervisors.

2.2 Case study

The case study has a starting point from a Skanska's reference houses with a concrete structural building system. The concrete system has then been adapted into hybrid scenarios by exchanging concrete structural elements to wooden structural elements. The development of hybrid scenarios was done with the aim of achieving the same qualitative aspects as the original reference house. For some issues, additional informal guidance was given from structural engineers, building physicist and BIM coordinators at Skanska.

2.2.1 SPIK

In this report a software called SPIK has been used, as a data source for the input data used in the LCA.

SPIK is Skanska's in-house developed software for making cost calculations. These are used in all project stages; tendering, cost monitoring during production and to retrieve statistics for future project. The calculation during production is regularly updated in order to monitor budget targets. Naturally the final cost of a building should correspond to the cost calculations. Any reasons for deviations can be tracked, and new experiences from cost-overruns or process efficiency measures can be added to the internal statistics. SPIK allows for highly detailed input data to be retrieved and used in an LCA.

A quick calculation function in SPIK allows for easy calculations of costs and quantity take-offs for the defined reference houses in SPIK. By defining certain parameters like gross floor area, gross facade area, roof area, number of stairwells and number of storeys the quick calculation function can estimate costs and quantity take-offs. Quantity estimation are based on formulas that are tied to one or many of the initial parameter that are required of the quick calculation.

2.2.2 Anavitor

Anavitor is a software that can import material lists containing a Bill of Resources (BoR), that describe the source information needed for the declared or functional unit related to the specific construction works, from SPIK. By doing so a Life Cycle Inventory (LCI) for the project can be created. The software then adds emission factors from the IVL-database in order to calculate CO_2 emissions of the project. The system allows for easy and quick Life Cycle Impact Assessments (LCIA) of a building project with regards to carbon equivalents.

Based on the input data from SPIK, two different types of resources are created: long resources and short resources. So-called long resources are based on specified amounts entered into SPIK, these give a very high quality for the analysis. Short resources are based on average generic data on cost for certain categories of building material. Having the cost of the material, the amount is then calculated. Naturally, this induces a large uncertainty of the material amount used in the project, mainly due to price fluctuations. Therefore, short resources should be avoided when possible. When short resources are used, Anavitor declare in detail the amount of long versus short resources that have been used and further present short resources accounting for the biggest emissions. Thus, it is possible to control and adjust assumptions of short resources that account for large emissions. An example of long and short resources is given in Figure 1.

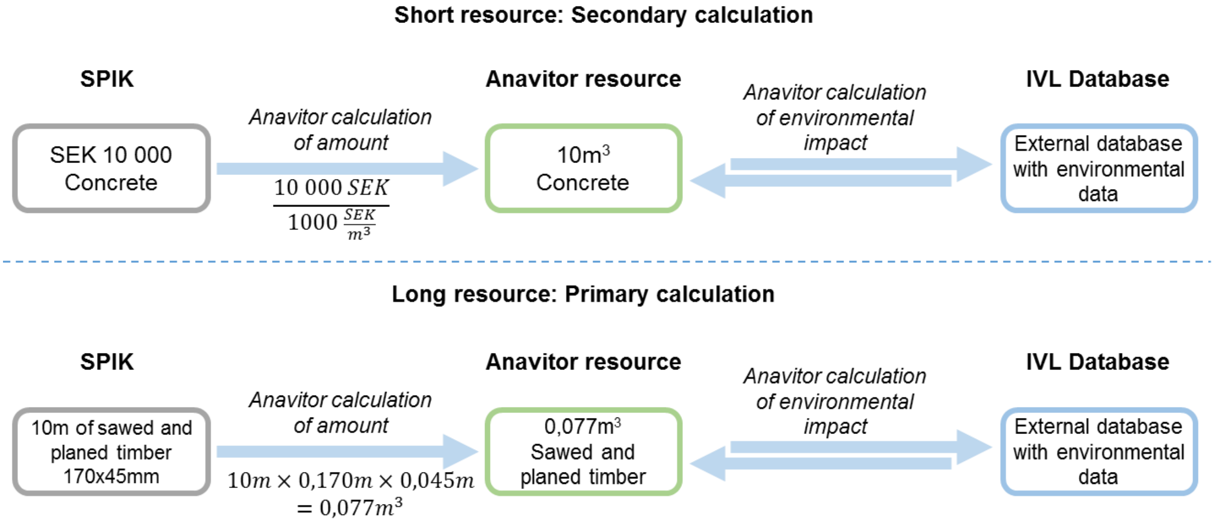


Figure 1: Example of how short and long resources are calculated in SPIK and Anavitor (Andersson & Barkander 2015).

Anavitor has the possibility to fully analyse the life cycle stages of the product stage (A1-A3) and construction stage (A4-A5). Also, parts of the use stage (B2-B6) and the end of life stage (C1-C4) can be included.

Maintenance and demolition factors are being implemented in Anavitor during 2017 and although not comprehensive, the largest factors are in place for this study.

2.2.3 IVL database

In order to quantify the environmental impacts of materials used in a certain project, Anavitor uses emission factors from the IVL database for each entry. The database considers the Swedish market and follow the guidelines set by ISO 14044. Generally, the data is generic for Sweden, although there is Skanska specific data, mainly regarding concrete recipes. Such data contain specific emission factors and are updated on demand from Skanska when data is updated or inaccuracies are found. It is recommended that project specific data which have a large impact on the result is updated. For example, transport distances can vary widely based on manufacturer and suppliers and should be updated accordingly.

Data for the maintenance, repair, replacement and refurbishments stages are based on Erlandsson and Holm (2015) with the aim to develop a Swedish generic data set and methodology for these stages.

2.3 Methods of post processing the result

The post processing of the result was done with the aim of adding new insights to the general discussion. As such, topics that were considered already covered was omitted. These include variance in operational energy use, energy mix and use of different data sets as input values. Instead focus was firstly put to study the potential of each material through downcycling of CLT and the addition of cement replacing materials. Secondly the impact of EPD data set from different CLT suppliers in conjunction with transport distances was covered.

3 LCA METHODOLOGY IN REGARDS TO BUILDINGS

A generally accepted standard approach to carry out LCA on buildings is the SS EN 15978 and SS EN 15804 “Sustainability of Construction Works”, which is a standard covering measurement of environmental sustainability of buildings (Swedish Standards Institute 2013). The SS EN 15804 is a regionally adapted standard using the ISO 14044 as an overarching umbrella standard, meaning that most of the framework from ISO 14040 and ISO 14044 is still valid. This include: the goal and scope definition, the Life Cycle Inventory analysis (LCI), the Life Cycle Impact Assessment (LCIA), the method for interpreting, reporting and critically reviewing the results. Figure 2 below illustrate the general framework for conducting an LCA.

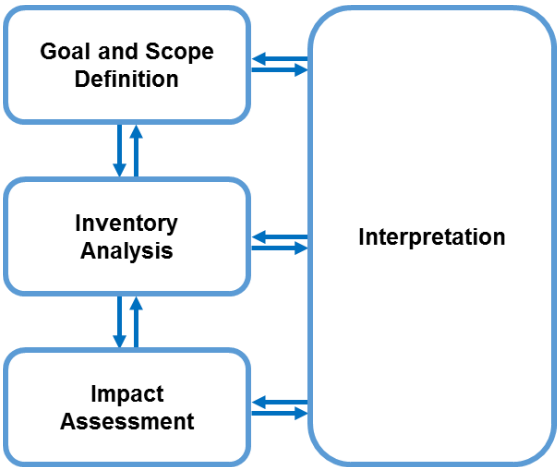


Figure 2: The general framework of a Life Cycle Assessment.

There are two main types of LCA methods; attributional and consequential (Kuno 2016). In short, an attributional LCA looks at the absolute impact of a system defined by its boundaries. A consequential LCA looks at marginal data, meaning that such an approach studies the impact due to certain changes in a given system.

3.1 Goal and scope definition

The goal and scope definition of an LCA states the purpose and overall goal of the study (Baumann & Tillman 2014). Based on the goal, a methodology and framework is defined, including what to model, the functional unit, choice of impact categories, method for impact assessment, system boundaries, allocation principles and quality requirements for the data.

3.1.1 Functional unit

The functional unit used in an LCA is critical for its result, as the impact of the whole system is related and measured by the unit. A building naturally fulfils many functions, while the result from an LCA only can relate to a single reference flow (Baumann & Tillman 2014). According to ISO 14044, a functional unit is a reference unit to quantify the performance of a building (ISO 2006b). The reference flow is defined as the output from the processes generated by the system. Such outputs should be measured and fulfil the function of the functional unit.

Therefore, a single function of the building must be chosen to be represented by the functional unit. Furthermore, LCAs for similar products using different functional units should be restrained from being used for comparison.

Since it is preferable that the functional unit for a building expresses a function, units such as mass, volume, U-value and other isolated characteristics are often not comprehensive enough for decision making (The Swedish Association of Local Authorities and Regions 2016). More common and comprehensive functional units for buildings are often based on different floor area measurements, such as heated area or total area of the building. Such measures can also be combined with energy performance indicators. Gustavsson and Sathre (2011), argue that the unit of a single building is a possible way of including the interaction of multiple functions in a building. However, this makes it difficult to compare the performance of a studied building with another. For example, size difference between the buildings would make a comparison unfit. Regardless of functional unit chosen for a study it will influence the result to a large degree and the risk for sub-optimising should be considered.

3.1.2 System boundary

SS EN 15804 include three mandatory phases: product and construction stages (A1-A5), use stages (B1-B7) and end of life stages (C1-C4) (Swedish Standards Institute 2013). A supplementary phase, Benefits and Loads beyond the Building Life cycle (D), is also included in the standard but is not mandatory to use when conducting a complete LCA. See Figure 3 for an overview of the life cycle stages. Stage D includes the reuse, recovery and recycling potential of materials and potential exported energy from such processes. As such the stage could have a large impact on the result of an LCA. However, if stage D is included, the allocation of credits between the first and second product have to be motivated.

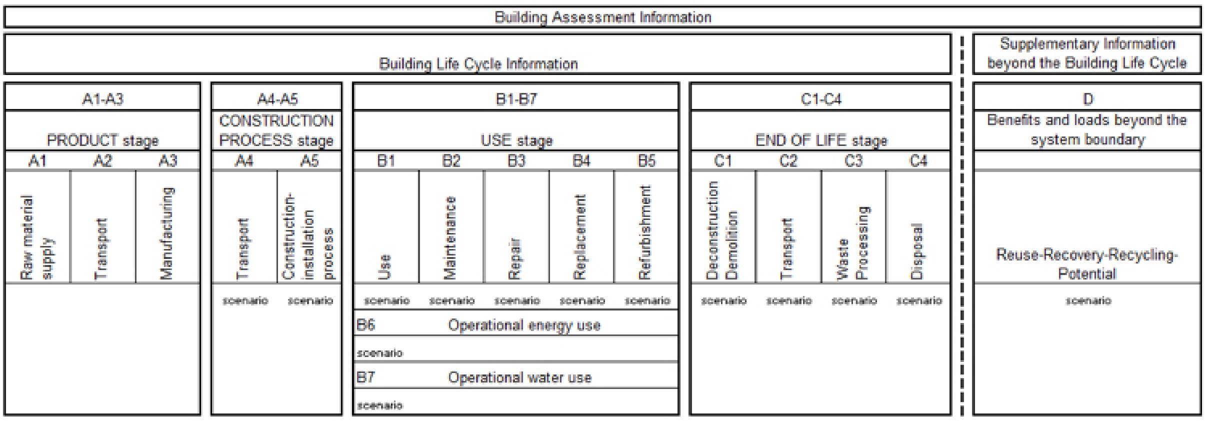


Figure 3: The different stages to consider when conducting an LCA of a building (Kuno 2016).

The choice of system boundary could potentially control the result of a LCA (Matthews et al. 2008; Gustavsson & Sathre 2011). Ylmén et. al (2017) found in a recent study that small changes in the goal and scope in terms of design in a building can have significant secondary effects on a building's overall GHG emissions. For example, a change of insulation in a wall have the secondary effect of making the wall thicker. In order to maintain the floor area in the building this might mean an external expansion that require more wall material and a larger ground slab. Hence, what appears to be small design changes can have large secondary effects on other building elements. This is especially relevant in a wood and concrete structural building system comparison as wood systems in general require more material to achieve same functional levels that of a concrete system.

All major benefits and loads during the lifecycle with regards to the functional unit should be considered. Both cradle-to-gate and cradle-to-grave boundaries are common in literature. The prior considers the first production stages before the product reaches the consumer, in the case of a building that would mean before the tenants move in. The latter describes the life cycle including the stages C1-C4. Cradle-to-cradle analyses, including the D-stage, are more uncommon. Depending on project context, the largest part of a building's environmental impact could be derived from either the production or use phase. Newly built buildings in Sweden generally have a fairly equal distribution between the two phases. Therefore, a cradle-to-grave approach is most suitable for the life time a building.

The service life of a building has a large impact on the LCA-results. It is however difficult to assess how long a certain building will be in use. Partly it could depend on material and maintenance quality, but O'Connor (2004) stated that function and economic viability of the building during a certain time are more important for its future. Many buildings from the past two centuries are still being used in larger cities. However, newer studies claim that the average age of building demolished is just above 40 years. Thus, when conducting an LCA, a sensitivity analysis covering different plausible time spans could be a good way to assess a reasonable uncertainty range of the results.

3.1.3 Impact categories and impact assessment

Before commencing an LCA it has to be decided what to measure, meaning what environmental indicators that are interesting for the commissioner of the study (Baumann & Tillman 2014). The ISO standards provide the impact categories resource use, ecological consequences and human health. In order to measure these, they have to be broken down into quantifiable measurements, such a global warming potential, cumulative energy use, acidification et cetera. To calculate, for example, the global warming potential of a building all the greenhouse gases emitted during the life cycle has to be aggregated into a single factor.

Quantifiable measurements, such as global warming's impact on the more general categories (resource use, ecological consequences and human health) finally have to be decided and weighted. For several software and methods, the weighting has been developed by a panel of experts. Nonetheless, this process invokes a certain information loss, meaning that an LCA presenting quantifiable measurements is more transparent.

3.1.4 Allocation principles

If two or more functions or products share the same process there is often an allocation problem, since the environmental load should be expressed in relation to one process only (Baumann & Tillman 2014). Therefore, there are several methods to allocate the environmental loads and benefits between functions and products within an LCA.

For a multi output process there are two common allocation methods in line the ISO 14044 standard; mass based and economic based. These are illustrated by Figure 4, where a significant difference can be observed when different allocation methods are applied. When producing a wood beam from a log several by-products is also produced. These contribute to a certain degree to the total mass of the log and the economic value of the finished products. If an environmental impact is allocated to one of the products in Figure 4 based on economic- or mass based allocation, different results will be obtained.

Figure 4: Example of mass- and economic based allocation of an industrial process of a wood log (Ebrahimi 2016).

For allocation issues of a multi-life cycle product there are three main approaches; recycled content approach, allocation at the point of substitution and avoided burden approach (Ebrahimi 2016). Regardless of what method used there are three main calculation options; to give the credits to the primary product, the secondary product or some form of shared agreement. It has to be noted that due to the long timespan between the life cycles of buildings, uncertainty is induced in the calculation.

3.2 Life Cycle Inventory Analysis (LCI)

The Life Cycle Inventory Analysis means to quantify all products and processes included within the system boundary of the LCA. This produces a flow model of the system, usually represented and illustrated by a flowchart (Baumann & Tillman 2014). Only in- and outflow that corresponds to the chosen impact categories are relevant to include in the inventory.

The input data used in an LCA provides a certain uncertainty range which have to be considered. According to ISO 14040, the data should be verified by comparison to other data sources (ISO 2006a). Tettey et. al (2014) compared datasets of certain insulation materials with different sample times and geographical origins. Although the results were fairly consistent for different types of insulation materials a non-negligible variance occurred. As such, it is of great importance to verify the relevance of data used in an analysis. Further, ISO/TS 14067:2013 states that the following key points should be considered; age of the data, sample time, geographical origin, technical systems included, precision, consistency, completeness and representativeness (ISO 2013).

Special care has to be taken when there is no available data for the studied region and Environmental Product Declarations (EPD) from manufacturers has to be imported to the analysis. Since the data from EPDs most often is non-transparent, uncertainty is introduced to the analysis. Therefore, sensitivity analyses with regards to the dataset could be carried out in order to determine how sensitive the analysis is to such data. The level of data quality requirements should be defined in the goal and scope of an LCA (Baumann & Tillman 2014).

3.3 Life Cycle Impact Assessment (LCIA)

The impact assessment of an LCA aims to create environmental impacts from the quantified environmental loads in the inventory analysis (Baumann & Tillman 2014). This is mainly done in order to create results that are more easily understood. Terms such as acidification and GWP are easier to relate to and to communicate, compared to amounts of certain chemical compounds.

In order to measure the environmental impact for chosen categories, the environmental loads from the LCI has to be grouped (Baumann & Tillman 2014). Generally, for a full scale LCA, this reduces the parameters from 50-200 to approximately 20. As such a Life Cycle Impact Assessment greatly increases the readability of the result of an LCA. On such a level, the environmental impact categories are labelled ‘midpoint indicators’.

Midpoint indicators can be further grouped, into endpoint indicators (Ebrahimi 2016). However, this has to be done with a weighting of the importance of midpoint indicators with regard to endpoint indicators. For established LCA methods and software, this is usually done by an expert panel. Endpoint indicators increases the readability of results further, but also induces certain uncertainty in the results. There are three generally accepted endpoint categories, although with slightly different names across literature: resource use, human health and ecological consequences (Baumann & Tillman 2014). Figure 5 provides a graphic overview of the process from LCI to endpoint indicators.

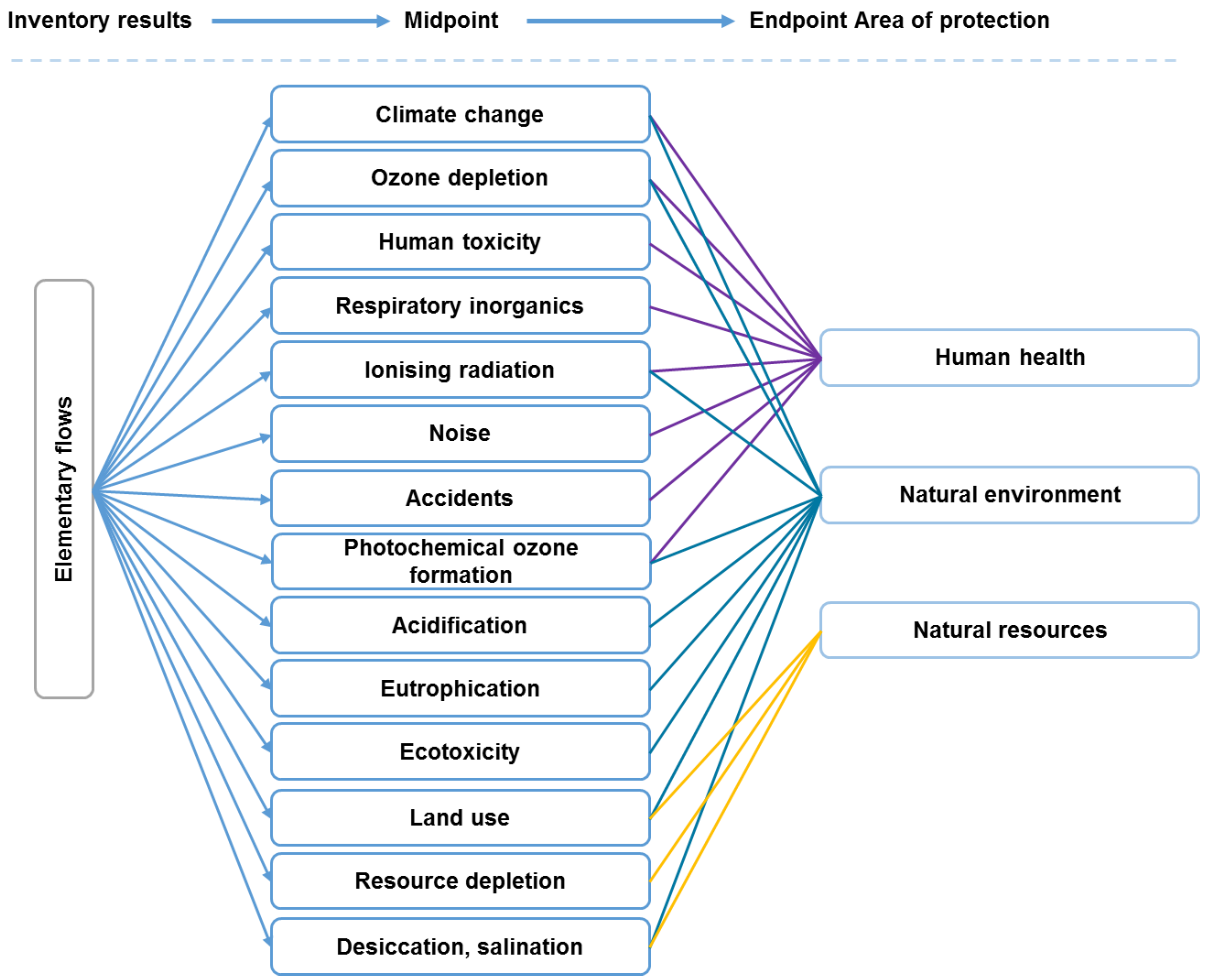


Figure 5: Illustration of the process from LCI through midpoints indicators to endpoint indicators.

ISO 14040 provides a work process for conducting an LCIA, that includes three mandatory phases; impact category definition, classification and characterisation (Baumann & Tillman 2014). First, the scope of the LCA must identify which impact categories that are of interest. Secondly, the result from the LCI must be assigned to their respective impact categories. Lastly, the scale of environmental impact per category has to be quantified.

The mandatory phases are followed by certain optional elements, including: normalisation, grouping, weighting and data quality analysis (Baumann & Tillman 2014). Using software or established LCA methods much of the phases of a LCIA can be predefined. It is however important that the practitioner is aware of the process and how the calculations are carried out by the software.

4 SCIENTIFIC LITERATURE REVIEW OF TIMBER AND CONCRETE BUILDING SYSTEMS

Performing LCAs on buildings is a complex task (Kotaji et al. 2003). This is mainly due to; buildings having long life times (not uncommonly over 50 years), the possibility of buildings undergoing significant changes in terms of function during their lifetime, the variety of actors having impact on the life cycle of the building, including designers, contractors and users, and the lack of standardisation making most buildings unique.

Data used in LCAs of buildings is collected from broad fields of values and supply chains. Furthermore, for certain products the level of customisation could be fairly high as most projects in the construction sector are unique. Challenges can also be found where theory meets reality. Simulated values do not always coincide with monitored values (Danielski 2012), and assumptions in simulations are not always systematically followed by the whole industry (Dodoo et al. 2017)

Most academic literature over the past decade, suggest that timber buildings are more environmentally friendly compared to buildings erected in steel and concrete in terms of GHG emissions and the use of primary energy, over the buildings complete life cycle. However, (Kurkinen et al. 2017) somewhat dispute such suggestions, claiming that concrete buildings could be competitive with regards to GWP. As such, this further highlights that interpretation and conclusions drawn from LCAs comparing different structural systems should be made with caution.

Past studies indicate that the competitive edge regarding GHG emissions of timber structural systems and concrete structural systems differ significantly depending on taken assumption in various activities (The Swedish Association of Local Authorities and Regions 2016; Dodoo et al. 2009; Dodoo & Gustavsson 2013; Gustavsson & Sathre 2011; Gustavsson & Sathre 2006). Many studies are made on wood frame structures and whether conclusions from these studies can be applied to modern wood structures such as CLT and glulam structures is not obvious.

Björklund and Tillman (1997) carried out an LCA study on buildings constructed with wood, steel and concrete frames. The study conclude that the wood buildings have significantly lower energy use and CO_2 emissions during the construction phase. Furthermore, the environmental impact of the buildings was assessed with three different LCA assessment methods. Wood-framed buildings emitted less fossil emissions during material production in all cases.

Oliver et al. (2014) concluded in a study that CO_2 savings can be achieved by using wood-based building components compared to alternative steel and concrete building components. Although, the significance of CO_2 savings varies depending on application and substitution system.

A meta-analysis using data from 21 different international studies concluded that wood products substituting non-wood materials result in less GHG emissions in all scenarios except from when worst-case alternatives of wood disposal is addressed, which means sending the wood to landfills (Sathre & O'Connor 2010)

4.1 Important aspects of the product stage (A1-A3)

Energy is expended and GHG emissions follows during the product stage of building elements for a range of activities including acquisition of raw materials, transport and processing of raw materials into building materials, and fabrication and assembly of materials into a ready building element (The Swedish Association of Local Authorities and Regions 2016). Below, the most important aspects for both wood and reinforced concrete products will be described.

4.1.1 Production of wood products

The forest industry has a typically long supply chain of forest regrowth. If included, it could be argued that the regrowth of trees could potentially make wood based products climate negative. The carbon released if incinerated have in such a case already been absorbed by a newly grown tree. The disposal and end life of timber is also a matter of allocation discussion. If incinerated, the energy could be argued to replace fossil fuels or the emission could simply burden the building project. If the wood is reused, more carbon would be bound in building material. Thus, possibly creating a carbon-sink if the wood outlives the regrowth of trees to bind the same amount of carbon. However, which building (the first or the second) that gets the environmental credit is a matter of allocation discussion.

When carrying out an LCA on wood products, biogenic carbon therefore has to be considered. Biogenic carbon is the carbon bound in the wood material in what could be considered a natural coal cycle. Opposed to the natural coal cycle is processes where new coal is emitted to the atmosphere (burning fossil fuel), which is therefore considered fossil. Different accounting principles of biogenic carbon exist. Only looking at the production stage, carbon bound in wood create a negative CO_2 footprint. With the assumption that the wood will be incinerated at the end of the lifecycle, the bound CO_2 will be released again, and thereby cancel out the biogenic carbon. The different accounting principles are different approaches to in what stage the biogenic carbon is accounted for. Table 1 show the three most common accounting methods.

Table 1: Summary of the three most common accounting methods for biogenic carbon (Adapted from Larsson et al. 2016).

Lifecycle stage		**1. EN 15804**	**2. PCR for wood products**	**3. ISO 21930**
A1-A3	Fossil	100kg	-400kg	100kg
	Biogenic	-		-500kg
C3	Fossil	10kg	510kg	10kg
	Biogenic	-		500kg
Total over the whole lifecycle		110kg	110kg	110kg

The assumption of wood products acting as carbon storage causing negative emissions is a common approach that can be found in EPDs from the wood industry (KLH Massivholz GmbH 2012) where only the production phase is accounted for, hence not showing the whole picture of wood products.

To simplify an LCA comparison of wood and concrete building systems Kurkinen et al. (2017) assumed the wood to be carbon-neutral regarding the biogenic carbon in accordance with ISO 21930. This can be done by assuming that the carbon storage created during the production phase (A) is cancelled out by incineration in the end-of-life stage (C), see Figure 6.

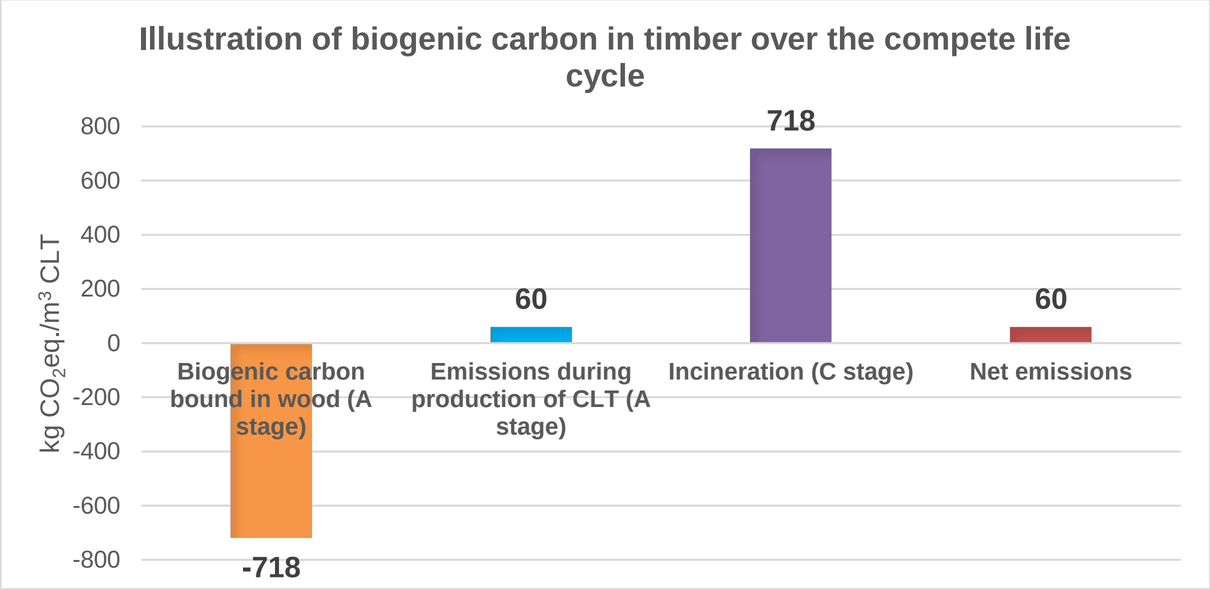


Figure 6: Illustration of carbon emissions and uptake during the production and end-of- life stages of wood.

A substantial amount of literature studies the potential of reducing energy use and GHG emissions of the built environment by using sustainably produced wood-based materials as a substitute to non-wood materials (Lucon et al. 2014; Dodoo & Gustavsson 2013; Upton et al. 2008). Sathre and O'Connor (2010) conclude that the manufacturing of wood materials requires less total energy than most alternative materials such as concrete and metal. Parts of the energy use in wood processing is thermal energy in the drying process, for which wood residues from previous production steps are commonly used.

Gustavsson and Sathre (2006) studied the variations in primary energy and CO_2 balances of wood and concrete buildings, concluding that the accounting for recovery of biomass residues have the greatest effect on the primary energy and carbon balances of the buildings. Gustavsson et al. (2006) came to a similar conclusion in their comparison of wood and concrete buildings. When including available energy from biomass residues from the logging, wood processing, construction and demolition stages, the wood alternative used less production energy and had significantly smaller CO_2 emissions compared to the concrete building.

4.1.2 Production of reinforced concrete products

The three most prominent processes included in the production of reinforced concrete are the production of aggregates, binder (most often Portland cement) and reinforcement steel.

Flower and Sanjayan (2007) studied the CO_2 emissions in concrete production using data collected from two coarse aggregates quarry, one fine aggregates quarry, six concrete batching plants and data from various other sources. They concluded that the production of Portland cement had the single biggest CO_2 emissions, with 74% to 81% of the total CO_2 emissions in typical commercially produced concrete mixes. The second biggest impact came from coarse aggregates with 13% to 20% of the total CO_2 emissions. However, 80% of the CO_2 emissions from production of coarse aggregates is derived electricity use with an Australian energy mix consisting of mainly brown coal use and should therefore be expected to vary significantly between countries. Another aspect of this study is that it does not account for emissions caused by reinforcements.

Flower and Sanjayan (2007) also found that using fly ash and ground granulated blast-furnace slag (GGBFS), as cement replacing materials, could help reduce the total CO_2 emissions of concrete with 13% to 15% and 22% respectively in a typical concrete mix. Kurkinen et al. (2017) used a new cement recipe (with the stated potential of being able to use up 30% fly ash), although cement mixtures used in the study only amounted to 18% of fly ash. The recipe of the cement mixture had significant effects on the total emissions of the concrete structural building systems, which came out with similar if not better total emission in comparison with a CLT structural building system. Hence, different concrete recipes could also be of interest when comparing concrete and wood structural building systems.

Reinforcement is a vital part in concrete construction and the emissions should be accounted for. Andersson and Barkander (2015) studied residential building designs from an LCA perspective and found reinforcement steel to account for 8.3% of the CO_2 emissions in the production phase (A1-A5). Furthermore, a sensitivity analysis comparing different databases (IVL, Eco-Bau and EcoInvent) indicated large variations in the emission factor of reinforcement steel, where IVL and Eco-Bau produced similar results and EcoInvent more than tripled the emissions of IVL.

The calculations of CO_2 emission from the reinforcement steel done by Kurkinen et al. (2017) is based on data from an EPD of the Norwegian reinforcement steel producer Celsa (370 kg CO_2 eq. /tonne). Using the same emission factor on the total amount of reinforcement steel found in Andersson and Barkander (2015), the CO_2 emissions of reinforcement steel is more than halved compared to the lowest emissions calculated by using the Eco-Bau data-set.

Therefore, considerations should be put to validate the data used for reinforcement steel. Different data-sets could be used in a sensitivity analysis of the main contributors to emissions, if the project has not specified a supplier.

4.2 Important aspects of the construction stage (A4-A5)

In an LCA comparing wood and concrete structures, transport distances can vary significantly. In-situ concrete is dependent on being produced in close proximity of the construction site and therefore can be expected to have low transport emissions. Prefabricated concrete elements does not have proximity restrictions and supplier distance should be specified in order to determine transport distances.

CLT components are not either restricted to proximity of construction, hence the distance can vary substantially depending on the choice of supplier. The limitation of suppliers within the industry aggravate the possibilities to choose local suppliers. Supplier distance could therefore be considered an important part of the construction phase for timber building systems. For conventional wood products there is a larger amount of local suppliers.

Energy use and emission during the construction and assembly of wooden structural systems is not obvious and differ between CLT, glulam and wood-frame systems. Björklund and Tillman (1997) estimated an energy factor for the construction machinery during the construction phase of a two-storey wood-frame or concrete-frame building. Both prefabricated and in-situ alternatives was studied for the concrete alternative. Same factors are oddly used by Kurkinen et al. (2017), when comparing CLT structural system and a prefabricated concrete structural system. The study come to the conclusion that CLT systems have a significantly higher energy use in the construction phase, which is questionable due to CLT’s lower weight.

It could be argued that modern CLT construction is to a large extent similar to construction with prefabricated concrete. However, differences exist in terms of the need for weather protection and construction times. Building with CLT require protection from humidity (often achieved through encapsulating the construction with a tent). An alternative approach would be to accept the risk of needing to replace certain elements that may be damaged by moisture.

4.3 Differences in the use stage between timber and concrete buildings (B1-B7)

Using a structural system of mainly timber or concrete products creates a set of different preconditions for the use stage of the building. Both regarding operational energy demand and the need for future maintenance. Also, there are several qualitative aspects not included in the LCA framework that are of large importance. Finally, the effect of carbonation of concrete is an important phenomenon to understand.

4.3.1 Energy efficiency

Danielski (2012) studied the variations in specific energy use during the use stage of 22 residential buildings in Sweden. Comparing simulated and monitored results it was found that most buildings had a simulated specific final energy results that was about 19% lower than monitored values. Furthermore, Dodoo et al. (2017) studied the variation of input data and assumptions in energy balance calculations in the Sweden, and found significant variations when calculating different annual final energy demands for a building case study. As such, the difficulty of drawing any general conclusions for projects with different kinds of preconditions is shown.

From a complete life cycle perspective, wood have a lower primary energy usage in most cases according to Dodoo, Gustavsson and Sathre (2012). Heeren et al. (2015) on the other hand, found that concrete and wooden buildings have a similar total primary energy demand over the life cycle. Further, Kurkinen et al. (2017) found that the two studied wood cases needed more primary energy compared to the concrete cases over the whole life cycle. This discrepancy of cumulative primary energy demand over a complete lifetime, for three multi residential houses in fairly similar regional conditions, shows the difficulty drawing general conclusions from LCAs without fully understanding each individual case.

4.3.1.1 Thermal inertia

In a general perspective concrete buildings have a lower operational energy usage than similar timber buildings with an equivalent overall U-value (Adalberth 2000; Heeren et al. 2015). This can partly be explained by the thermal inertia of the building (Heeren et al. 2015). Heavy materials have a greater ability to buffer heat, effectively reducing the peak power demand of heaters or coolers. The effect is very much dependent on the amount of exposed heavy material indoors and regional differences. It is also influenced by occupation patterns, ventilation, window configuration and insulation (Dodoo et al. 2012)

Heeren et al. (2015) claims, in a comparison of wooden and massive residential buildings, that thermal inertia has a 2-6% impact in heat demand. The result is valid for Switzerland and similar regions. This is line with the findings of Kurkinen et al. (2017), who made a study of a Swedish residential buildings in central Gothenburg. The study shows that a concrete structure, both cast-in-situ and prefabricated have a lower energy demand during operations. However, most studies conclude that the effect of thermal inertia varies widely and in order to utilize it effectively in an LCA a dynamic energy analysis of the building is needed.

4.3.2 Maintenance, repair and refurbishment needs

The general and most common approach to account for maintenance or replacements in an LCA on buildings is in line with the European calculating rules of LCAs on buildings, EN 15978 (Erlandsson & Holm 2015). To account for a maintenance or replacement, it has to occur within the reference lifetime expectancy set in the LCA. For example, a building with a 50-year reference lifetime expectancy does not include the environmental loads of a maintenance or replacements occurring in year 51. Erlandsson and Holm (2015) argue that in reality, a specified time for a replacement interval, may differ with +/- 10 years. Because reality is hard to avoid, a threshold effect may occur when applying the calculation rules of EN 15978 where replacements are not accounted for. To mitigate this threshold effect, it is proposed to use a periodic approach of replacements loads, where they are spread over every year.

As illustrated by Kurkinen et al. (2017), the service life of the buildings and time span used in an LCA can be of great importance. When considering a reference lifetime expectancy of 100 years, large scale maintenance, repair and refurbishment needs to be considered. The precise extent of future maintenance needs is an important aspect to consider. It could be argued that Kurkinen et al. (2017) have a sound approach in assuming extensive maintenance needs that incur significant emissions on wood structural building systems. However, the study fails in the aspect of applying maintenance loads on the compared concrete structural system.

Data in Erlandsson and Holm's (2015) report is not presented as a final data-set and should be considered to be under development. However, compared to the lack of any other compiled data within this area it could be considered some of the more reliable and developed.

4.3.3 Qualitative aspects not directly considered in an LCA

The development of timber engineering over the last decades has enabled the construction of taller timber buildings, although there are many areas still in development. However, structural engineering matters are not considered the main issues when designing a timber residential building.

Concrete products usually provide good sound insulation, mainly derived from its heavy weight (Thorsson 2016). Due to its low weight and ability to easily transfer sound, wood elements need to be complemented by sound insulation (Schmidt & Griffin 2013). This increase the size thickness of all elements substantially. In most cases, it leads to CLT elements becoming thicker than concrete equivalent, especially floor slabs. Also, structural joints need to be designed with special care, mainly due to the risk of flanking transmission. Decision regarding the design of joints should be made in cooperation between an acoustic engineer and a structural engineer in the design phase.

Naturally wood products perform worse than concrete with regards to fire safety. However, CLT and glulam products have a much greater fire resistance compared to conventional stud walls, due to their larger cross sections (Schmidt & Griffin 2013). This allow the wood to char, effectively reducing the speed in which the structural integrity is lost. According to Gagnon and Pirvu (2012) a char rate of 0,67 mm per minute have been obtained through testing for CLT-panels.

Most fire regulations concern personal safety in case of fire. A wood building contains more material that are susceptible to fire. Hence a wood building is more prone to severe property damage compared to a conventional concrete building (Björk 2016). It could also produce larger risk for the fire brigade. Key issues in the design phase regarding fire safety could be: visible wood indoor, wooden facades, reducing unwanted cavities and the possible need for sprinkler systems.

Timber products are generally more moisture sensitive than concrete elements. Construction and assembly should be done in dry conditions, because of the risk of mould growth and structural deformation. Therefore, the climate and moisture conditions during construction is critical. The manufacturer and moisture experts should be involved early in the design process in order to be able to minimize the risk for moisture damages.

Some of the large-scale timber buildings built in Sweden have utilized weather protection systems during construction. It allows the construction to proceed under dry conditions which greatly reduces moisture risks, also the weather's factors affecting the time schedule are minimized. Further, it improves the working environment on site. SBUF (Svenska Byggbranschens

Utvecklingsfond) believes that the use of weather protection system will increase as the industrialized building methods will be further implemented (SBUF 2006). However, there are examples of large scale timber buildings constructed without a weather protection systems. In these cases it is assumed that the risk of damaging certain wood element was accepted.

However, it produces certain challenges regarding the quality of the weather protection, logistics on site and not least regarding the extra costs involved. Today there any many different types of weather protection, none being standardized (SBUF 2006). This area need development in order to reduce costs and promote the production of timber buildings. It could be argued that the lack of knowledge regarding implementation and costs of weather protection systems is hindering the development or large scale timber buildings.

4.3.4 Carbonation of concrete

During the lifetime of concrete, a reaction called carbonation occurs. In the carbonation process CO_2 in the air reacts with calcium hydroxide in the concrete which results in the creation of calcium carbonate (Lagerblad 2005). The carbonation process depends on variables such as time, composition of cement used to make the concrete, temperature, relative humidity, grade of exposure of concrete to air, exterior material and binding substitute.

Studies show that carbonation uptake increase considerably if the concrete is crushed and exposed to air in the end of life stage. However Dodoo et al. (2009) point out that CO_2 emissions from fossil fuel used when crushing the concrete significantly reduce the carbon benefits gained from an increase in carbonation due to this process. Furthermore, questions regarding practicality in terms of space constraints also arise. The carbonation uptake is always less than the initial calcination emission (Dodoo et al. 2009). Lagerblad (2005) presented a formula for calculating the amount of CO_2 absorbed from the atmosphere (kg/m3):

$$CO_2\ uptake = a = 0{,}75 * C * CaO * \frac{M_{CO_2}}{M_{CaO}}$$

where

- 0,75 is a correction factor for the amount of CaO carbonated
- C is the amount of Portland cement per m^3
- CaO is the amount of CaO in the cement (wt-%)
- M is the molar weight of oxide

4.4 Important aspect of the end of life stage (C1-C4) and potential benefits and loads beyond the life cycle (D)

According to ISO/TS 14067:2013 “all the GHG emissions and removals arising from the end of life stage of a product shall be included in a carbon footprint study”. The end-of-life stage of buildings include demolition or disassembly of building and materials and a post-use management of materials in terms of disposal (The Swedish Association of Local Authorities and Regions 2016).

According to the ISO 14044 and SS EN 15804 standards, it is not mandatory to include benefits and loads beyond the system boundary (D stage). The D stage may contain the potential of reuse, recovery and or recycling potential of materials.

Börjesson and Gustavsson (2000) studied GHG balances in building construction of a multi-storey house comparing a wood-frame versus a concrete-frame. The study points out the importance of having long time frames to account for the carbonation process of concrete and forest growth related to wood-frames. The study concludes that the GHG balance of wood materials is heavily dependent on how the wood is handled at the end of life phase. The GHG emissions become clearly positive when wood is deposited in landfills, slightly positive when wood is used to substitute fossil fuels, and slightly negative if parts of the wood is reused.

The end-of-life stage for wood-based building systems could potentially be the single most important variable to account for carbon emittance throughout the life cycle (Sathre & O'Connor 2010; Gustavsson et al. 2006). The outcome varies significantly if wood is put to landfill, used as bioenergy, or if parts of the wood is reused for something else (Börjesson & Gustavsson 2000)

While some studies assume that demolished material from buildings are landfilled (Junnila et al. 2006; Ochoa et al. 2002), there is also studies that look into the effects of post-use material management of wood-frame and concrete-frame buildings (Dodoo et al. 2009; Dodoo et al. 2012). The latter, more explicitly assume that demolished concrete, steel and wood materials were recovered and reused. Furthermore, it is concluded that wood-frame buildings have a greater end-of-life primary energy benefit when recovered. Kurkinen et al. (2017) avoided implications of the end-of-use stage by assuming all wood material in a building to become bioenergy at the end of use making the wood materials climate neutral.

When wood products are considered to be waste they are according to Swedish law supposed to be sorted for incineration. While, Sweden in line with EU guidelines promote reuse or recycling of material this is not bound by law (Stockholm Stad 2006). A conservative assumption regarding wood products in Sweden is arguably that they are incinerated at the end-of-life.

In the Nordic countries (except from Iceland) concrete is commonly recycled by being crushed and used as aggregate (Engelsen et al. 2005). In Sweden the amount of recycled concrete was estimated to 60% as of 2005 which is mainly used in road construction or as ballast in new concrete. Structural systems in concrete also have the possibility to being reused during a complete refit of the building on site or at a different location.

When calculating the energy use of demolition of a wood-framed eight-storey apartment building, Gustavsson et al. (2010) assumed 10kWh/m^2 or 36MJ/m^2 based on previous studies. This is further strengthened by Kuikka (2012) that calculated the energy use for demolition of a school (37 MJ/m^2) based on calculations including input from a demolition and general data for construction machinery. Björklund and Tillman (1997) calculated the energy demand in diesel to 18,7MJ/m^2 for a precast concrete frame based on biddings from demolition companies. However, gable walls, roofs and foundation is excluded in these calculations that are not disclosed. Due to the nature of prefabricated components it could be argued that the demolition and demounting phase of such a building would consume less energy. Since they are able to be demounted and are not needed to be demolished in a full extent.

Kurkinen et al. (2017) use Björklund and Tillman's (1997) energy demand factors for demolition, but does not pay attention to the fact that the energy factor for the wood-frame building incorporates the demolition of the whole building while precast concrete does not. Furthermore, Kurkinen et al. (2017) is comparing a concrete structural building system with a CLT structural building system, both prefabricated construction method. It could therefore be argued that demolition energy demand between the two should be similar.

Due to the process of rot, wood release methane when landfilled. Börjesson and Gustavsson (2000) claim that if wood is not left to rot, wood constructions consequently have lower GHG emission compared to concrete structures over very long time frames. The study took into consideration several forest rotations, concrete carbonation, decomposition of landfilled wood and with a 100-year life span of the studied building.

4.5 Summary of the most important aspects to consider based on the literature review

The following section will summarize the most important findings from the literature study regarding wood and concrete systems.

4.5.1 Effects of chosen system boundaries

An important aspect to consider is the secondary effects that occur when setting the system boundary. When the goal is to achieve similar functional aspects of compared buildings with different building systems secondary effects will arise. Wood and concrete have big differences on material level and therefore have different functional qualities. For example, walls in a wood building system will be thicker to achieve the same acoustics and energy efficiency demands. If the same liveable heated area in the compared buildings is to be achieved, the timber building will need to be slightly bigger and use more material. Kurkinen et al. (2017) found that to achieve the same liveable heated area in a house built with a CLT building the volume had to be increased with 4% compared to the concrete alternative.

The time span set in the system boundary effect both wood and concrete materials. A long time frame in terms of 100 years or more is in general positive for both materials. Wood materials initially work as carbon storage, while if a wood product outlive a forest rotation it could be argued that it become a carbon sink possibly causing negative net CO_2 emissions. A long time frame also cause drawbacks on wooden building materials in terms of maintenance and repair work. The durability of CLT-building systems when used in the proportions we see today can be considered unproven over long time and therefore inherent uncertainty in terms of maintenance and repair works. Kurkinen et al. (2017) considered the need to switch out timber building elements according to certain intervals depending on building element, which could be a reasonable approach.

4.5.2 Most prominent aspects of the production and construction process

The type of concrete has proven to be of great significance. Therefore, consideration should be put to incorporate what can be considered more environmentally friendly concrete mixes e.g. mixes with fly ash or GGBFS. Such concrete mixes were incorporated by Kurkinen et al. (2017) with great result comparing GWP reduction. However, there are issues that needs more attention using such binders, for example prolonged dry out times and the future availability of fly ash, as it is a by-products of coal power plants.

Regarding transport distances, it is considered safe to assume concrete cast on site have short transport distances. For prefabricated concrete and CLT, suppliers and transport distances need to be chosen specifically for each LCA.

4.5.3 Uncertainties in the use stage

Much of the interesting factors during the use phase are associated with large uncertainties. Thermal inertia and carbonation of concrete needs further project based studies in advance of an LCA in order to be incorporated. Assumptions regarding repair, replacement and general maintenance can be made to some extent. Several studies on the matter are being done and should bring more accurate data ahead. One of the largest uncertainties is the technical life span of timber buildings.

4.5.4 Potential in end-of-life stage

Similar to repair and maintenance issues, the End-of-life stage lack updated and accurate data for residential houses. Also, the GHG emission related to demolishing and depositing the waste of a torn down building is uncertain. Assumptions done to the matter should be considered with care.

Much of the future potential of reducing GHG emission for timber products is related to the D stage. A worst-case scenario includes wood being put to landfill, where it decomposes producing methane gases that are a more potent GHG than CO_2. The most common assumption in studies is that the wood is incinerated at its end-of-life stage. The ideal outcome of wood at the end-of-life would be re-use or downcycling of the material, prolonging the carbon storage. In such a case, wood products become climate negative as it binds carbon within the society.

5 PRESENTATION OF THE CASE STUDY

This chapter will give a description on the case study and the scenarios analysed. A certain set of functions to be maintained was predefined in order give a framework of demands. All scenarios have been utilising certain structural components consisting of standard building element provided by Skanska and CLT elements provided by Martinsons.

The method of generation for the reference houses is described in Section 5.1 and the inventory lists for each scenario is found in Appendix D. These inventory lists are complemented through secondary effect, calculated in Appendix D, and the finished cases are finally presented in Section 5.6.

5.1 Description of reference house

The aim when choosing a reference house was to find a design that very much reassemble a normal sized residential building. In such a way, the result of the case study is relevant for as many future projects as possible.

The reference house used in this study is generated from generic data. From a certain set of variables such as heated area, number of apartments, floors and stairwells, inventory lists and amounts are produced in SPIK. These amounts are calculated by a set of formulas based on experience relating to the used variables. The formulas are made to fit a building size of 3-8 stories, where story 2-8 are identical. On the entrance level there are technical rooms, storage rooms and passage ways. 40 percent of the apartments are two rooms or smaller and 18 % of the apartments have two toilets. All apartments have a balcony.

The method allows for a fairly accurate and quick calculation of project costs at early stages. Since Anavitor imports data amounts directly from SPIK it also allows for easy assessment of the LCIA. For an actual project cost calculation should be updated and become more detailed throughout the process, also allowing for a more detailed assessment of the environmental impact.

A large benefit of the method is that it utilises Skanska's standard build components. As the components are used widely it allows for accurate assessments. Also, improvements made to the products naturally have a large penetrating power.

The method allows for easy modifications between scenarios in the case study. However, it does not deliver accurate estimations until later stages. Nevertheless, different options for a project can easily be compared in such an early stage. One variant of a reference house already in place in SPIK will be used as a basis for the case study. An illustration of the Reference case can be seen in Figure 7. It should however be noted that the illustration does not replicate the actual inventory lists.

Figure 7: Illustration of the Reference case of the reference house.

The input data for the Reference case have been the following:

- 513 m^2 foundation area
- 2565 m^2 heated area
- 1415 m2 facade area
- 545 m2 roof area
- two stairwells
- 5 stories, including entrance level
- 28 apartments

All scenarios will have a slab directly supported on ground as foundation. The roof structure, consisting of prefabricated timber trusses, is supported by the uppermost slab. Installations for ventilation in the building is placed in the attic, which is non-insulated. All scenarios have the same set of doors, installations, non-load bearing walls and appliances. Minor changes occur for several data sets due to secondary effects between the scenarios.

A floor plan does not exist for the original reference building, however, for illustrating purposes an example of a possible floor plan was made. All necessary measurements for complementary calculations regarding amounts and secondary effects will be based on the floor plan below. It is valid for storey 2-5 and can be seen in Figure 8. Also, the input data for the Reference case have been adapted to the floor plan.

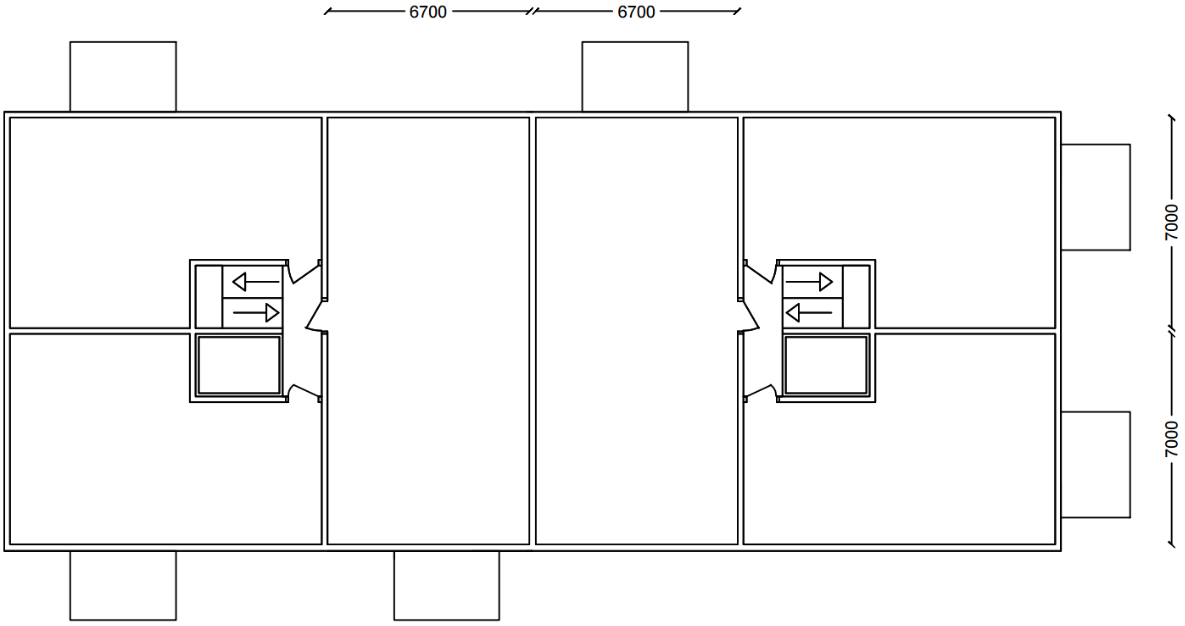


Figure 8: The floor plan for storey 2-5. Only load bearing walls are illustrated and all measurements are in millimetre.

The longest span in the example floorplan is 7 meters, showing that it is possible to use CLT slabs without any load bearing walls within the apartments. The CLT elements are technically described in Section 5.4.

5.2 Functions to be maintained for all cases

For all the scenarios, the goal has been to fulfil the same functional requirements of the building. This goal is mainly motivated by the argument of giving a fair comparison between different building systems.

One of the most important functions is to maintain the same amount of liveable area in each scenario. Buildings with a structural system in wood, will inevitably have a larger volume for the same living area. Simply due to the timber elements being larger in size for most cases. Kurkinen et al. (2017) found that their timber case had a 4 % larger volume.

If similar functions are to be kept between scenarios, the building's design, layout and installations will have to undergo minor changes. These changes will have secondary effects as described by Ylmén et al. (2017), all of which will be summarized in Section 5.6.

5.2.1 Acoustic performance

The acoustic performance demands of residential buildings in Sweden are governed by the standard SS 25267:2015 and by the Swedish building regulation, BBR - BFS 2011:6. The used classification ranges from A to D, where A is the highest grade. The grade of C has to be met according to BBR for all new building. However, if C cannot be met during a refit, the grade of D is allowed. The included demands are:

- sound transmitted by air ($D_{nT,w,50}$ and $D_{n,T,w,100}$)
- through impact noise ($L_{nT,w,50}$)
- exterior sounds (L_{Aeq}+L_{AFmax})
- noise from installations (L_{Aeq}+L_{AFmax})

$D_{nT,w,50}$ and $D_{n,T,w,100}$ have replaced the earlier denominations $R'_{w+C50-3150}$ and R'_{w} with the only adjustment being that the limits have been lowered by 1 dB. The following tables state the demand to meet sound class A, B and D according to SS 25267:2015. Sound class C is stated in in the latest BBR.

The demands covered in this case study will be sound transmitted by air and through impact noise. Further, the regulations cover finished apartments and rooms while this study only will cover structural components. Acoustic demand on windows and door are also not included. One of the most important aspect of acoustics in timber buildings, flank transmission, is not included. Simply due to that no connections details will be provided through the generation method of the reference house scenarios. As such, the defined sound classes for the scenarios should only be considered as very coarse values.

Table 2 states the lowest allowed values for sound transmitted by air, while Table 3 state the highest allowed values for noise impact.

Table 2: Lowest allowed values for apartments regarding sound transmitted by air (adapted from SS25267:2015).

Type of space	Denomination	A	B	D
From space outside apartment to inside apartment	$D_{nT,w,50}$	60	56	48
From stairwell to apartment	$D_{nT,w,100}$	42	58	40

Table 3: Highest allowed values for noise impact for apartments (adapted from SS25267:2015).

Type of space	Denomination	A	B	D
From space outside apartment to inside apartment	$L_{nT,w,50}$	48	52	60
From stairwell to apartment	$L_{nT,w,100}$	58	62	66
From stairwell to apartment at entrance level	$L_{nT,w,100}$	48	52	62

5.2.1.1 Acoustic design decisions

Timber buildings have a great potential reaching good acoustic performance according to Thorsson (2016). However, the same principles used for concrete structures cannot be applied if a sufficient quality is to be reached. He further states that hybrid structures utilising the potential of each material to its fullest have a great potential from an acoustic point of view.

The already existing scenarios of the reference house fulfils sound class C with an aim of achieving sound class B between apartments. Therefore, building components fulfilling sound class B will primarily be chosen.

5.2.2 Fire safety demands

The Swedish building regulations (BBR) describes certain regulations for all building types and occupancy classes (Blixt & Svanteson 2014). The fire safety of the load bearing structure is regulated by the Swedish adaptation of Eurocode.

There are two general ways of fulfilling the demands set by BBR and Eurocode, either through a simplified procedure or follow an analytic procedure (Blixt & Svanteson 2014). Solutions that are not allowed through the simplified procedure may be shown safe following an analytical procedure. This case study will follow the simplified procedure.

By first defining a building class and occupancy class, detailed demands are given by the simplified process (Blixt & Svanteson 2014). The detailed demands cover: building components and cladding, prevention of fire spread, evacuation possibilities of the building, the fire safety to other buildings and fire related installations.

Regarding building components there are three common definitions (Blixt & Svanteson 2014):

- R - covers the load bearing capacity
- E - covers the function of keeping flames and smoke isolated
- I - covers the insulation capacity, meaning the temperature on other side of the fire

The letters are followed up by a number, which create a demand or property of a building component. For example, a demand of R60 simply means that the component must withhold its load bearing capacity for 60 minutes during a standard fire on one side.

As the reference house used consists of five stories and 28 apartments it will, according to BBR 5:22, be given the building class Br1. Residential houses are given the occupancy class Vk3 by BBR. This means that the spread of fire and smoke should be minimized between fire cells. Also, the stairwells need to be fitted with smoke ventilation hatches.

BBR BFS 2011:6 states that the façade of buildings with building class Br1 should fulfil the following:

- The separating function should be maintained between fire cells
- Fire development within the wall should be minimized
- Fire development along the façade should be minimized
- Risk of personal damages due to falling debris from the façade should be minimized

Generally, an exterior wall with fire class A2-s1, d0 fulfils these demands (SS-EN 13501-1). Where:

- A is the second highest level of demand regarding mechanical impact
- s1 is the highest level of demand regarding released fumes from the product
- d0 is the highest level of demand regarding burning droplets or particles from the product

Alternative an exterior wall with fire class D-s2, d2 (usually fulfilled by a non-treated wood panel façade) is acceptable in the following cases (BBR BFS 20112:6):

- The building is maximum two stories tall
- The alternative cladding only covers the bottom storey

- The building is maximum eight stories tall and equipped with sprinklers in addition of having the entrance level façade in fire class A2-s1, d0.
- If the façade of fire class only D-s2, d0 only covers a limit amount of the area

If evacuation through the apartment's windows is not possible a stairwell of standard Tr2 is needed (Blixt & Svanteson 2014). The stairwell is allowed as the only escape route up to eight stories, and should have a direct access into the outdoors. If it is the only escape route, a direct access to the basement is not allowed. All walls in a Tr2 stairwell should fulfil EI60.

5.2.2.1 Fire safety design decisions

The most relevant demand based on occupancy class for this study is that all apartments should be designed as independent fire cells that fulfil EI60. Also, the load bearing structure of the building should fulfil R60. This apply for all chosen CLT products and is fulfilled by all standard built components used by Skanska.

Due to the strict fire regulations regarding façade design, all scenarios will have a brick facade with an airgap. The potential environmental benefits of having a wood panel is therefore not considered in this study.

5.2.3 Energy performance demands

In order to have reasonable comparison of all scenarios, the different exterior walls were chosen to have the same U-value. The insulation of the exterior CLT was increased so that the wall systems equal the U-value of the concrete and brick exterior wall. The U-value for both walls was recalculated without taking any consideration for thermal bridges or openings for any case. See Appendix C for the energy calculations. All scenarios are designed with the same amount of insulation for the foundation and the roof.

The original reference house was designed to achieve an energy consumption lower than 67,5 kWh/year/m^2. A detailed energy calculation specifically stating the energy performance have not yet been carried out. As such, the choice was made to use the most conservative value of 67,5 kWh/year/m^2.

5.2.4 Structural system demands and design

The feasibility of the structural CLT-elements will very briefly be covered. Based on the floorplan in Figure 8, dead and live loads have been calculated for an exterior and interior load bearing wall. The slabs will be chosen based on a design table provided by Martinsons. The vertical load bearing capacity in Ultimate Limit State (ULS) and Service Limit State (SLS) of the vertical elements will be verified by the CLT design software 'Calculatis', provided by the manufacturer Stora Enso. Calculatis also provide ULS calculations during a fire scenario. No stability check of the structural system is provided as no horizontal loads are derived. The goal of the structural analysis is only meant to provide a coarse feasibility check of the system and is not intended to go into any further detailed calculations. This is mainly due to the low level of structural and architectural detail provided by the generation method of the scenarios and time limitations of the study.

The utilization rate of the vertical elements analysed in Calculatis range from 32 % to 80 %. The load derivations and the result in Calculatis are seen in Appendix C. It is questionable to choose elements with such low utilisation rate. However, many more aspects and phenomena have to be considered. The choice of element size are further motivated by the fact that they have been used in similar projects (Larsson et al. 2016).

A timber building is lighter than a comparable building in concrete. As such, it could be argued that a thinner concrete slab could be used. However, the same 150 millimetre thick that is used for the Reference case will be used for all scenarios. Mainly due to the lack of a detailed structural analysis. Such a slab is already used for the Reference case and will therefore not be changed. However, the area of the slab will change as the area of the building will differ between scenarios.

5.3 Standard build components used

Skanska are using a set of standard build components in design in order to minimize risk for construction errors and unforeseen costs. The components are to be used as input for design of both residential and commercial buildings. The aim of having standard components is to promote the development of rational products that helps to minimize costs and increase the technological performance of the buildings.

All standards products that Skanska uses have been thoroughly tested both in theory and practice and provide a reliable platform. The standard build components described below have been used earlier in the reference houses. As such, they work as a basis for the scenarios in the case study. The standard build components used for the study and their properties are described in Table 4. All building elements are described in detail in Appendix B.

Table 4: Chosen standard build components and their technical properties.

Description	**Thickness [mm]**	**Acoustic performance**	**Fire safety performance**	**U-value [W/(m^{2}K)]**
Concrete wall with brick façade	500	Rw+Ctr50 > 45 dB(A)	N/A	0,1629
Apartment separating wall	200	Sound class B	R60	N/A
Filigree slab	245	Sound class B	R60	N/A
Hollow core slab	355	Sound class C	R60	N/A

Two types of concrete slabs have been used in the case study, a filigree slab and a hollow core slab. Generally concrete slabs have certain major advantages over pure CLT-slabs. They provide better sound insulation and a better thickness to span ratio. As the CLT-slabs need extra sound insulation measures to meet building regulation demands, that ratio becomes substantially worse

5.3.1 Stairwells with elevator

Skanska has several standard and modifiable stairwells. Having cost and area efficient stairwells are an important part in having a successful multi residential project. The most relevant demands regarding stairwells for this study is sound insulation and fire safety.

The standard configuration uses a 200 mm concrete wall. In order to fulfil sound class B, it may have to be complemented by extra concrete, insulation or certain details depending on situation.

The existing scenario of the reference houses uses the standard 200 mm concrete wall separating the apartments and creating the stairwell. As the apartments are designed to be able to be evacuated from the windows, with help from the fire brigade, the stairwell will not fulfil Tr2. In some scenarios, the apartment walls will be replaced with appropriate CLT elements.

5.4 Introduced CLT products

The CLT products used in the case study are taken from the Swedish manufacturer and supplier Martinsons. Simply due to Martinsons being the largest supplier of CLT products in Sweden and that they provide adequate technical info regarding their products. The technical differences from other manufacturers is considered as small.

Since the span of CLT slabs are generally shorter than filigree and hollow core slabs, the floor plan was designed to utilise a maximum span of seven meters in order to be able to have the same layout for both types of slabs.

The CLT products have been imported to SPIK and put into the method of generic data for the reference house, so that they can easily be used in the analysis. An overview of the chosen products can be seen in Table 6.

Table 5: Description of the chosen CLT elements and their properties.

Description	Thickness [mm]	Acoustic performance	Fire safety performance	U-value [W/(m^2K)]
Exterior wall	397*	Rw= 52 dB(A)	REI 90	0,1629**
Apartment wall	369	Rw>60 dB(A)	REI 60	N/A
CLT slab, with noise impact reducing mat	438***	Sound class C, Rw>48 dB(A), Lnw= 54 dB(A)	R60	N/A
Balcony with decking	297	N/A	N/A	N/A

* Modified with extra insulation to match the U-value of VAB 12
** According to own calculations, not taking openings into account
*** Increased size of the CLT slab in order to obtain a sufficient span

For detailed illustrations of the components, see Appendix B.

5.5 Secondary effects due to the choice of built components

Ylmén et. al (2017) provides examples of secondary effects due to extra insulation added in exterior walls. Similar effects will occur in this case study, due to the enlargement of building components when substituting concrete for timber. Figure 9 shows the secondary effects Ylmén et. al (2017) identified in their study.

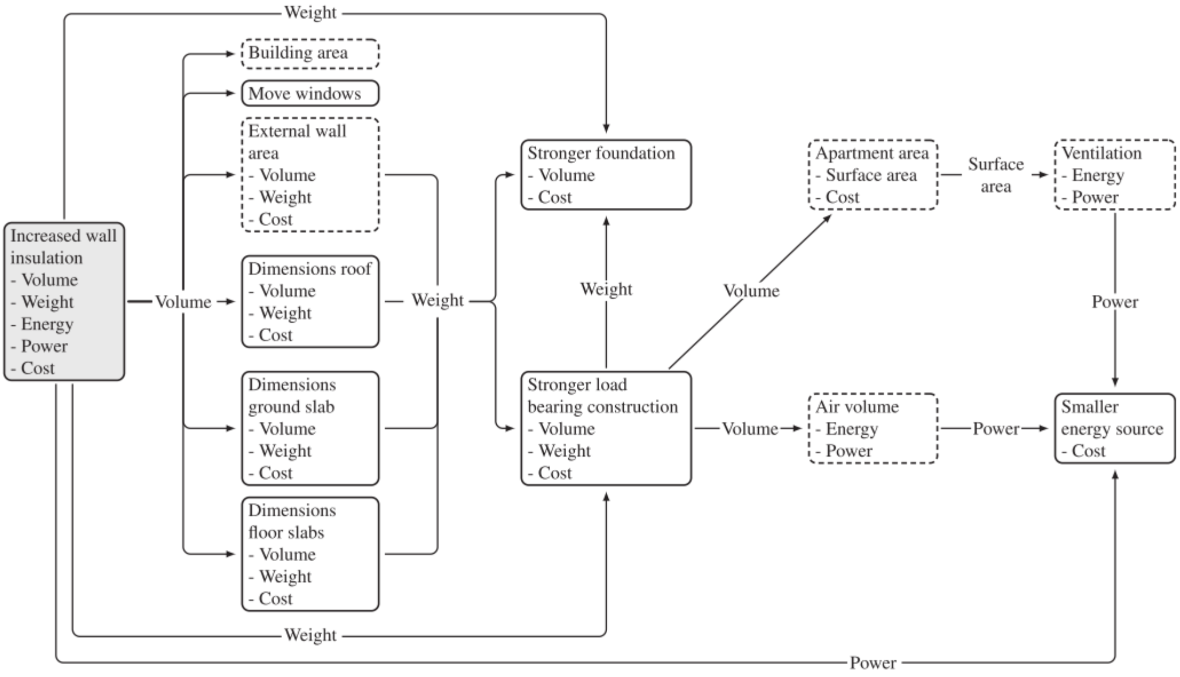


Figure 9: Example of secondary effect for a residential building (Ylmén et al. 2017).

A somewhat simplified principle will be used in the case study. Each CLT element introduced will induce certain secondary effect, except the balconies. The most prominent secondary effects are illustrated in Figure 10.

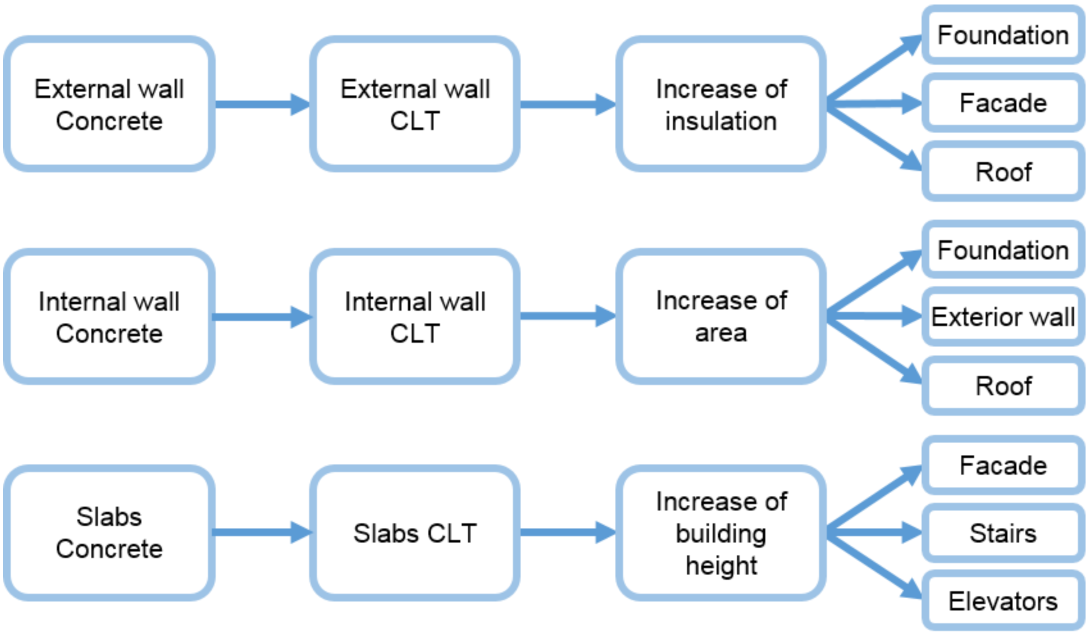


Figure 10: Illustration of the most prominent secondary effects occurring in the scenarios.

Basically, this study will only cover the amount of materials added or reduced. Effects on installations, indoor climate, daylight properties, acoustic properties and the fire safety are omitted. The secondary effects included for each scenario is stated in Section 5.6 and their calculations are presented in Appendix D.

5.6 Scenarios for the case study

The scenarios of the case study have been based on one variant of the existing reference house, called the Reference case. The idea for the scenarios A-E is to gradually increase the amount of CLT in the structure to give a clear illustration of the potential of each group of components. A summary is given in Table 7.

Table 6: Summary of scenario content.

Scenario	**Exterior walls**	**Balconies**	**Apartment walls**	**Slabs**
Reference case	Concrete	Concrete	Concrete	Filigree
A	CLT	CLT	Concete	Filigree
B	Concrete	Concrete	CLT	Filigree
C	CLT	CLT	CLT	Filigree
D	CLT	CLT	CLT	Hollow core
E	CLT	CLT	CLT	CLT

In Figure 11 an illustration of the Reference case can be seen. As described in Table 7 all elements for the scenario are in concrete, which is illustrated by grey colour in the figure.

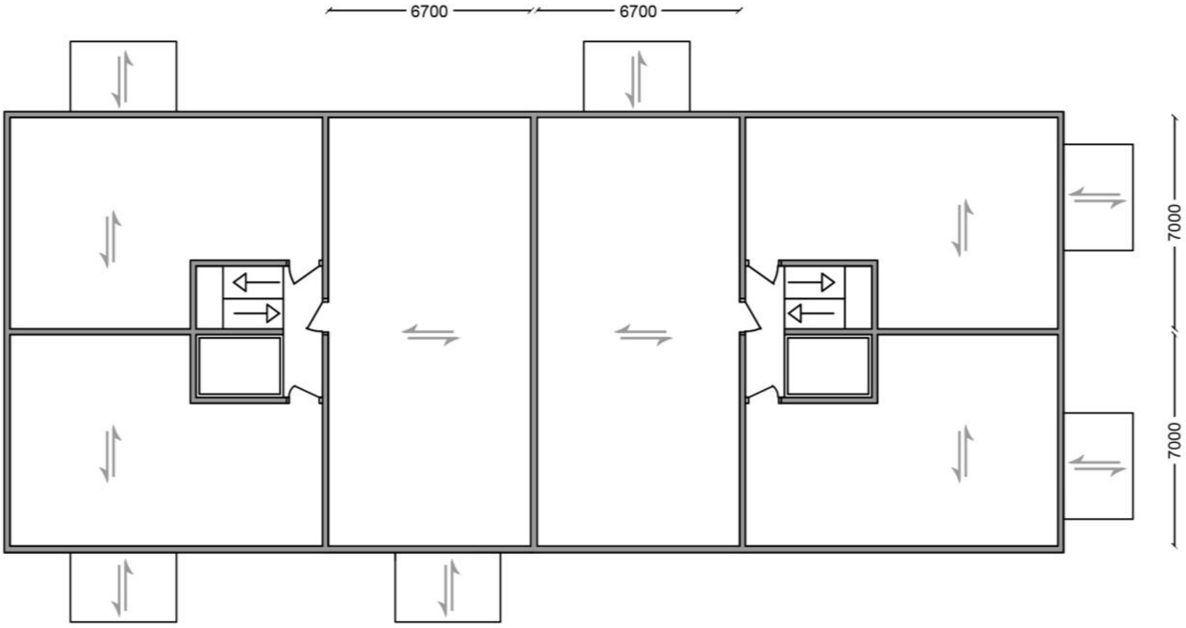


Figure 11: Illustration of the load bearing members in the Reference case, the grey colour indicates concrete members.

5.6.1 Scenario A

As described by Table 7, the exterior walls and balconies are replaced by CLT elements in Scenario A. In order to obtain an equal U-value for the CLT exterior wall compared to the concrete comparison, approximately 17.5 % more mineral wool was added. However, the secondary effects on the volume of the house affecting the slab and façade are much smaller from a relative point of view. The changes in the floor plan are illustrated in Figure 12.

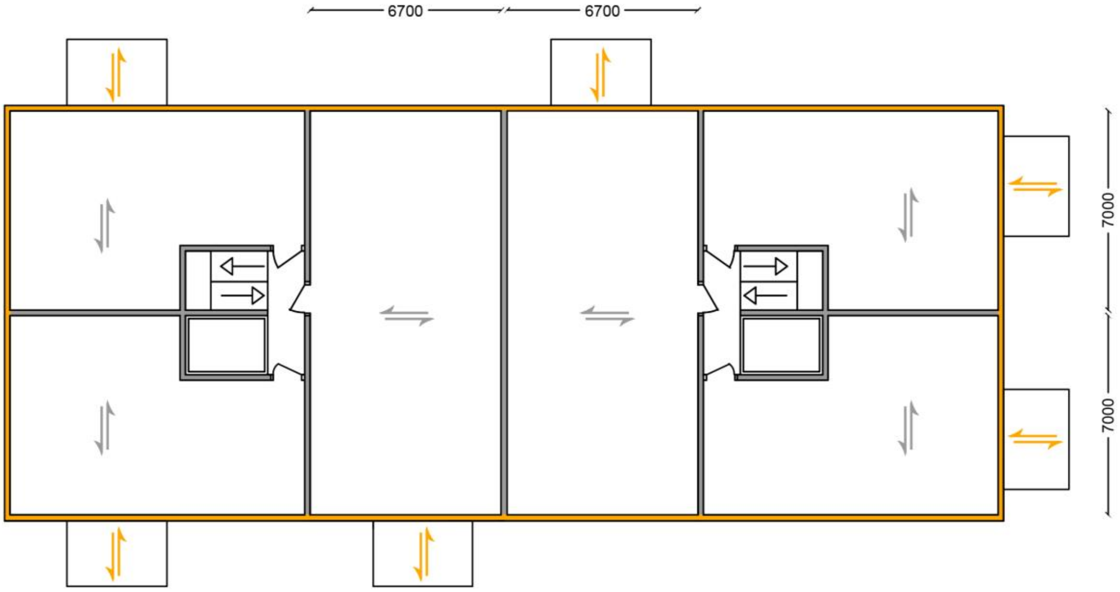


Figure 12: Illustration of the changes made for the load bearing members in Scenario A, where the exterior walls and balconies were replaced by CLT elements, represented by orange colour.

The following secondary effect were accounted for:

- Insulation thickness: From 200 mm to 235 mm
- Foundation area: From 513 m^2 to 514 m^2
- Roof area: From 545 m^2 to 548 m^2

- Façade area: From 1415 m² to 1417 m²

5.6.2 Scenario B

In Scenario B the load bearing walls between the apartments are replaced to CLT elements. These walls utilise two separated load bearing components in order to achieve the acoustic demands. Due to their increased thickness, the area and volume of the house is increased. The floor plan for Scenario B is illustrated by Figure 13.

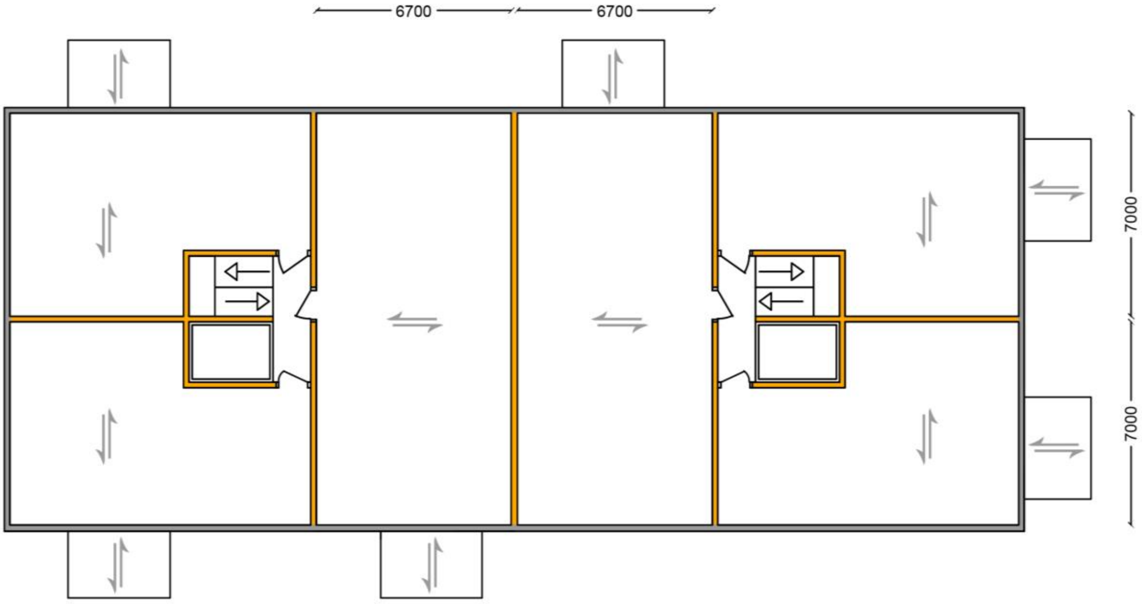


Figure 13: Illustration of load bearing components in Scenario B, where orange represent CLT and grey concrete members.

The following secondary effect were accounted for:

- Foundation area: From 513 m² to 531 m²
- Roof area: From 545 m² to 565 m²
- Façade area: From 1415 m² to 1444 m²

5.6.3 Scenario C and D

The only difference between Scenario C and D are the concrete slabs, where C utilise a filigree slab and D have a hollow core solution. The hollow core elements are 362 mm thick and the filigree slabs are 250 mm thick. Both scenarios have all vertical members and the balconies in CLT. Hence, the floor plan in Figure 14 serves for both scenarios.

Also, the secondary effects for both cases are similar. For Scenario C, the following applies:

- Insulation thickness: From 200 mm to 235 mm
- Foundation area: From 513 m² to 535 m²
- Roof area: From 545 m² to 568 m²
- Façade area: From 1415 m² to 1448 m²

For Scenario D, the following changes occurred:

- Insulation thickness: From 200 mm to 235 mm
- Foundation area: From 513 m² to 535 m²
- Roof area: From 545 m² to 568 m²
- Façade area: From 1415 m² to 1505 m²

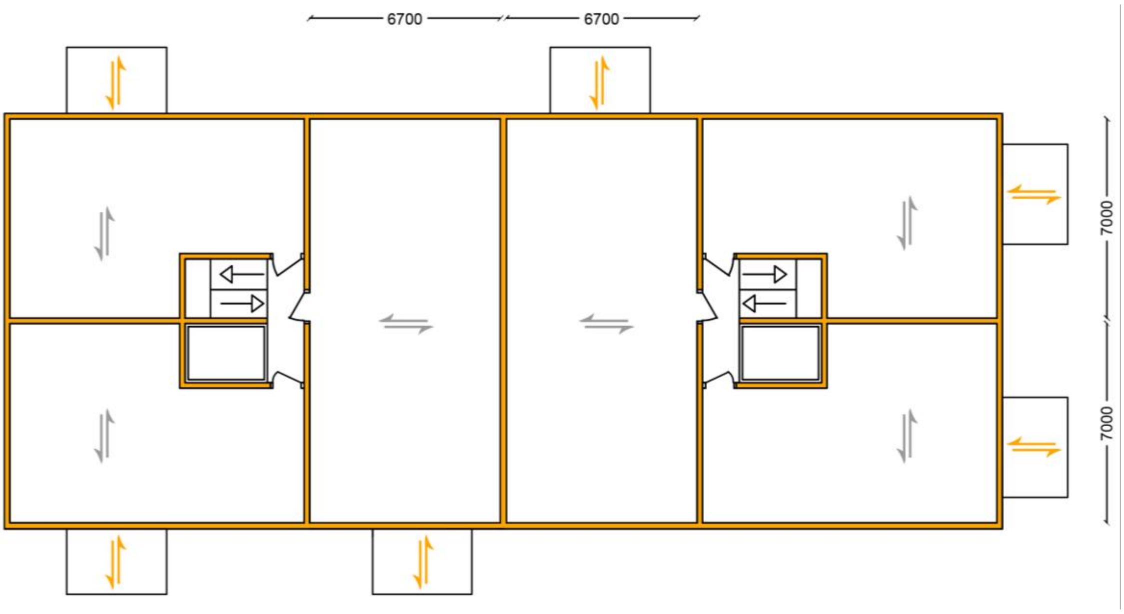


Figure 14: Illustration of load bearing components in Scenario C and D, where orange represent CLT and grey concrete members.

5.6.4 Scenario E

In Scenario E all load bearing member consist of CLT elements. Naturally, the largest secondary effects are therefore seen in this case. For Scenario E, the following changes occurred:

- Insulation thickness: From 200 mm to 235 mm
- Foundation area: From 513 m^2 to 535 m^2
- Roof area: From 545 m^2 to 568 m^2
- Façade area: From 1415 m^2 to 1543 m^2

The load bearing system for the scenario is illustrated by Figure 15.

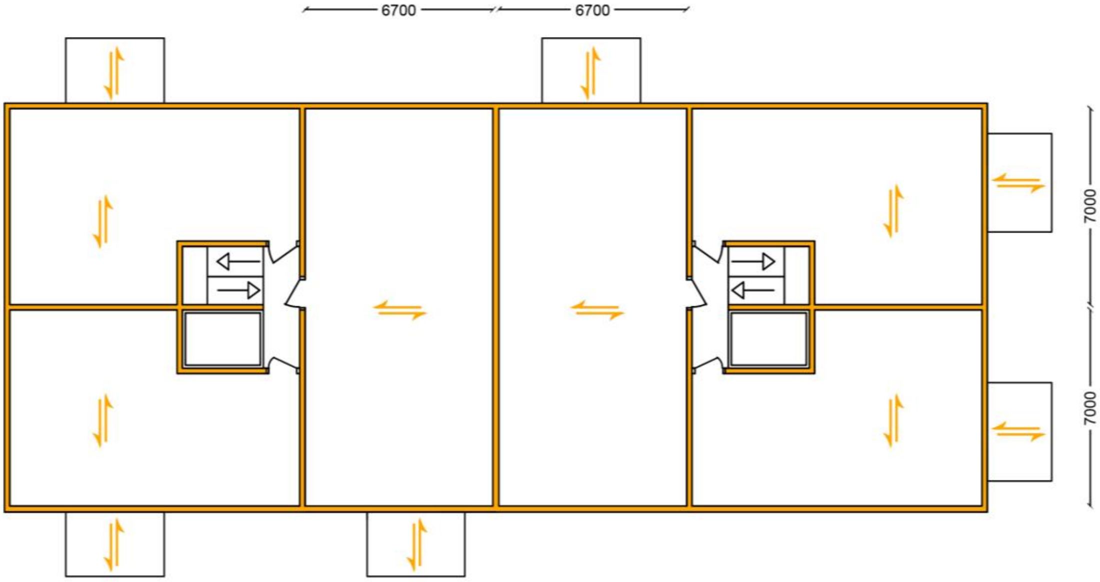


Figure 15: Illustration of Scenario E, where all load bearing components consist of CLT elements.

6 LCA OF THE CASE STUDY

This chapter covers the choices made with regards to LCA methodology for the case study and its result. The goal and aim of the study is stated in Section 6.1, along with important frameworks for the LCA. Section 6.2 includes the LCI where the material data for the scenarios are quantified. Further important common data, such as operational energy use, is also described. Finally, Section 6.3 states the result of each scenario with regards to the functional unit chosen and general GWP.

6.1 Goal and scope

The goal of the LCA is to study the environmental impact by gradually increase the amount of CLT in the load bearing structure of a reference house. Functional demands of the building stated in Section 5.2 must be kept and secondary effects between the scenarios are to be considered. The aim of the study is to shed light on the possibilities of hybrid structures, where theoretically the benefits of each material could be maximised. The intended audience is therefore decision makers within Skanska and the Swedish construction industry.

6.1.1 Functional unit

The functional unit used for this study is 1 m^2 of heated floor area (A_{temp}). Heated floor area includes usable area within apartments, entrance, stairwells and storage areas. The unit is commonly used in similar studies and is therefore a viable choice with regards to comparability.

6.1.2 Impact categories

The only impact category considered in this study is Global Warming Potential (GWP). Mainly because it is the main focus of the industry today, including Skanska. Sveriges Byggindustrier and IVA (2014) states that the emissions from the construction industry in Sweden accounts for 17 % of the country's greenhouse gas (GHG) emissions. GHG include many other gases than CO_2, which are all weighted into CO_2-equivalents in order to calculate the GWP of the complete reference flow of the system. The weighting process is regulated by SS EN 15804 and calculated with help of Anavitor and the IVL database.

Regarding potential allocation issues, the IVL database follows the allocation standard stated in SS EN 15804.

6.1.3 System boundaries

The LCA cover the production stage (A1-A5), maintenance and replacements (B2 & B4), operational energy use (B6), and the end of life stage (C1-C4). Hence, the use stage (B1) and water usage (B5) are excluded due to being highly dependent on the end users. The system boundaries are illustrated through Figure 16. The potential benefits of recycling material (D stage) are later studied in a sensitivity analysis in Chapter 7.

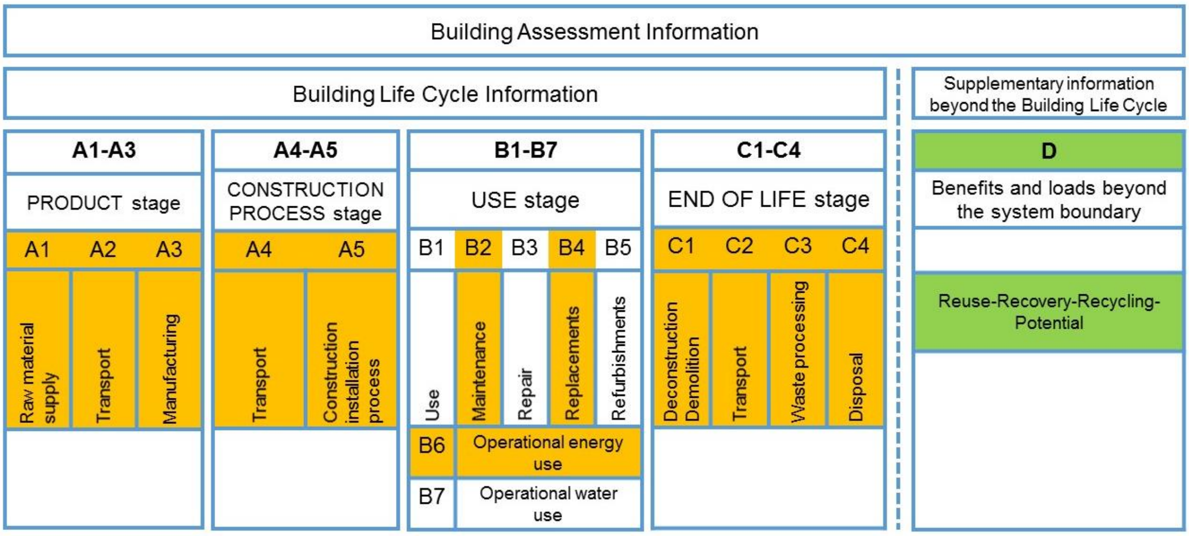


Figure 16: The included stages for the case study LCA, the D stage marked in green is covered through a sensitivity analysis.

The time frame for the study is 50 years. It is a common time frame used in LCA for residential buildings and a common time span between major renovations, further it is a common design parameter for structural systems (Liljenström et al. 2015).

All the scenarios will geographically take place in Gothenburg. Several important aspects differ regionally within Sweden, such as energy mix, heating methods and transport distances. As such, the result of the study may vary between different choices of project location. However, the main scope of the study is the differences of environmental impact differences between structural hybrid scenarios in the production stage (A1-A5), therefore Gothenburg will serve as a location for the LCA.

Due to the high level of detail in calculation from SPIK, the LCA could be argued to have a fairly high detail level. For example, appliances, interior cladding and some installations are included and accounted for with regards to GWP.

For natural reasons, not everything relating to a construction project can be included. Environmental impact based on the activity of individuals and production of capital goods are excluded. This include for example extended commuter distances for workers due to the site location.

Data and assumptions is aimed to be relevant with current technical development. Hence, the LCA does not account for potential technical development progression in critical areas. However, the potential of technical development is discussed in Section 8.3.

6.2 Life Cycle Inventory

The flowchart in Figure 17, gives an illustration of the different scenarios from a life cycle perspective. Only products that differ between the scenarios have been chosen to be included in the flowchart, although all aspects that are similar the scenarios are included in the assessment.

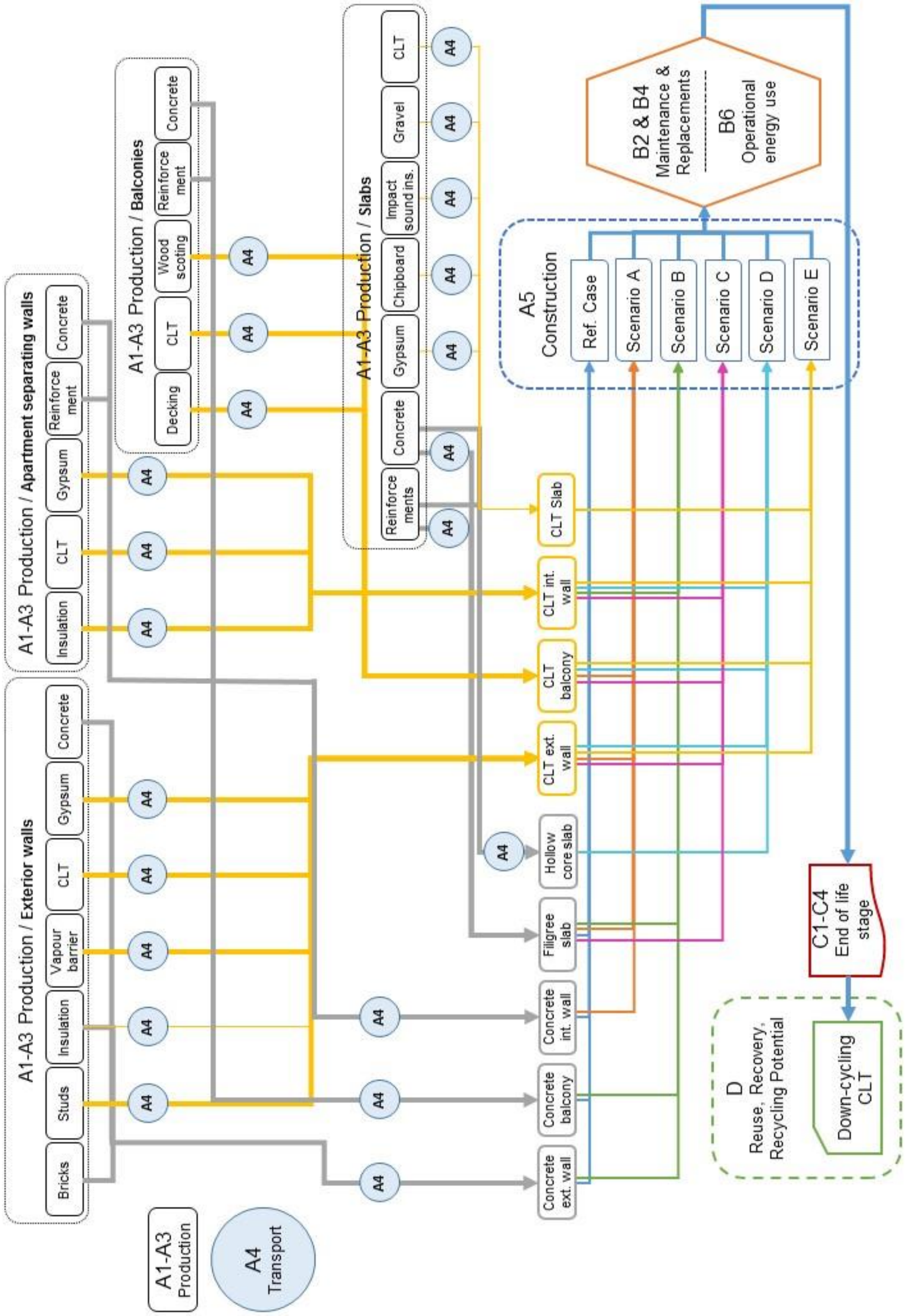


Figure 17: A flowchart over the components that are changed within the scenarios.

6.2.1 Inventory lists of materials

The heaviest material groups for each scenario are listed below. Differences occur due to the scenario design and secondary effects. For complete inventory lists of each scenario, see Appendix D. As shown below for each scenario, the heaviest material groups contribute to a very large majority of the total weight and GWP.

The level of detail of the calculation is considered to be satisfactory. Only minor details, such as detail fittings, are not included and their impact for the result is evaluated as negligible.

The amount of parquet is calculated through the area footprint of the building and therefore increasing throughout the scenarios. This effect is not adjusted for due to the low impact of the total result.

6.2.1.1 The Reference case

No secondary effects occur for this scenario, as it is the Reference case of the study. The scenario includes load bearing members mainly in concrete, as seen in Section 5.1.

Table 8, show the heaviest material groups included in the building. Unsurprisingly, concrete is clearly the dominating material, which is explained by the whole structural building system is in concrete, followed by mortar and plaster, and finally bricks.

Table 7: The heaviest material groups included in the Reference case.

Material	Amount [kg]
Concrete	3105490
Mortar and Plaster	128050
Bricks	91514
Steel	65838
Gypsum boards	43537
Glazed tiles	41532
Wood products	37859
Parquet	33458
Mineral wool	27933
Gravel	25170
Windows	23459

These products and material groups account for 98 % of the total weight of the building and 79 % of its GWP in the production phase (A1-A5).

6.2.1.2 Scenario A

Scenario A replaces the exterior walls and balconies into CLT elements. In Table 9 below, this is illustrated by the decrease of concrete and steel together with the increase of wood, gypsum and mineral wool.

Table 8: The heaviest material groups included in Scenario A.

Material	Amount [kg]	Percentage of the Reference case
Concrete	2572539	83%
Wood products	137579	363%
Mortar and Plaster	123730	97%
Bricks	91860	100%
Steel	58307	89%
Gypsum boards	57341	132%
Glazed tiles	41536	100%
Parquet	33553	100%
Mineral wool	31627	113%

Gravel	25221	100%
Windows	23465	100%

The heaviest material groups included in Scenario A accounts for 98 % of the total weight of the building and for 75 % of its GWP in the production phase (A1-A5).

6.2.1.3 Scenario B

Scenario B replaces the interior walls and much of the same trends as in Scenario A can be observed in Table 10. Due to the increased thickness of the walls, the area and volume of the building is enlarged, leading to small increments in the amounts of parquet, gravel and windows.

Table 9: The heaviest material groups included in Scenario B.

Material	Amount [kg]	Percentage of the Reference case
Concrete	2528790	81%
Wood products	132139	349%
Mortar and Plaster	127010	99%
Gypsum boards	115593	266%
Bricks	93539	102%
Steel	59372	90%
Glazed tiles	41556	100%
Mineral wool	37002	132%
Parquet	34753	104%
Gravel	25975	103%
Windows	24095	103%

The material groups in Table 10 account for 98% of the total weight of Scenario B and 74% its GWP in the production phase (A1-A5).

6.2.1.4 Scenario C

Scenario C uses CLT elements for balconies, exterior and interior walls. As such, the amounts of wood products, gypsum and mineral wool is increased. The same trend of secondary effects as in Scenario B is also observed in Table 11.

Table 10: The heaviest material groups included in Scenario C.

Material	Amount [kg]	Percentage of the Reference case
Concrete	2011971	65%
Wood products	224866	594%
Gypsum boards	130221	299%
Mortar and Plaster	127540	100%
Bricks	93782	102%
Steel	59878	91%
Glazed tiles	41560	100%
Mineral wool	39791	142%
Parquet	35000	105%
Gravel	26151	104%
Windows	24095	103%

The heaviest material groups in Scenario C make up 98 % of the building's total weight and 72 % of its GWP.

6.2.1.5 Scenario D

The hollow core elements of Scenario D results in a lighter building, due to the decreased concrete usage. This in combination with an increased thickness of the slabs leads to a relative increment of most materials, as seen in Table 12. However, the steel usage is notably decreased, mainly due to less reinforcement bars used in the hollow core slabs.

Table 11: The heaviest material groups included in Scenario D.

Material	Amount [kg]	Percentage of Reference case
Concrete	1842301	59%
Wood products	228045	602%
Mortar and Plaster	151892	119%
Gypsum boards	130780	300%
Bricks	97507	107%
Steel	51690	79%
Glazed tiles	41560	100%
Mineral wool	36524	131%
Parquet	35000	105%
Gravel	28200	112%
Windows	24892	106%

Accumulating the weight of the materials in Table 12, they account for 98 % of the total weight of the building. Further, they account for 68 % of its GWP in the production phase (A1-A5).

6.2.1.6 Scenario E

Wood is the dominant materials in Scenario E and the concrete usage is decreased by 85 percentage units compared to the Reference case. Also, it is clearly shown by Table 13 that the secondary effects are largest in this scenario.

Table 12: The heaviest material groups included in Scenario E.

Material	Amount [kg]	Percentage of Reference case
Wood products	575188	1519%
Concrete	469560	15%
Gypsum boards	130991	301%
Mortar and Plaster	124668	97%
Bricks	98943	108%
Mineral wool	52766	189%
Glazed tiles	41560	100%
Steel	35588	54%
Parquet	35000	105%
Gravel	26151	104%
Windows	25522	109%

For Scenario E the heaviest material groups account for 95 % of the total weight and 64 % of the total GWP in the production phase (A1-A5).

6.2.2 Databases and other key data used

The main data used in Anavitor stem from the IVL-database. The following sections go into detail on crucial data points from the IVL-database and describe the origin of such data. Firstly, a review regarding long and short resources, as described in Section 2.2.2, of the different scenarios is made. This is followed by sections where; a case is made regarding choice of transport distances of products, choice of data regarding construction methods, what maintenance and replacements that is accounted for and total operational energy use during the life cycle.

Table 14 below, show the percentage of short resources calculated in the production and construction stages of each scenario. All scenarios have the same fixed amount of secondary calculated resources, but the percentage increase in the latter scenarios as the GWP is reduced. The main contributors to secondary calculated resources are found in resource groups such as ground work, VA, plumbing and electricity, and elevator installation. The uncertainty for these groups are mainly due to that they are carried out by subcontractors. Scenario E stand out with 23 % secondary resources, the extra increase comes from impact sound insulation material in the CLT slabs.

Table 13: Percentages of resources being short in each scenario.

Reference case	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
16%	17%	18%	19%	18%	23%

The effects of carbonation of concrete are not included due to the large uncertainties associated with the amount of exposed concrete in the building.

6.2.2.1 Transport distances

A critical data point in terms of transport concerns CLT-elements. Building components containing CLT elements are based on Martinsons' product portfolio. Hence, it is also assumed that the CLT elements are delivered from Martinsons' production facility in Bygdsiljum in the north of Sweden. Due to the limited amount of CLT suppliers in the national market of Sweden, the transport distance from Martinsons' facility to Gothenburg (1055 km) could be considered both reasonable and conservative at the same time. Reasonable in relation to the present state of the market and conservative in terms of future development, where production could potentially take place with a closer vicinity. A summary of all transport distances used is shown in Table 15.

Table 14: Summary of all transport distances used for the analysis.

Transport	Distance [km]
CLT elements	1055
Recycling station	50
Waste	40
Landfill	40
Waste incineration	70
Concrete reinforcement	100
Bathroom elements	300
Concrete	40
Concrete elements	300
Tiles and ceramics	200
Steel	250
Misc. materials	250
Bricks	250
Local stone	5

6.2.2.1 Production of CLT elements (A1-A3)

Data regarding the production of CLT elements is based on an EPD from Martinsons' production. It should be duly noted that the principles of EN 15804 regarding biogenic carbon in the product stage (A1-A3) has been applied to data from said EPD (Martinsons Såg AB 2015). This means that the biogenic carbon is assumed to be climate neutral in the production stage already, while in reality such an assumption is true first when the wood is incinerated at the end of the life cycle.

6.2.2.2 Production of concrete (A1-A3)

The emission factors used for concrete products are adjusted according to type of quality of the concrete. All concrete types have been calculated with the same density of 2350 kg/m^3. Table 16, list all emission factors used for materials related to concrete.

Table 15: Emissions factors used for included concrete types.

Material	Unit	Emission factor [kg CO_2- eq./ unit]	Transport distance [km]
Reinforcement steel	kg	0,824	500
Construction steel, galvanized	kg	1,795	250
Construction steel	kg	1,712	250
Concrete balcony	kg	0,169	300
Interior walls 200 mm	m^3	273,0	300
C25/30	m^3	286,3	40
C28/35	m^3	303,3	40
C35/45	m^3	358,1	40
Hollow core slabs 270 mm	kg	0,193	300

6.2.2.3 Construction stage (A5)

Due to the lack of data concerning the construction with CLT elements certain assumptions have been made. It has been assumed that the construction process with CLT elements is more similar to prefabricated concrete elements than classic wood-frame structures. Therefore, construction data regarding prefabricated concrete is used in favour of data used by Kurkinen et al. (2017) stemming from Bergman and Tillman (1997). Data regarding construction with prefabricated concrete origins from the IVL data-base.

6.2.2.4 Maintenance and replacements (B2-B5)

Maintenance and replacements have been considered on the brick facade, windows and concrete roof tiles. This, is mainly due to these being the most important components to uphold the functionality of the building envelope. Data stem from Erlandsson and Holm (2015), with the aim of establishing a data-base regarding maintenance and replacements of building elements. Assumed maintenance and replacements intervals are presented in Table 17 below.

Table 16: Assumed maintenance and replace intervals used in the analysis.

Building element	Type	Interval [years]
Brick facade	Maintenance	25
	Replacement	49
Windows	Maintenance	10
	Replacement	40
Concrete roof tiles	Maintenance	10
	Replacement	40

Maintenance or replacement of structural building components are not considered in this LCA. While, concrete systems for residential buildings have a proven possible life time expectancy of 50 to 100 years, depending on design decisions, CLT components have a (according to industry) life expectancy of at least 50 years. Any maintenance or replacements of structural building system components is therefore assumed to take place outside the system boundary time frame. Also, such replacements could be argued to be so extensive that the initial build decision could be dependable of the outcome.

6.2.2.5 Operational Energy (B6)

The original reference house was designed to achieve an energy consumption lower than 67,5 kWh/year/m^2. A detailed energy calculation specifically stating the energy performance have not yet been carried out. As such, the choice was made to use the most conservative value of 67,5 kWh/year/m^2.

The energy mix used in the LCA is 'Nordic Residual'. The Nordic Residual consist of the energy that is left once all environmentally friendly energy have been bought on the Nordic energy market. Therefore, the choice of energy mix should be considered as conservative. The Nordic Residual energy mix used in Anavitor is based on old data from 2005-2007.

6.2.2.6 Key data for the end of life stage (C1-C4)

Demolition is assumed to be carried out with machinery running on diesel and construction tools running on electricity. Wood products are assumed to be sorted out and transported to a facility for incineration, while concrete is assumed to be transported to a facility for crushing, based on Erlandsson and Holm (2015). Transport distances can be found in Table 15.

6.3 Life Cycle Impact Assessment - Results of the study

The following section presents the result of the case study for each scenario. In Section 6.3.7 a comparison of all scenarios is presented.

6.3.1 Reference case

From Figure 18 it is clear that the largest GWP is derived from the operational energy usage during the life time of the building. The second largest GWP comes from the production stage with 39% of the total GWP. Maintenance and replacements during the life cycle account for 4% of the total GWP.

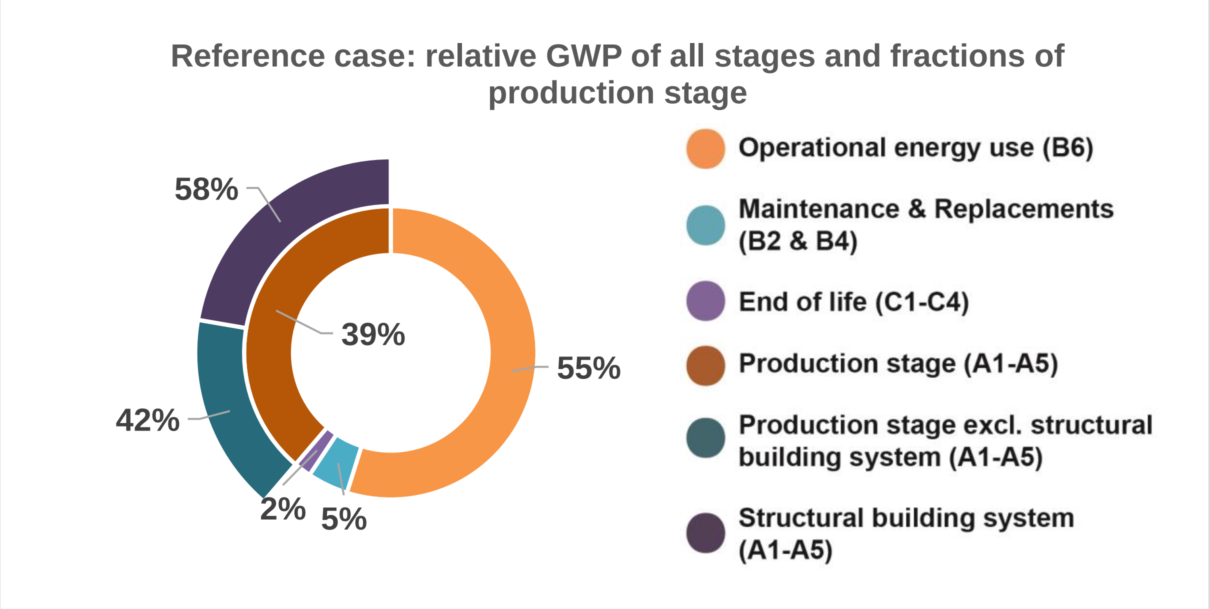


Figure 18: Impact distributions between life cycles for the Reference case.

Figure 18 also illustrate how the structural building components account for the majority of the GWP in the production stage. The largest GWP can be assigned to the filigree slabs, as seen in Figure 19. This is followed by the 'Miscellaneous' category, containing activities that do not fit the other categories such as operational resources at the construction site and complementing activities. The 'Miscellaneous' category is followed by 'Exterior walls' and 'Apartment separating walls (Prefab 200mm)'.

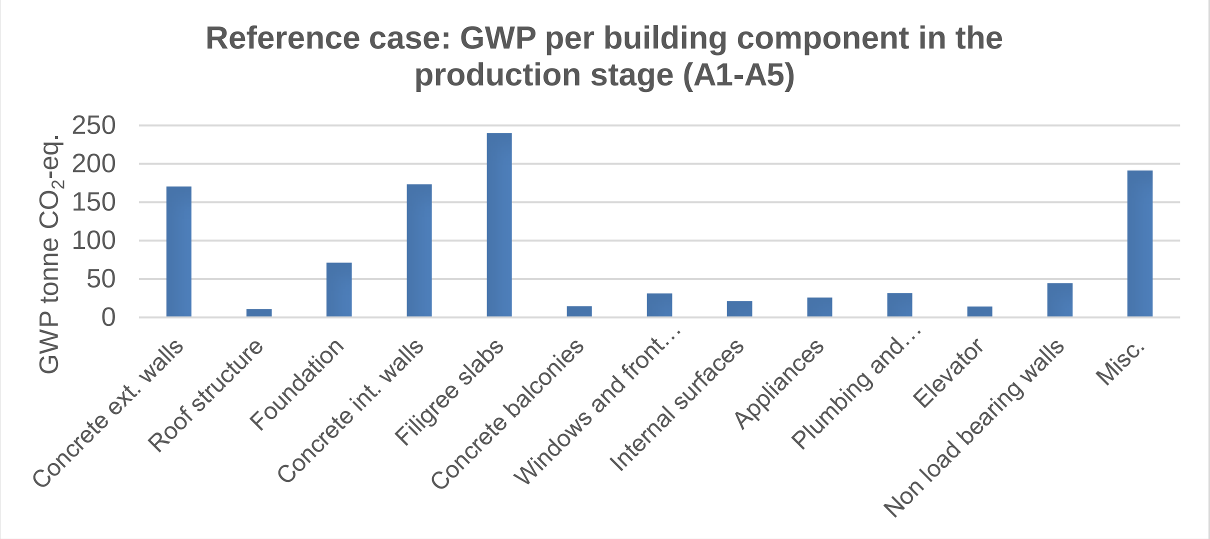


Figure 19: GWP contribution for included building components in the Reference case.

6.3.2 Scenario A

Due to the reduced GWP in the production stage, the operational energy use account for larger relative emissions in Scenario A. Also, the operational energy usage increase due to secondary effects. The effects are summarized by Figure 20.

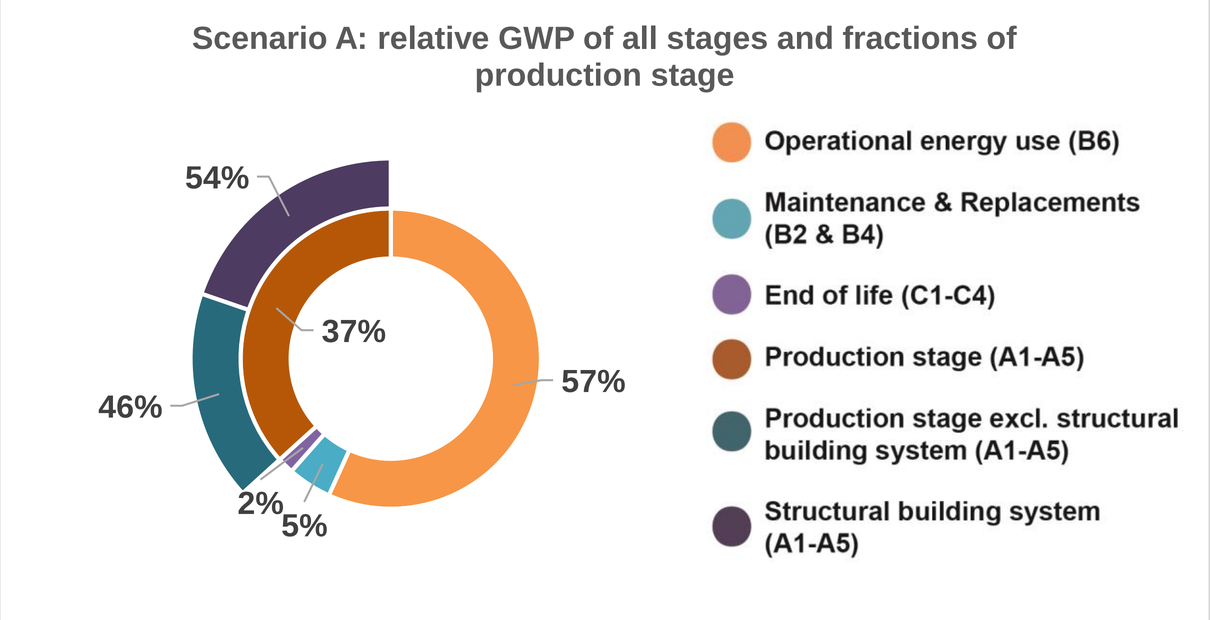


Figure 20: Impact distributions between life cycles for Scenario A.

As seen in Figure 21, filigree slabs continue to be largest GWP contributor in the production stage. The second largest post is again the 'Miscellaneous' category. The third biggest GWP can be assigned to the concrete 'Apartment Separating Walls (Prefab 200mm)'. The CLT 'External walls (YV-22-01)' have the fourth biggest GWP. Less than half the GWP of the replaced concrete exterior wall is produced by the exterior CLT wall.

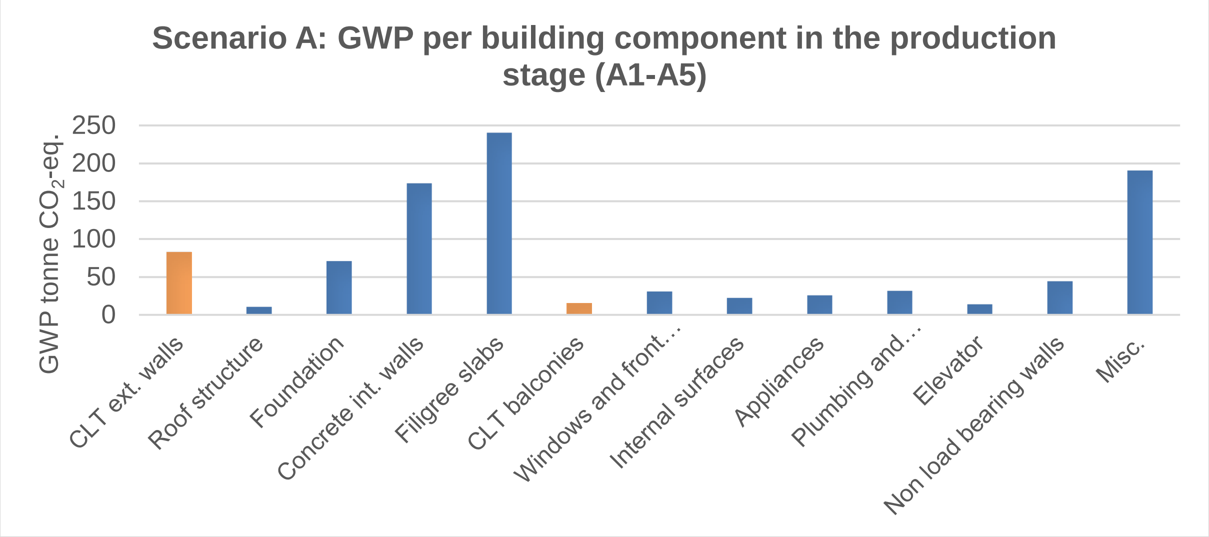


Figure 21: GWP contribution for included building components in Scenario A.

6.3.3 Scenario B

The same trend regarding operational energy usage can be seen in Scenario B, in Figure 24. The proportion increase because of a total reduction of GWP compared to the Reference case scenario, but also due to an increase in energy use deriving from secondary effects caused by replacement to apartment separating walls in CLT (LS-11-01)", which also result in a significant reduction of GWP in the 'Production (A1-A5)' stage.

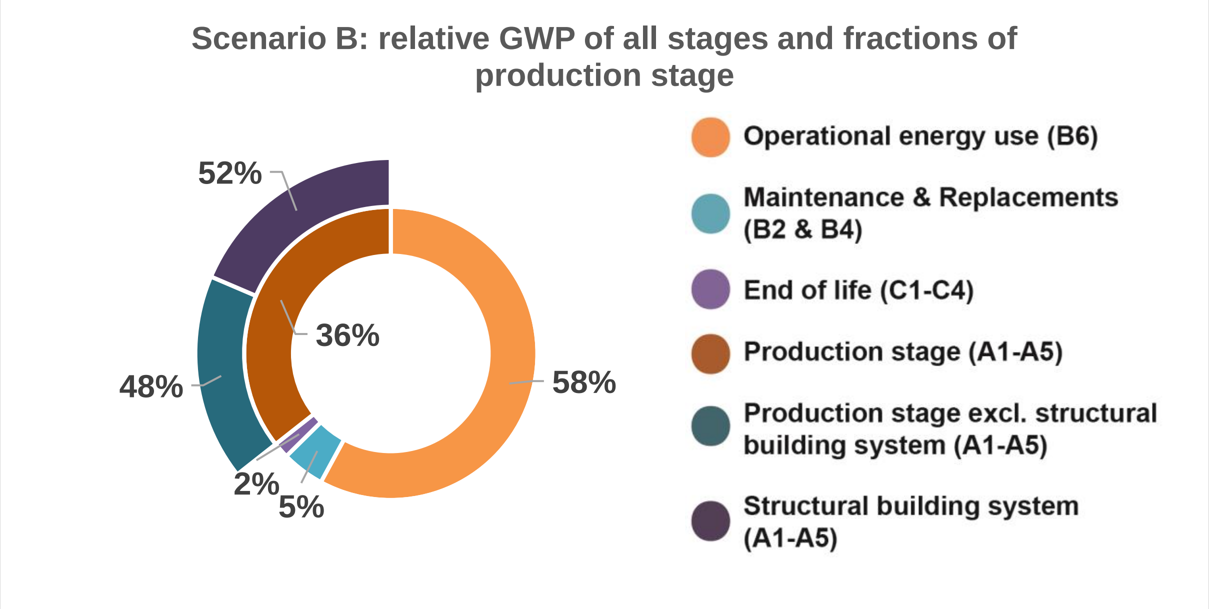


Figure 22: Impact distributions between life cycles for Scenario B.

A significant reduction of GWP for the apartment separating wall can be seen in Figure 25 compared to the Reference case, from 173203 kg CO_2-eq. to 47576 kg CO_2-eq.

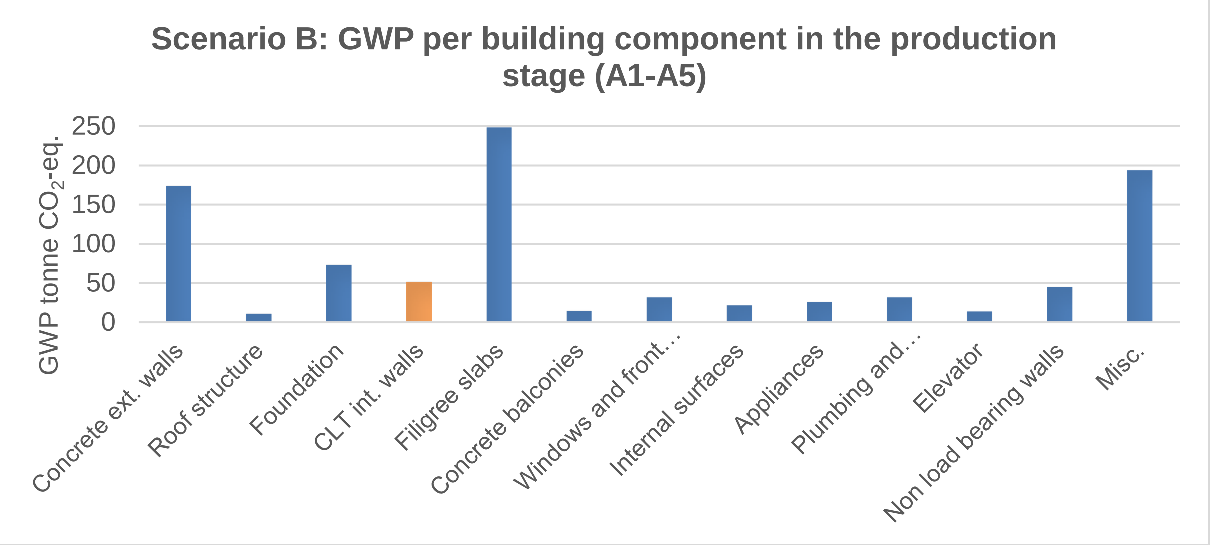


Figure 23: GWP contribution for included building components in Scenario B.

6.3.4 Scenario C

The operational energy use (B6) continue to increase both in absolute and relative numbers, see Figure 22. Again, this is due to a reduction of GWP in mainly the production stage (A1-A5) in combination with a total increase of operational energy use caused by secondary effects when replacing external walls and apartment separating walls to CLT alternatives.

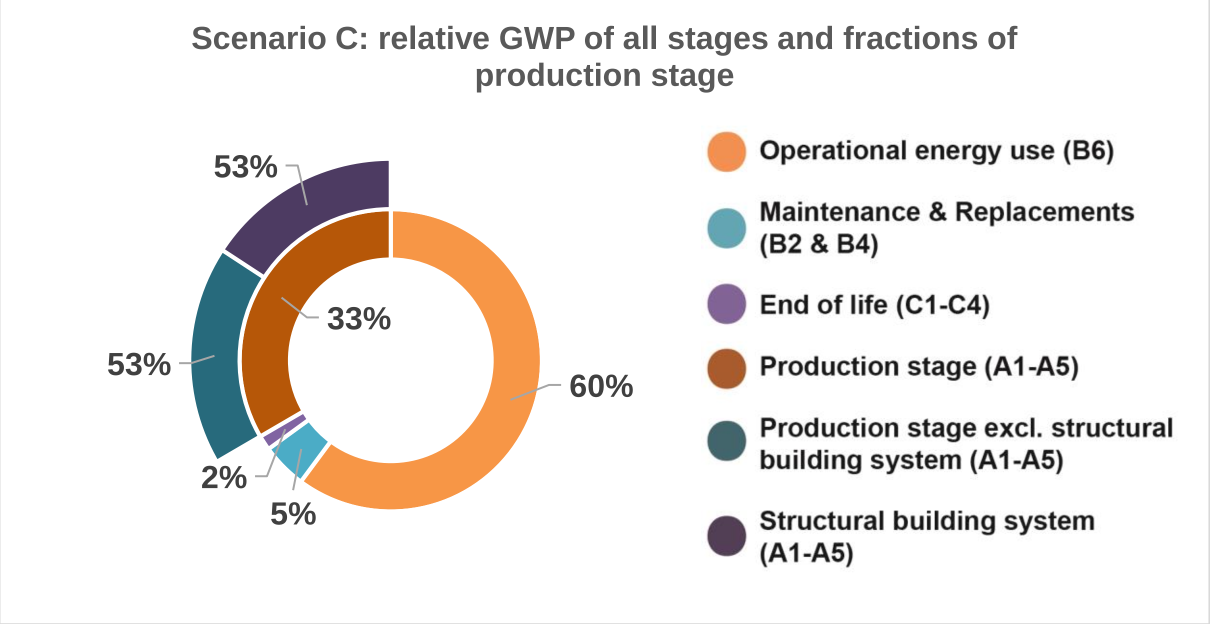


Figure 24: Impact distributions between life cycles for Scenario C.

Three posts been exchanged to CLT alternatives (external walls, apartment separating walls and balconies). In both external walls and apartment separating walls significant reductions in GWP is evident, see Figure 23. However, the CLT balconies actually have a small increase in GWP compared to the concrete alternative not visible in comparison of the bar charts.

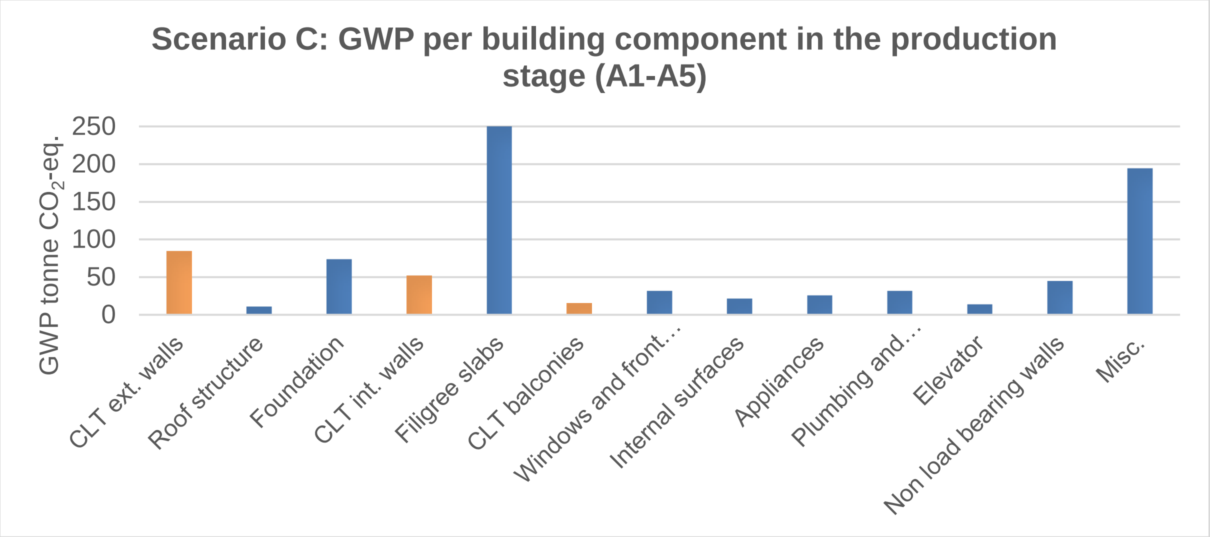


Figure 25: GWP contribution for included building components in Scenario C.

6.3.5 Scenario D

The operational energy usage continues to remain high both definitely and relatively, although smaller compared to Scenario C, see Figure 26. This is mainly due to the production stage of Scenario D has a larger GWP than Scenario C.

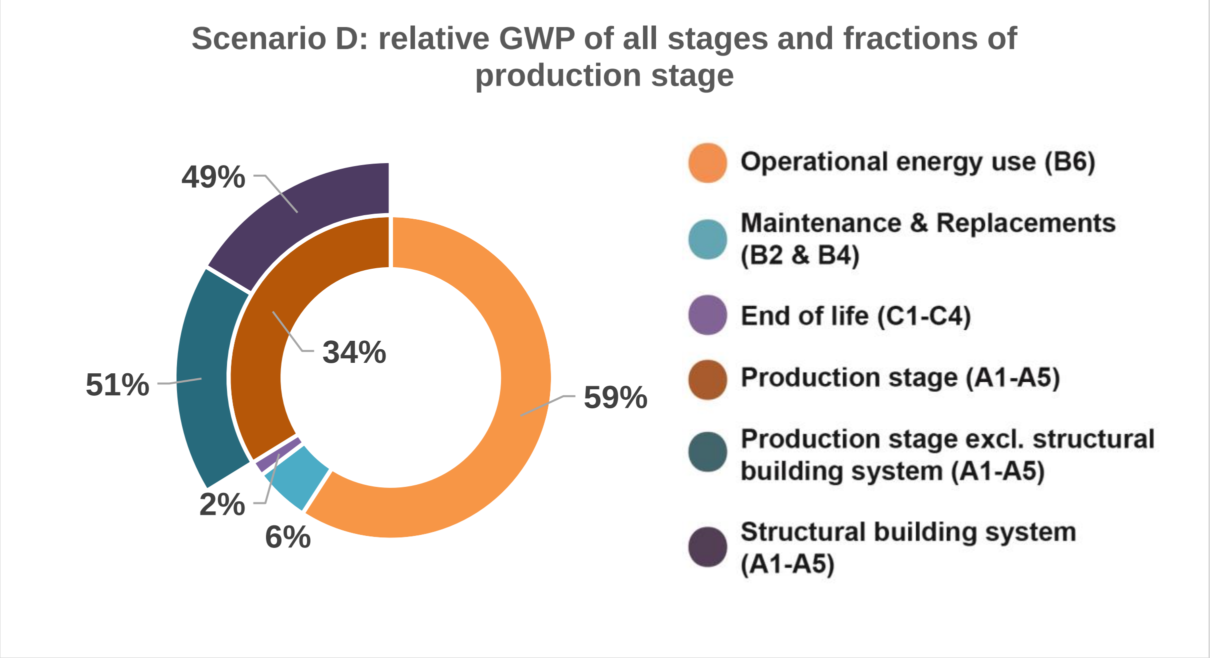


Figure 26: Impact distributions between life cycles for Scenario D.

Significant in this scenario is an actual increase in GWP in the slabs post compared to the filigree slabs of the Reference case, see Figure 27. However, the reduction of GWP using CLT alternatives in external walls and apartment separating walls still give a total reduction compared to the Reference case.

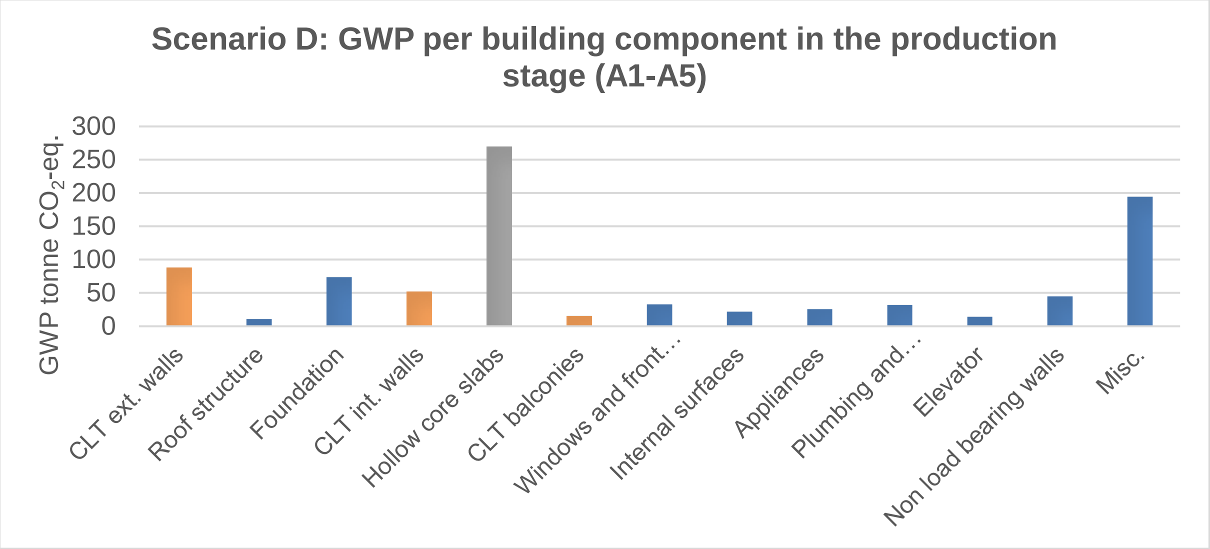


Figure 27: GWP contribution for included building components in Scenario D.

6.3.6 Scenario E

Scenario E shows the largest reduction of GWP in the production stage, as such the operational stage is largest for all scenarios, both absolute and relative, as seen in Figure 28. The scenario also produces the largest secondary effects.

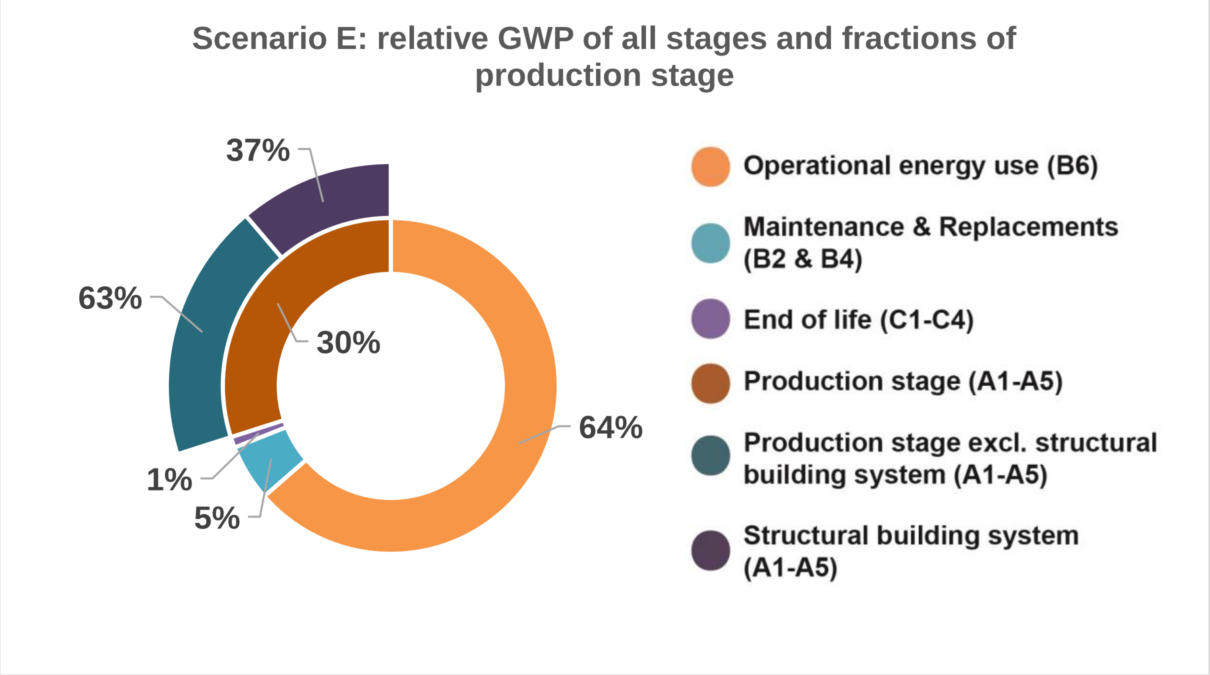


Figure 28: Impact distributions between life cycles for Scenario E.

As all structural elements have been replaced in Scenario E, the category miscellaneous is largest in Figure 29. Just as with a structural system in concrete, the slab produce the largest GWP. The apartment separating walls show the largest reduction of the vertical members, due to the exterior walls include the brick façade.

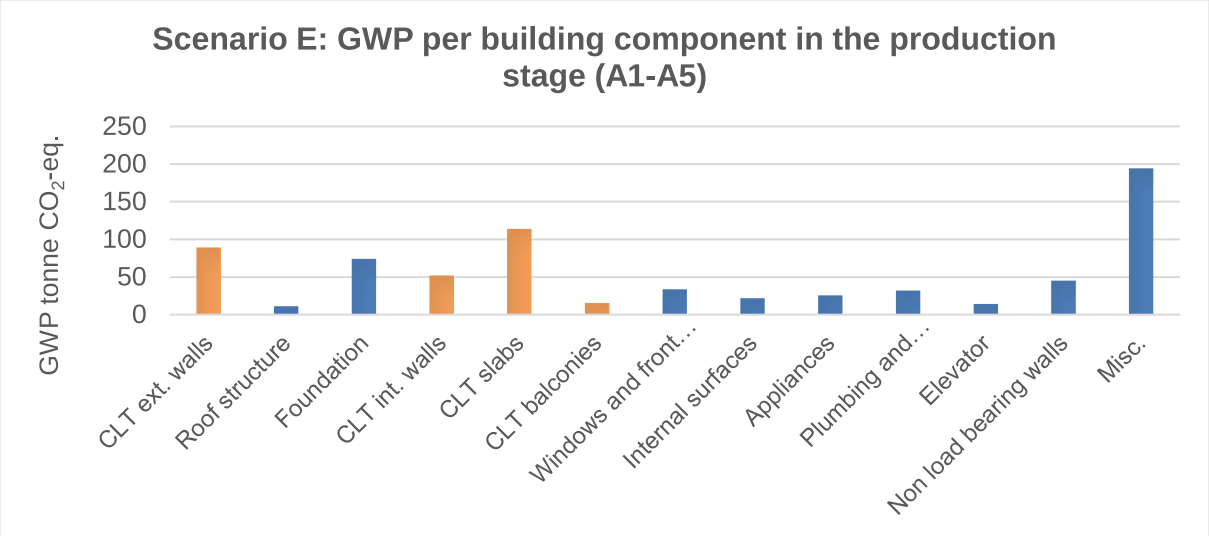


Figure 29: GWP contribution for included building components in Scenario E.

6.3.7 Comparison of all scenarios

A comparison, in Figure 30, of the different scenarios show that the main difference in GWP is found in the production stage, where the trend show that an increase of CLT elements reduces the GWP. However, opposite differences are found in operational energy use where secondary effects lead to higher GWP for more CLT intensive scenarios.

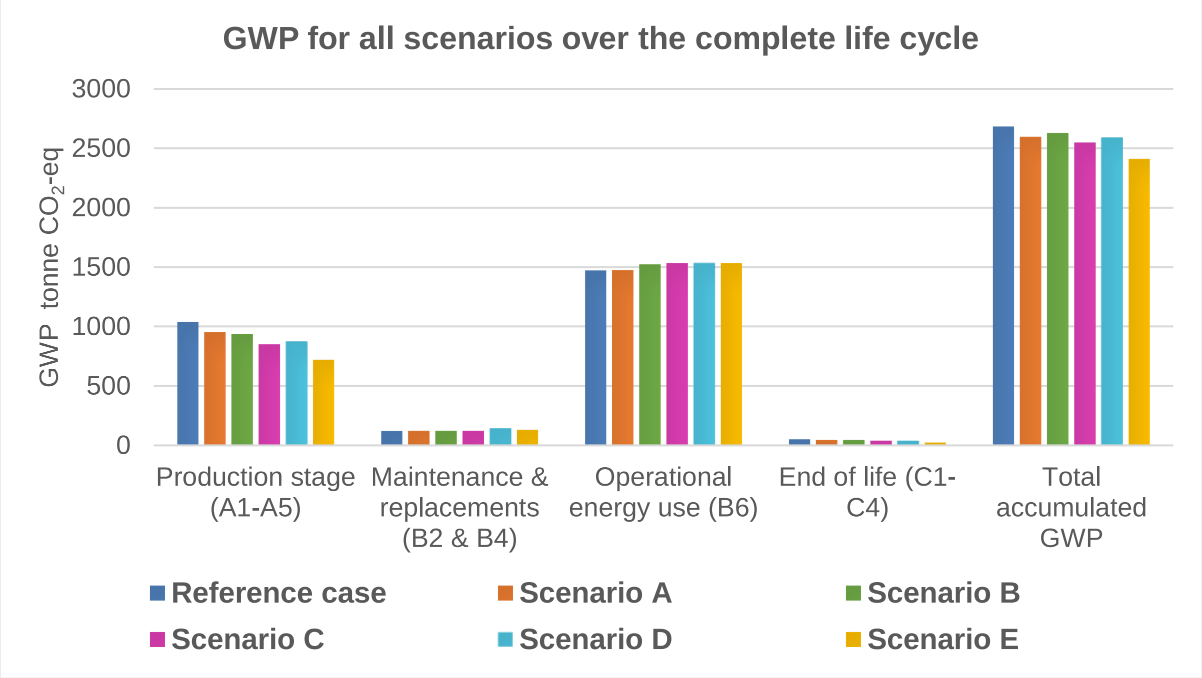


Figure 30: A comparison of all life cycle stages between the scenarios.

In Figure 31 below, the total GWP of all scenarios relative to the Reference case is shown.

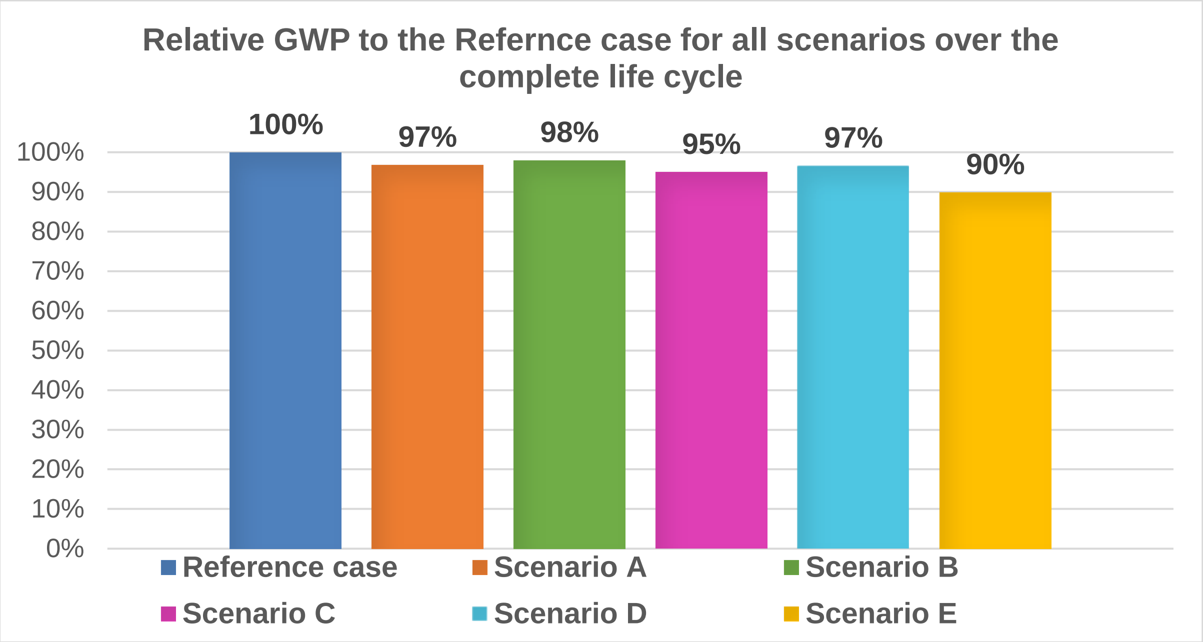


Figure 31: A relative comparison of the total GWP for all scenarios.

Including the secondary effect for A_{temp}, the total result related to the functional unit can be seen in Figure 32.

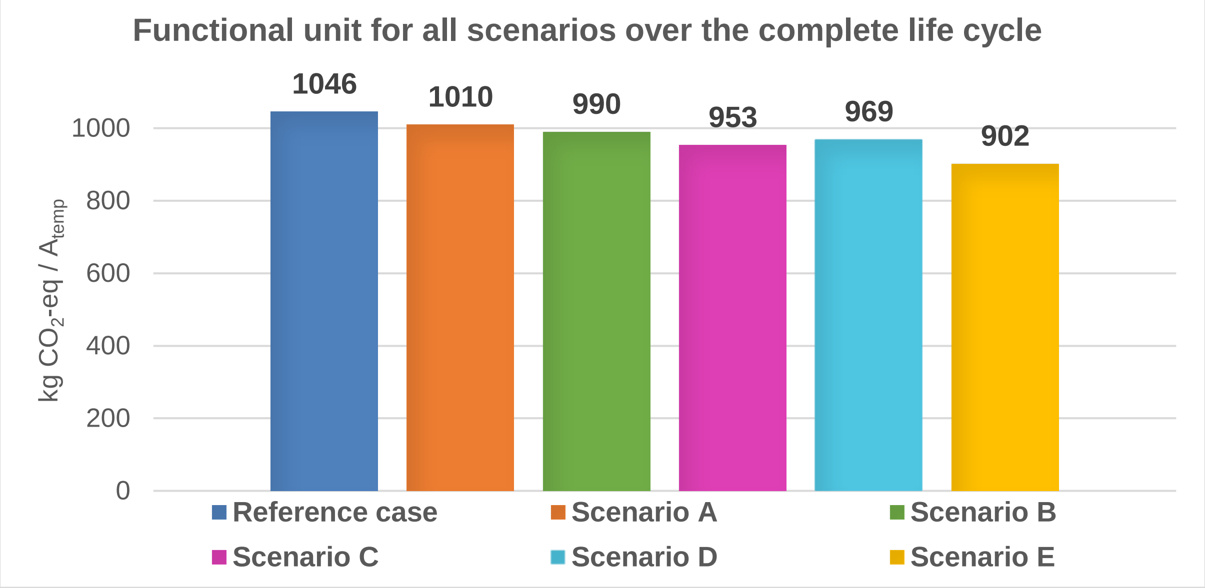


Figure 32: Total emissions based on functional unit for all scenarios.

Having the comparison isolated for the categories in the production stage, the impact of the CLT elements are clearly visible in Figure 33. However, with the high level of detail of the LCI, including the categories interior surfaces, appliances and miscellaneous the effect is smeared out for the total result from the production stage.

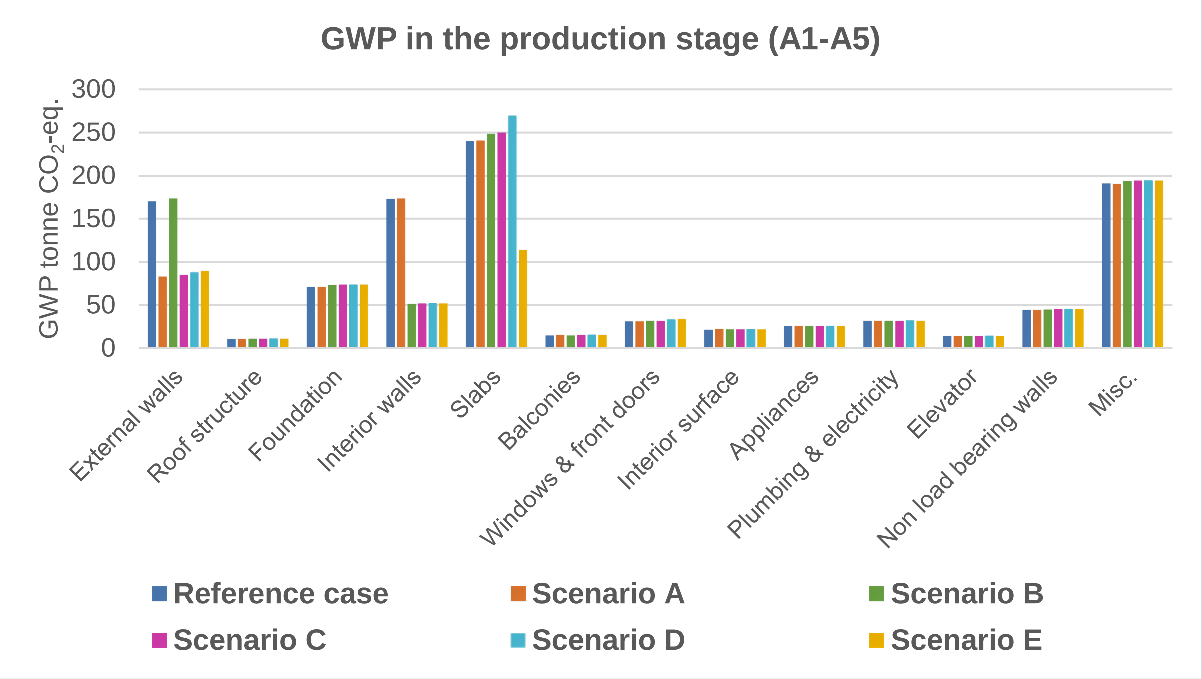


Figure 33: Comparison of GWP for all included components in the productions stage for all scenarios.

The relative result for the production stage for all stages related to the Reference case is shown in Figure 34.

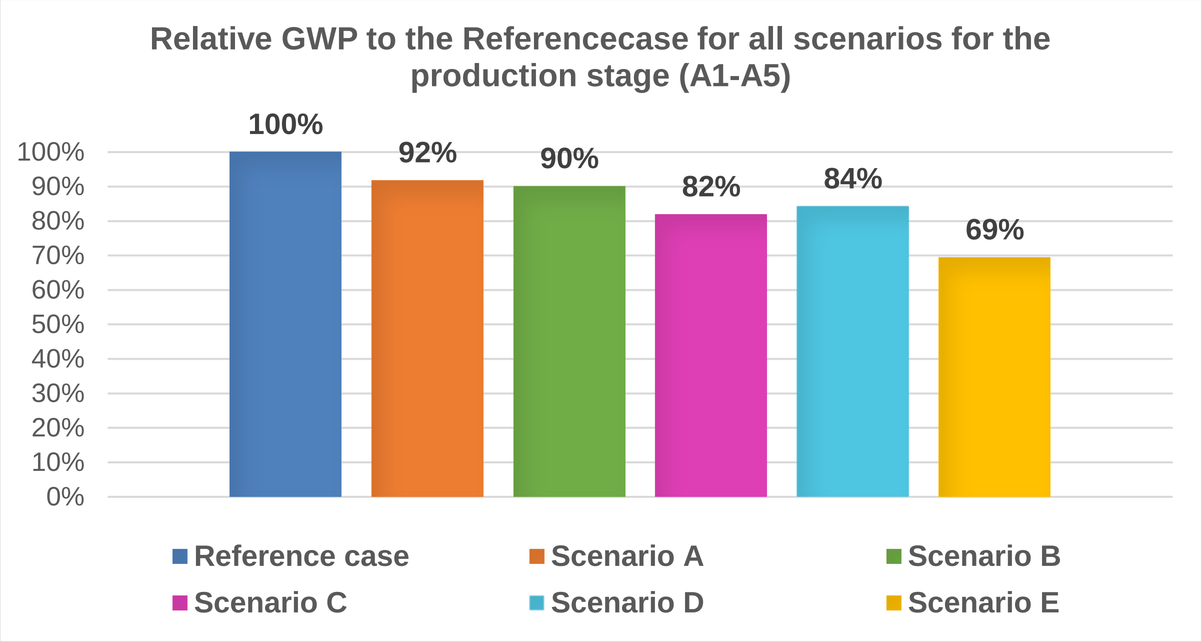


Figure 34: A relative comparison of the production stage for all scenarios.

The result based on the functional unit is shown in Figure 35 for all scenarios, taking secondary effects on A_{temp} into consideration.

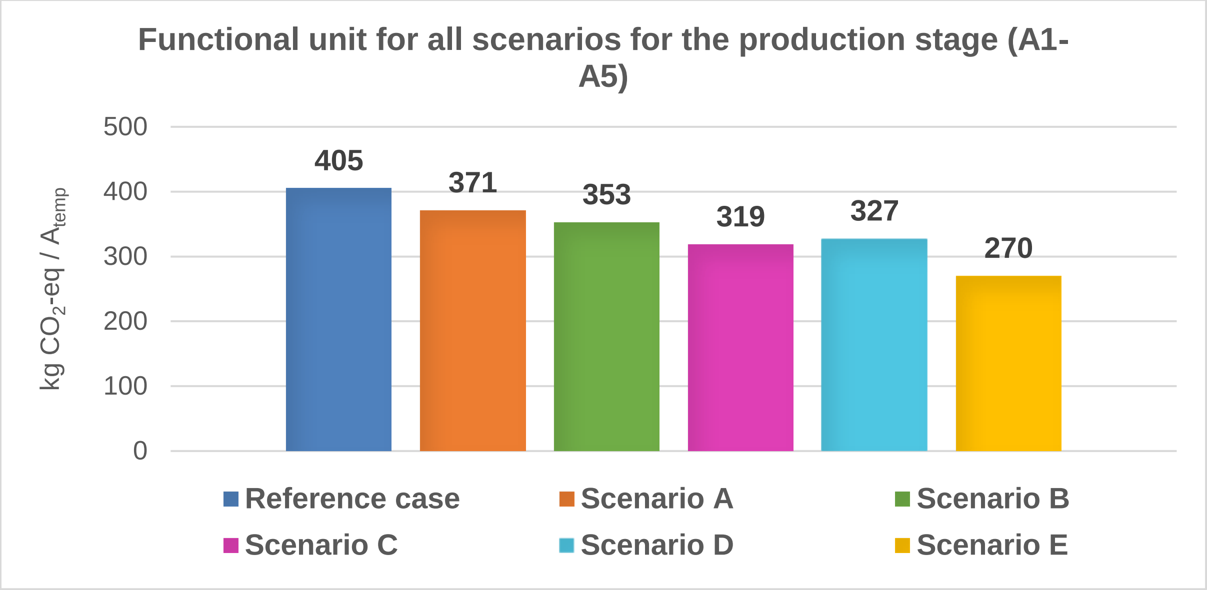


Figure 35: Result from the production stage based on functional unit for all scenarios.

The effects seen in the production stage is shown more clearly when the structural elements are isolated. In Figure 36 below the potential of CLT in reducing GWP is clearly shown.

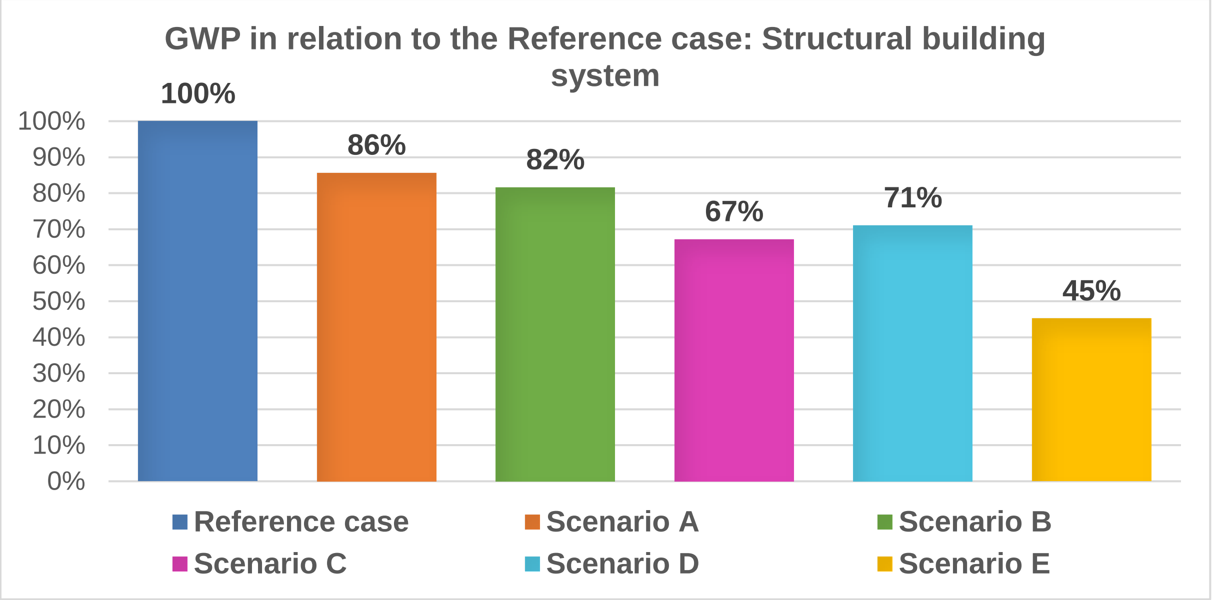


Figure 36: The GWP of the structural system of each scenario.

In Figure 37 the GWP from the external walls is shown. The implications of secondary effect are clearly shown for the two wall types. Generally, the CLT wall produce half the GWP of the concrete wall.

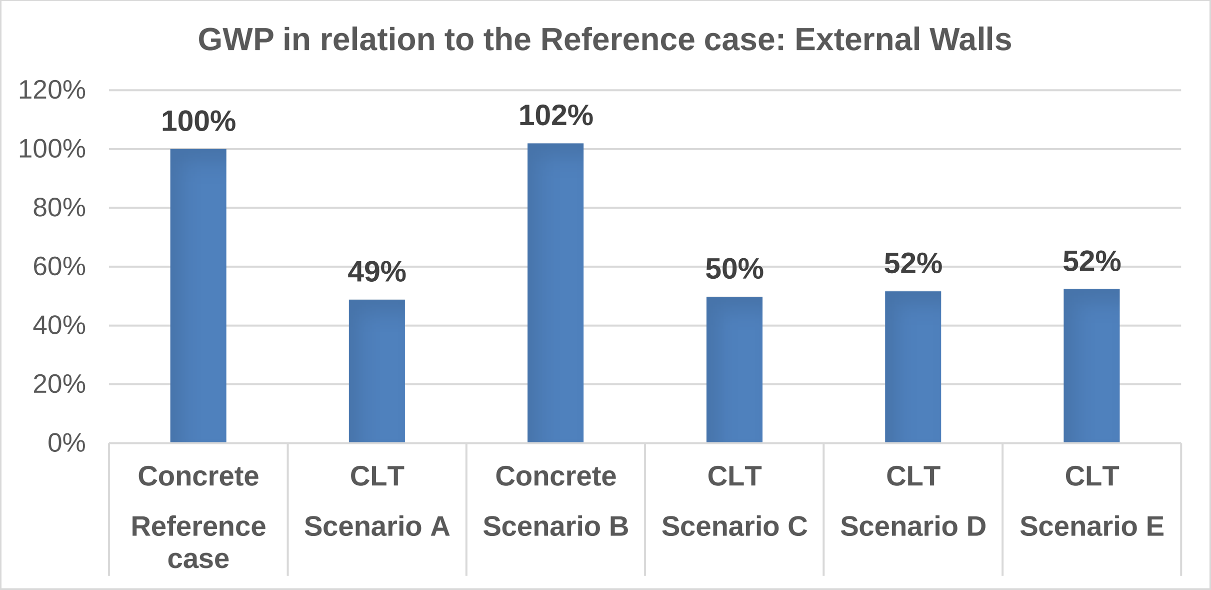


Figure 37: The GWP of the external walls for each scenario.

Figure 38 below, illustrate the potential in GWP reduction by using CLT apartment separating walls. The CLT scenarios produce slightly less than a third of the Reference case's GWP.

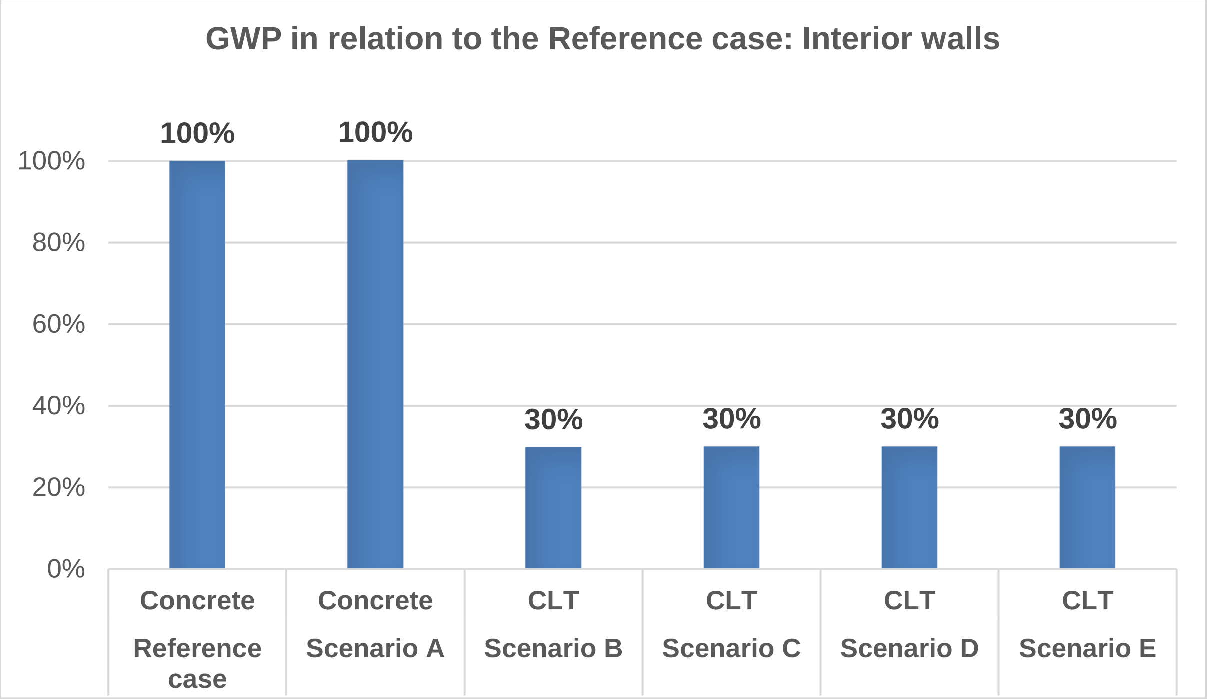


Figure 38: The GWP from interior walls for each scenario.

Regarding the slabs the increase in GWP for the hollow core slabs is clearly seen for Scenario D, in Figure 39. Further, implications of secondary effects and the introduction of CLT slabs in Scenario E are also easily seen.

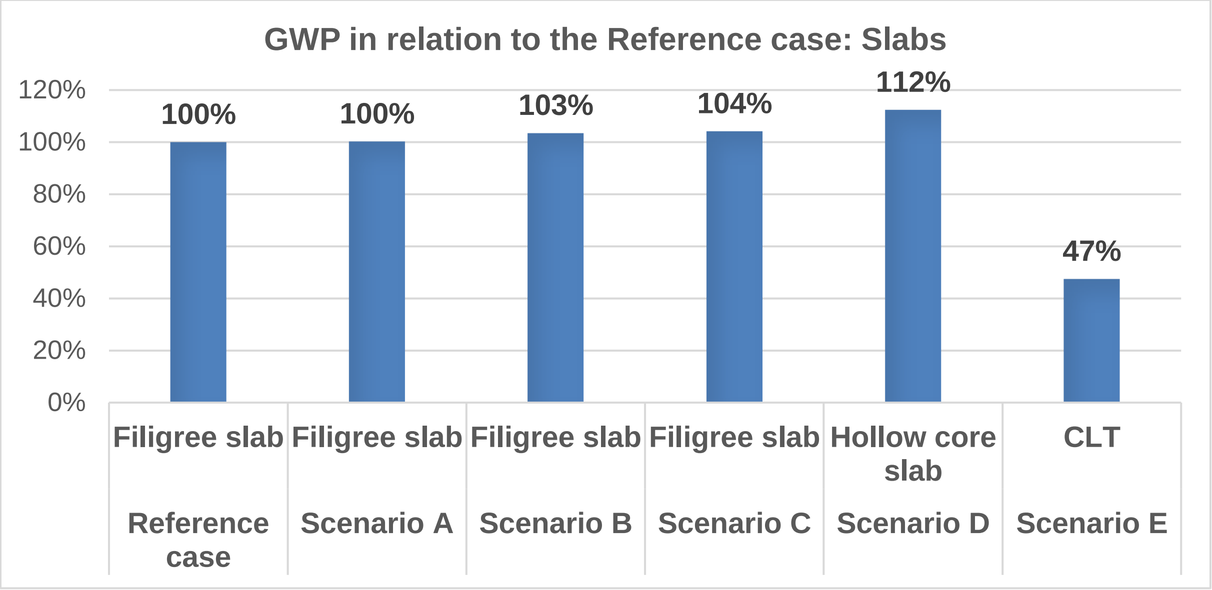


Figure 39: GWP for the slabs for each scenario.

As seen in Figure 40, the CLT balconies does actually have a larger environmental impact compared to conventional concrete balconies. This is mainly due to a bitumen layer that has to be added to the CLT balconies.

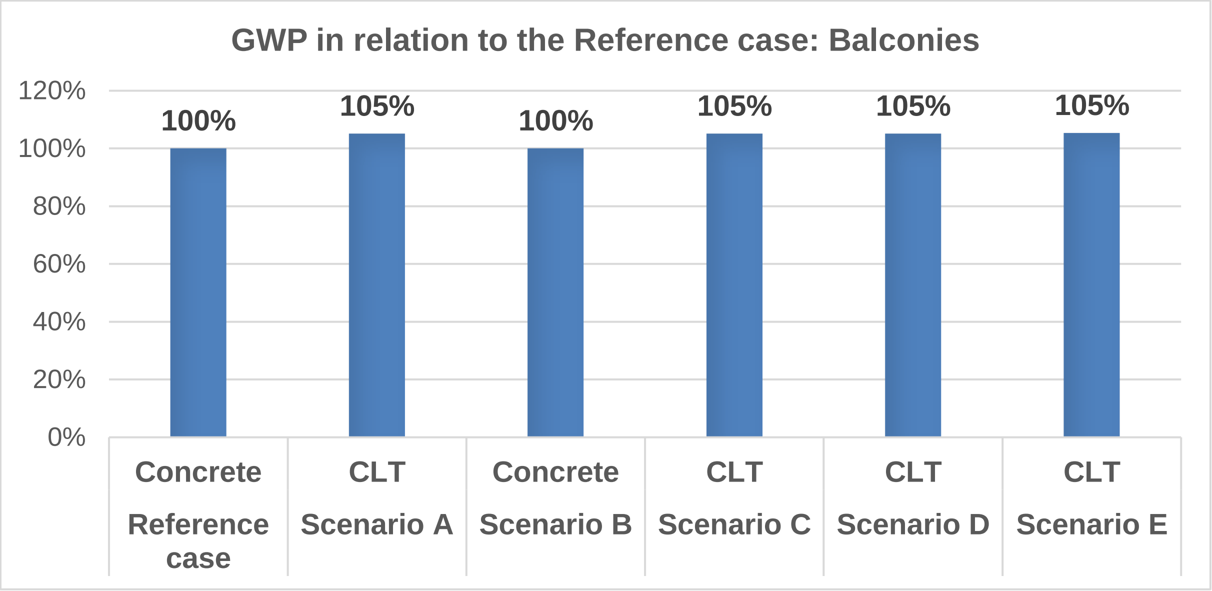


Figure 40: GWP for the balconies of each scenario.

7 SENSITIVITY ANALYSIS

The following chapter covers a sensitivity analysis of the results in the previous chapter. Recycling potential of CLT and the use of cement replacing materials are considered key issues to be able to reduce the impact from both building systems. Also, the importance of using different EPD data from suppliers of CLT in combination with their transport distance was considered very topical.

Important aspects to consider that already have been covered by similar studies have been omitted, such as choice of database, among others covered by Andersson and Barkander (2015). The possible impact of questionable EPD data have already been mentioned in Section 4.1 and is illustrated by the study of Kurkinen et al. (2017). Reliable and transparent data is without a doubt a fundamental part in conducting a trustworthy LCA.

The importance of energy efficiency and energy mix has been shown several times in literature. Most topical for this study are Andersson and Barkander (2015), Liljeström et. al (2015), Larsson et. al (2016) since they are located in Sweden and primarily use similar data (IVL). Their sensitivity analyses show a great relative impact range for the production stage (A1-A5) depending on the impact from the operational stage. As such, no energy scenarios will be carried out in this study.

The implication of the life time when comparing CLT and concrete building systems is undoubtingly a key issue ahead. However, the knowledge and input data regarding the lifespan of CLT structures exceeding 50 years was considered too small in order to conduct such an analysis.

7.1 Downcycling of CLT products and use of environmental friendly concrete

In most of the studies covered in Chapter 4 and in literature in general, conservative assumptions regarding reuse and recycling have been made. Regarding wood and concrete products it primarily includes the recycling potential of concrete aggregate and downcycling of wood products.

During its growth, a tree absorbs 718 kg/m^3 CO_2, but the effect is neutralised as the final product is assumed to be incinerated after its life cycle, leaving a net-emission of 60 kg/m^3 due to machinery used during production (Martinsons Såg AB 2015). If wood products would be down cycled as default throughout the building sector, more wood products would be introduced in the total building stock. Ultimately, this could allow for a so-called forest rotation, where new trees would grow while their predecessors are down cycled from CLT products to lower quality products. As long as the downcycling process continue on a wide scale, wood products could as such, in some extent, be considered as carbon negative.

The main potential of recycled concrete is not within the impact category of GWP, as stated in Chapter 4. The main benefits are related to land use and ecological scarcity, which is outside the scope of this study. Recycled and conventional concrete show very similar result regarding GWP according to Knoeri et al. (2013) and Braunschweig et al. (2011).Therefore, downcycling of structural concrete is omitted. Instead, the impact of using concrete with cement replacing materials will be studied. This will be done with the same values used by Kurkinen et. al (2017).

7.1.1 Results from downcycling CLT products in the case study

By allocating 50 % of the recycling benefits to the primary product (the house of the case study) and assuming a CLT downcycling rate of 50%, the results in Figure 41 are given. Detailed data for each scenario is provided in Appendix E. Naturally there is a clear correlation between the amount of CLT within the building and the potential CO_2 reduction. Scenario E have a much larger CO_2 reducing potential compared to Scenario A.

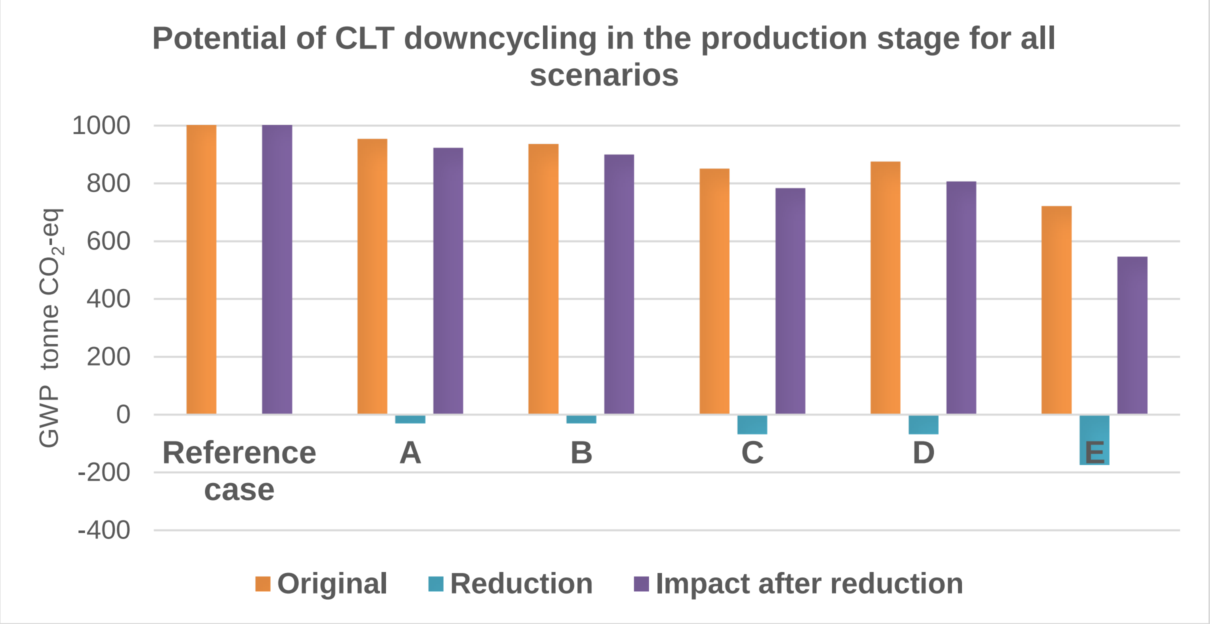


Figure 41: The potential of downcycling CLT for each scenario, comparison made for the production stage.

Figure 42 shows the same result as in Figure 41, but from a relative point of view. Meaning the relative reduction of each scenario. The result ranges from 3 % to 24 % CO_2 reduction during the production stage (A1-A5).

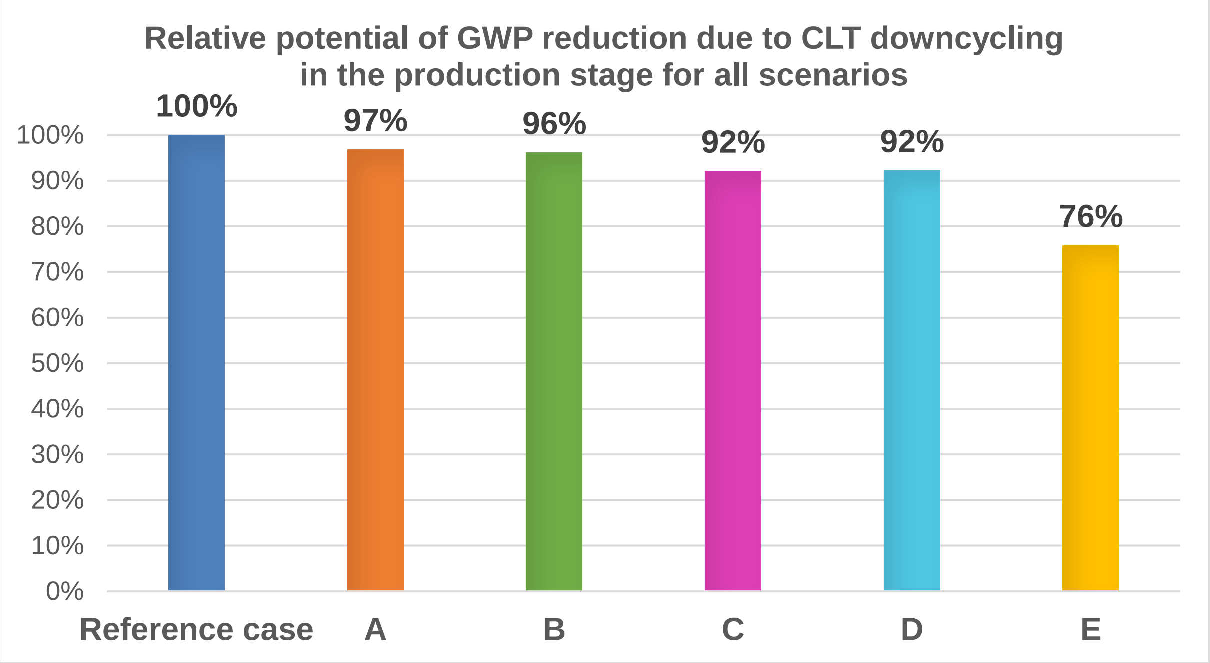


Figure 42: Relative reduction due to downcycling of CLT for each scenario.

However, without recycling policies or demand from the client, the amount of actual down cycled CLT after the building's life cycle is a large source of uncertainty. Figure 43 shows the potential CO_2 reduction of each scenario at different downcycling rates with an equally shared allocation principle. The result is clearly linear towards the amount of CLT in each scenario.

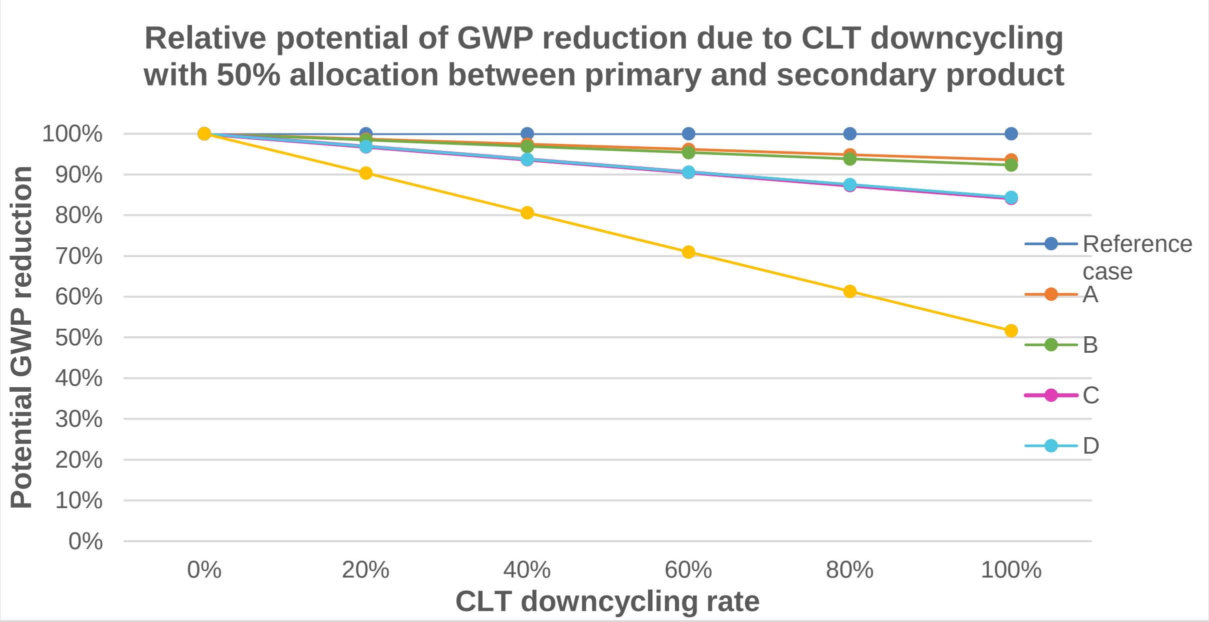


Figure 43: The GWP reduction potential of each scenario at different downcycling rates.

7.1.2 Results from using cement replacing materials in the case study

By simply using the same concrete recipes used in the residential buildings (Viva) studied by Kurkinen et al. (2017), the environmental potential of cement replacing materials in the concrete is shown. Table 18 describes the concrete mixes used. Detailed data for each scenario is provided in Appendix E.

Table 17: Description of concrete mixes used.

Concrete type	IVL [kg CO_2 eqv./m3]	Viva [kg CO_2 eqv./m3]	Comments
Prefabricated interior walls	273	214,2	Viva-recipe provided from Strängbetong
C25/30 prefab	286	223,3	20 % fly ash, recipe according to Betonghandboken
C28/35	303	213,2	Filigree slabs
Hollow core elements	-	-	Not replaced, due to small differences
C35/45	-	-	Not replaced, concrete type not used by Kurkinen et. al (2017)

The reduction is highly dependent on the amount of concrete in the scenario. Although Scenario C and Scenario D is very similar, Scenario D gets a smaller reduction due to the hollow core concrete mix is not replaced. The result in absolute values is shown below in Figure 44.

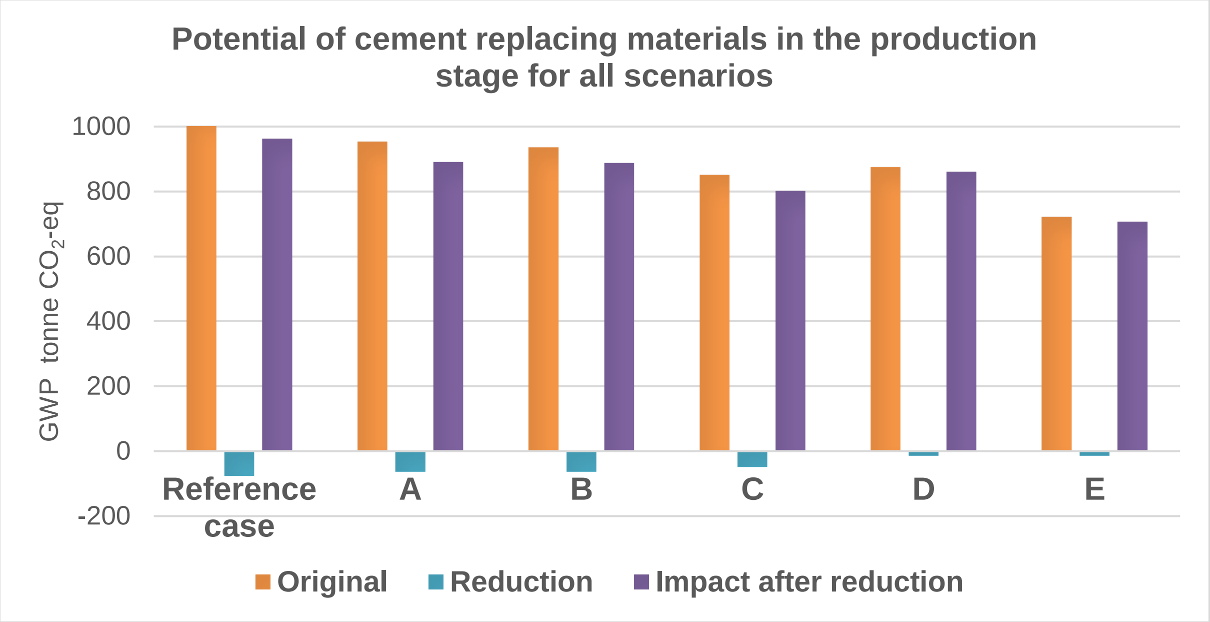


Figure 44: Reduction of GWP in the production phase when using cement replacing materials.

The relative result in production (A1-A5) compared to the Reference case is shown in Figure 45. The CO_2 reduction range from 7 % to 2 %.

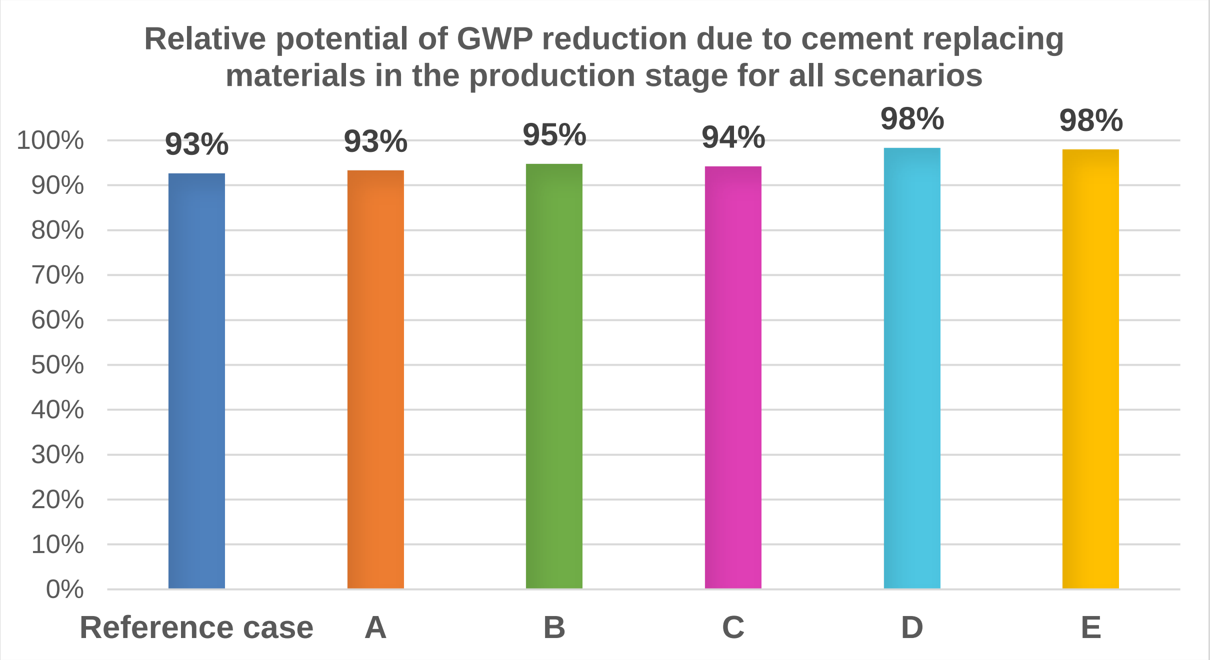


Figure 45: Relative reduction using cement replacing materials for each scenario.

7.1.3 Results from combining downcycling of CLT products and using cement replacing materials

By combining downcycling of CLT products and cement replacing materials, the CO_2 reducing potential of each hybrid scenario could be improved. This is done by simply adding the reductions in Section 7.1.1 and Section 7.1.2. Figure 46 shows the absolute result of each scenario, at 50 % downcycling rate and an equally shared allocation principle. Detailed data for each scenario can be found in Appendix E.

Even though the reduction between concrete (A) and CLT intense (E) scenarios is smoothened out, it is clear that the downcycling of CLT provides a larger potential with provided assumptions.

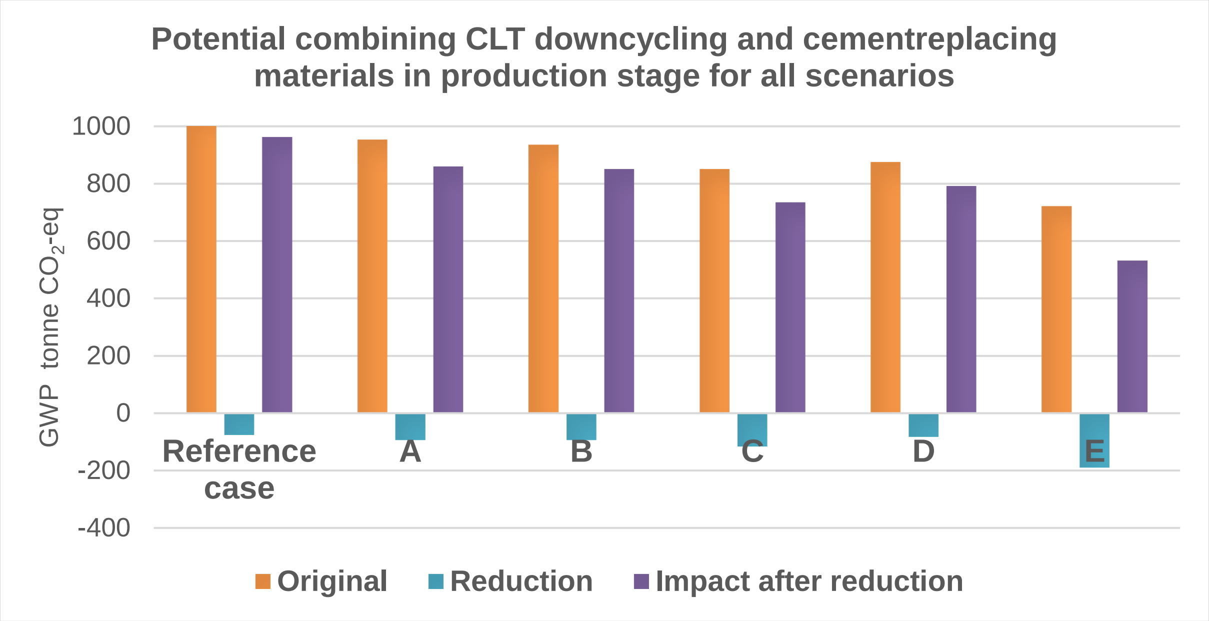


Figure 46: GWP reduction when combining cement replacing materials and downcycling of CLT for each scenario.

Figure 47 gives the relative reduction for each scenario compared to the Reference case. With provided assumptions regarding downcycling of CLT, a reduction range of 7 % to 26 % is given.

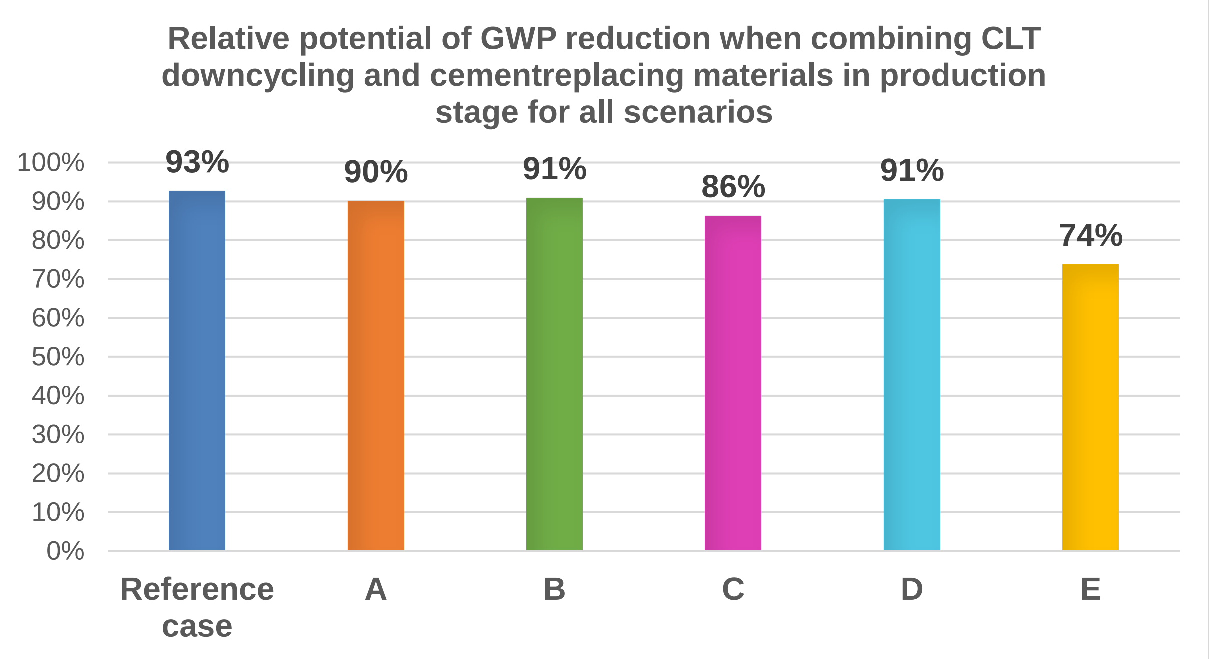


Figure 47: Relative GWP reduction when combining cement replacing materials and downcycling of CLT for each scenario.

As with the result in Section 7.1.1, the potential CO_2 reduction is highly dependent on the downcycling rate of CLT. Figure 48 provide an overview of the combined potential of cement replacing materials and equally shared allocation, for the range of 0-100% down cycled CLT.

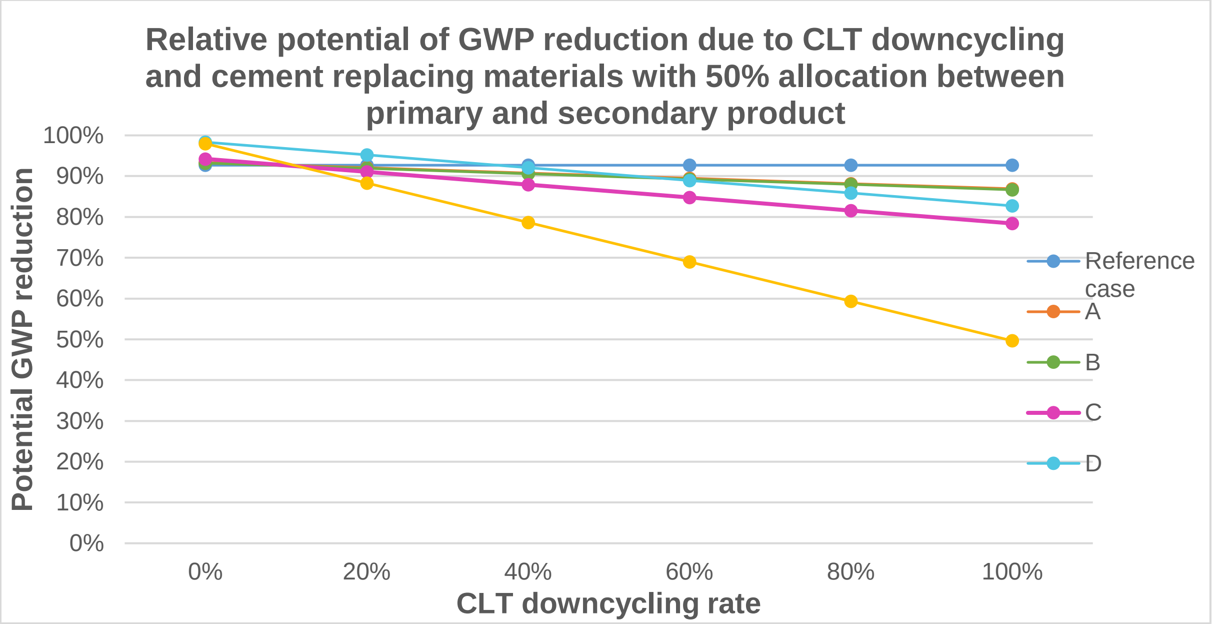


Figure 48: Relative reduction when combining cement replacing materials and downcycling of CLT at different downcycling rates.

7.2 The impact of different CLT EPD data and transport distances

In Chapter 4 it is pointed out that different data sets for certain products can vary to a large degree. Arguably, the non-transparency of data from EPDs can be a weakness in a LCA. Furthermore, Kurkinen et al. (2017) illustrate that transport of wooden products can have a significant impact on the total GWP of a building. Therefore, it is of interest to test the LCAs sensitivity to these factors.

Because EPDs are company specific, the distance to production facility has been changed accordingly. Following alternatives have been used, see Table 19.

Table 18: Distance and emission factor for different EPDs provided by CLT suppliers.

Company EPD	Location	Distance [km]	Emission [kg CO_2 eq/m3]
Martinsons	Bygdsiljum, Sweden	1055	60
KLH	Teufenbach-Katsch, Austria	1566	77
VL*	Värmland, Sweden	245	77
Egoin	Barrio Olagorta, Spain	2445	181

**Company VL is an imaginary company in Värmland Sweden, created to indicate potential reduction with a nearby supplier, with an emission factor stemming from the KLH EPD.*

Figure 49 show the ratio between the production of CLT and the transport of the material to building site. It can also be concluded that transport account for a large portion of the CLTs environmental load.

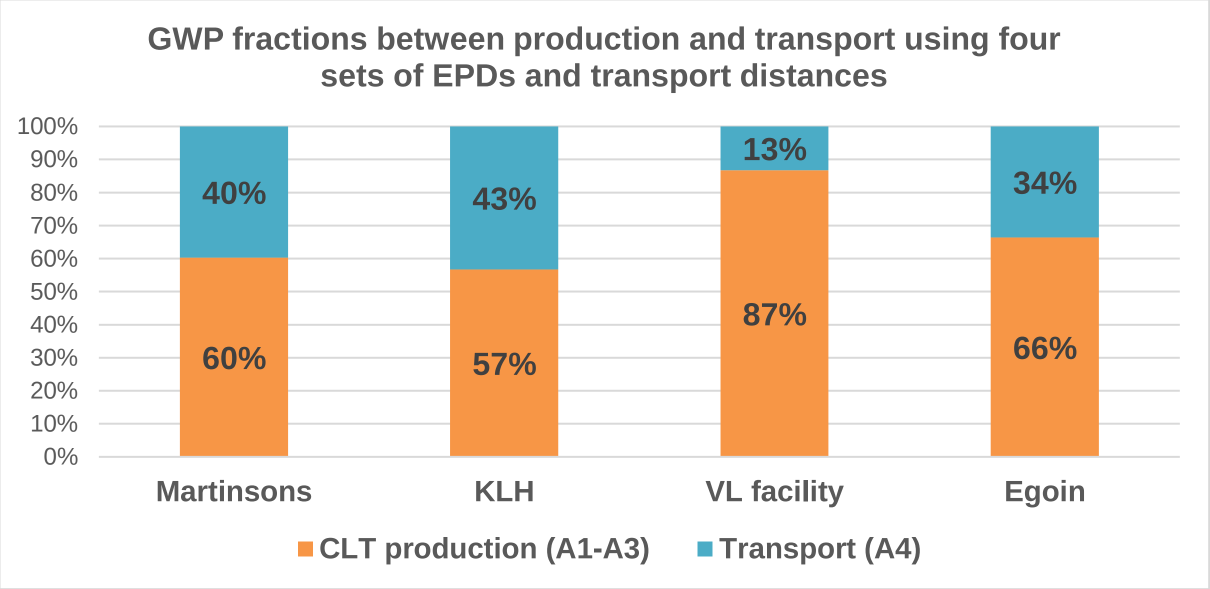


Figure 49: The ratio between production and transport emissions for four different CLT suppliers.

Naturally the effects of different EPDs and supply distances are elevated in scenarios with more CLT. With the emission factor and distance of the KLH production facility the GWP increase a little compared to Martinsons, mainly due to a higher emission factor, but also because of a greater transport distance. In the imaginary case of a production facility in closer vicinity of Gothenburg with the emissions factor of Martinsons, a small decrease in GWP of the production stage can be found, see Figure 50. The Egoin alternative have the highest GWP in the production stage. This is mainly due to a much higher emission factor and significantly longer transport distance.

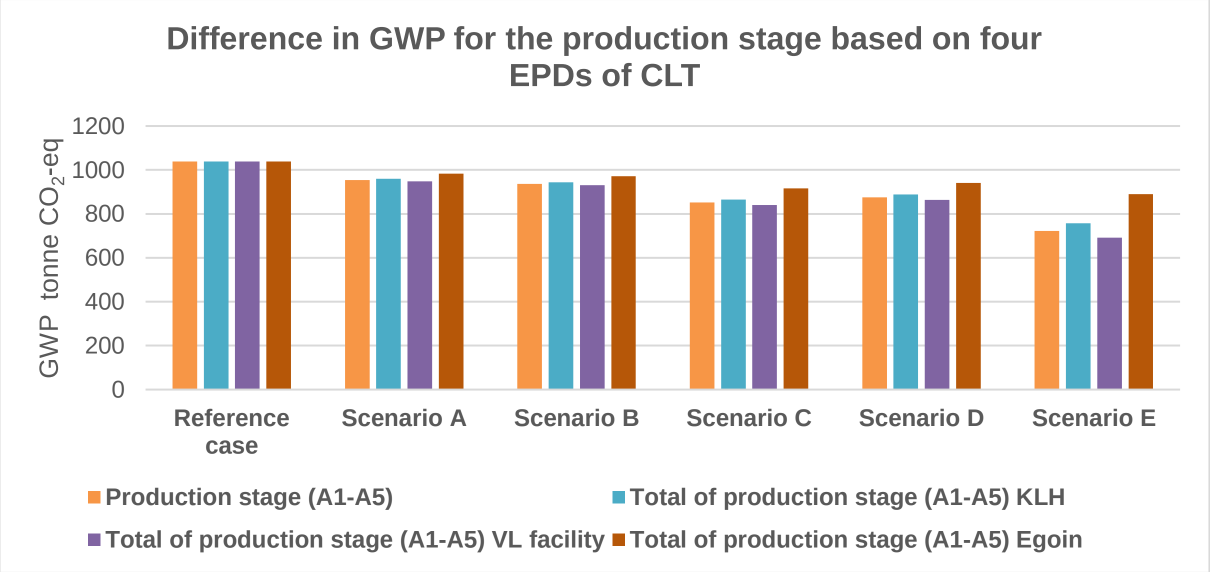
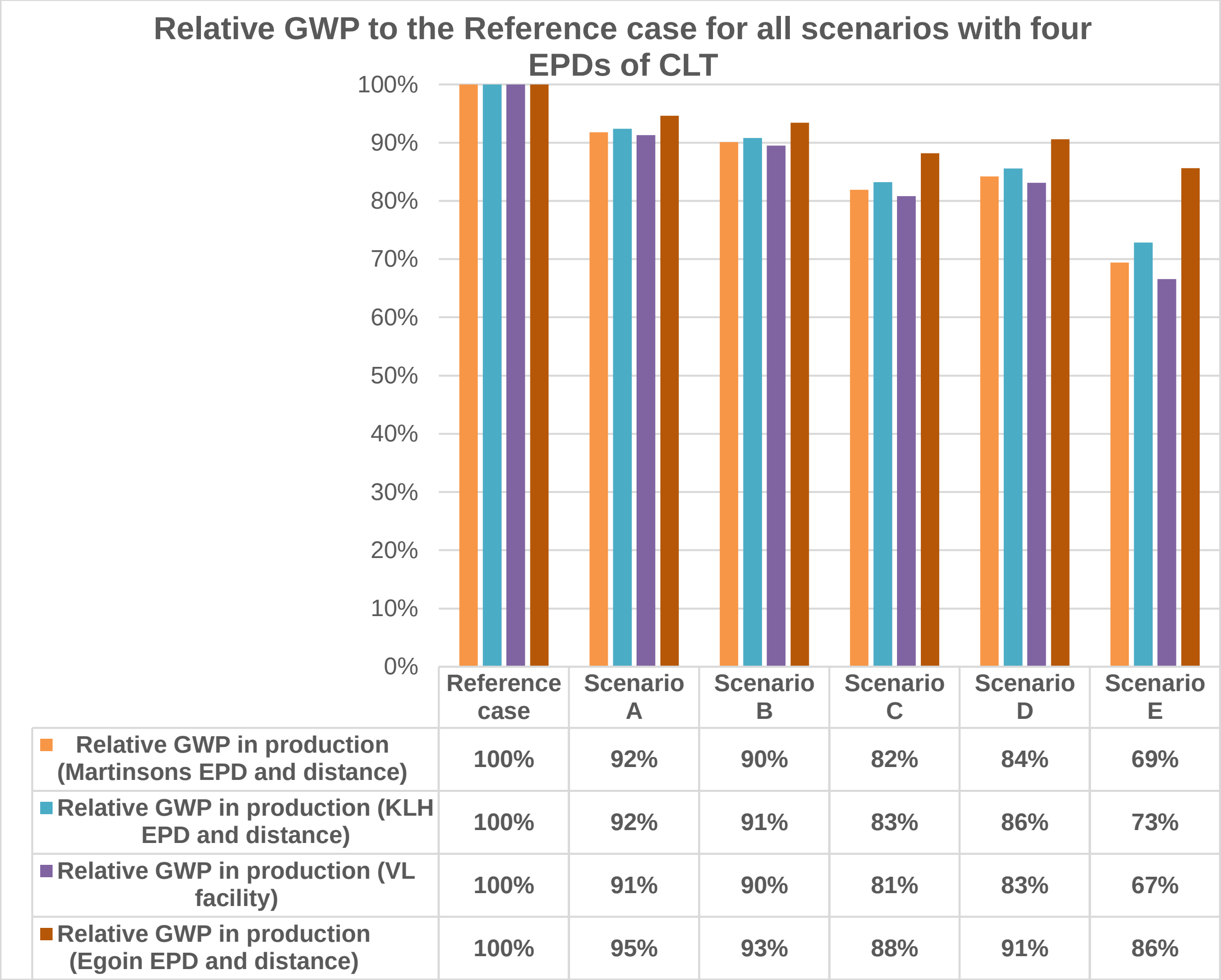


Figure 50: Applying the different EPD data on each scenario in the production phase.

Figure 51 further illustrate the potential of shorter supplier distances. For Scenario E, GWP in the production stage can be reduced with 2.4% with a production facility in for example Värmland, Sweden with the same emission factor as Martinsons. Furthermore, it shows that choosing CLT from a production facility with a more CO_2 intensive energy mix combined with a longer distance can result in a significant increase of GWP in production stage.



	Reference case	Scenario A	Scenario B	Scenario C	Scenario D	Scenario E
🟧 Relative GWP in production (Martinsons EPD and distance)	100%	92%	90%	82%	84%	69%
🟦 Relative GWP in production (KLH EPD and distance)	100%	92%	91%	83%	86%	73%
🟪 Relative GWP in production (VL facility)	100%	91%	90%	81%	83%	67%
🟫 Relative GWP in production (Egoin EPD and distance)	100%	95%	93%	88%	91%	86%

Figure 51: The potential of GWP reduction for each scenario with the four different supplier data.

8 DISCUSSION

The following discussion cover the result from the impact assessment and the sensitivity analysis. Further the topics of a building's lifetime, implementing CLT and hybrid structures on a larger scale, additional impact categories and a general discussion looking forward are covered. Finally identified key factors for future work and studies are presented.

8.1 Discussion regarding the results of the case study

In Section 1.2 it is stated that the environmental potential of each scenario should be identified. From the results in Chapter 6 it is clear that the amount of wood introduced into the building correlates to a reduced environmental impact. All scenarios follow the pattern of an increase of CLT results in a reduction of GWP.

The focus of this study and report have primarily been the production stage (A1-A5). This is mainly due to three reasons: changes in the scenarios have only been made to their structural elements, no energy analysis has been made for the reference house and the production stage is most interesting for Skanska at this point.

The results from the case study show GWP range of 1-10 % from Scenario A to Scenario E, compared to the Reference case. However, Scenario D perform worse than Scenario C due to a high content of cement in hollow core slabs. Only considering the production stage, the reduction span from 7% to 31%. 'Operational energy use' and 'maintenance and replacements' increase slightly due to secondary effects throughout the scenarios. As such, the GWP reduction potential is marginally reduced.

It should also be noted that the assumptions regarding operational energy use was conservative, choosing a maximum value for the reference house together with 'Nordic Residual' energy mix. This reduces the relative positive impact of choosing wood in the total result. A more energy efficient house and cleaner energy mix would increase the importance of the production stage and thus promote GWP reductions on structural elements to a higher degree. This is clearly illustrated by Andersson and Barkander (2015), Larsson et al. (2016) and Liljenström et al. (2015), where the production stage account for as much as 85 % in very energy efficient scenarios.

Scenario C where all vertical load-bearing members are replaced to CLT and the concrete filigree slabs are kept, show the greatest potential of the hybrid scenarios. This scenario can maintain technical benefits of a concrete slab while at the same time reduce the total GWP by up to 5%. Especially the slab thickness is important to consider, where timber slabs are much thicker compared to concrete slabs due to structural but mainly acoustic reasons.

However, Scenario E having the complete structural building system in CLT show the greatest GWP reducing potential. It obtains a 10 % reduction considering all life cycle stages. Due to the increased size of the timber elements, it subsequently has the largest secondary effects. Especially the increased building height is non-negligible from a project developer's point of view. A hybrid structural system utilising concrete slabs could therefore be of large interest for projects trying to minimize their GWP but have restriction on the building's height.

The size of the potential GWP reductions have to put into perspective of the emissions of the construction industry as a whole. According Sveriges Byggindustrier and Iva (2014) 17 % of Sweden's CO_2-emission could be derived from the construction industry and approximately 7 % due to construction activities. These numbers only consider upstream emissions, meaning the stages A1-5. As such, they should be compared with the GWP reducing potential of the scenarios in the production stage. From Scenario A to E, this reduction potential ranges 7-31%. It is clear that hybrid and timber residential buildings have a large potential to significantly reduce the GWP of the construction sector. Due to the construction sectors large share of Sweden's total GWP, even small relative improvement have a large impact on absolute numbers.

On a building element level, the potential GWP reduction between concrete and CLT elements is substantial. For each element, a range of 50-70% GWP reduction was obtained excluding balconies. Isolating the complete structural building system, it results in a 55 % reduction from the Reference case to Scenario E. Regarding the impact of the production stage, these numbers are important as the structural system account for a majority of the GWP of the production stage. In the Reference case, the structural system account for 58 % of the GWP in the production stage. For Scenario E, the number is reduced to 37%, mainly due to the reduced emissions also leads to smaller relative impact of the production stage. Nonetheless, it is shown that the structural system account for a majority of the GWP in the production stage.

In Section 6.2.1 it is shown that eleven types of products and material make up 95-98% of the total building weight. These material groups account for 64-75% of the GWP during the production stage of the scenarios. Following the structural system, it is therefore within these groups that improvements of trying to reduce GWP should be made.

The above results show the need of working with improvements on all levels and not just trying to reduce concrete and cement content in a building. Besides energy efficiency and the production phase, building flexibility and robust apartment's layout are considered as important factors in order to reduce the GWP over the life cycle. Such measures could minimize the need of refurbishments, adding new materials to the building life cycle.

According to Femenías et al. (2016), apartments are usually refurbished within ten years of completion. The environmental impact of such activities is rarely accounted for in LCAs of residential buildings. Therefore, it could be the aim of developers to design apartments that to a certain degree are flexible in their design. Femenías et al. (2016) further states that it is most often kitchens and bathrooms that are refurbished. Providing more alternatives for the tenants who first buy the apartments could potentially counteract such a trend. Next to energy performance and materials choices with low GWP, focus should also be put on high quality products within the apartments that are more seldom replaced.

Table 20 shows a comparison of previous studies primarily using similar data (IVL database). It should be noted that the studies vary significantly in content, the most important aspects are mentioned in the table. Only the production phase was included as it is the focus of the study and all the mentioned studies have shown the large variance occurring due to energy performance.

Table 20: Comparison with earlier fairly similar studies.

Project	Author	GWP A1-A5 [kg CO_2-eq./m^2Atemp]	Comment
The Reference case	Brandt & Sonesson (2017)	405	-
Scenario E	Brandt & Sonesson (2017)	282	-
Daggkåpan	Andersson & Barkander (2015)	391	⅔ of the houses have basements
Strandparken	Larsson et al. (2016)	265	Including basement and garage. Excluding ground work.
Strandparken	Larsson et al. (2016)	161	Excluding basement, garage and ground works.

Blå jungfrun	Liljenström et al. (2015)	351	Excluding ground works, elevators, garage and basement

Table 20 show the difficulty in comparing LCA studies on construction project with different preconditions. An attempt was made by Larsson et al. (2016) in order to provide comparability with the Liljenström et al. (2015), removing the basement with garage and all ground work. Strandparken excluding basement and garage is most comparable to this study, showing a large difference from Scenario E (282 kg / CO_2 eq. /m^2 A_{temp}). Part of the reason could be the level of detail of both studies. The 'Miscellaneous' post is the largest for A1-A5 in Scenario E and it is also substantial (25 % of A1-A5) in the Strandparken study. What the 'miscellaneous' post entails might differ between the studies. Further different design choices regarding facade, windows, roof structure and other members have a substantial impact on the comparability. If an LCA is meant to be published to a wider audience, it is of great importance to communicate these difficulties in fair comparison between studies.

All scenarios were calculated to achieve an energy performance of 67,5 kWh/year/m^2. This choice was motivated through adapting the exterior CLT wall to match the U-value of the concrete wall. The number of openings (windows and doors) were in this case assumed to be the same for all scenarios. Due to secondary effects this is not true, as the number of windows is generated based on the facade area. In theory, the complete U-value of the building envelope should therefore differ between the scenarios. Without having an energy simulation of each scenario, this put more emphasis on the production stage.

Uncertainties in the results do exist in terms of methodology, with 16-23% of the production stage's GWP being calculated as secondary resources (based on price rather than quantity). The majority of secondary resources GWP stem from the post regarding 'Groundwork'. Since the reference house is generic, this is a typical resource that is highly dependent on pre-conditions on site and therefore not very accurately calculated. While, the secondary resources induce uncertainty to comparisons with other building LCAs, it does not affect the comparison between the scenarios in this study. Since the GWP of secondary resources are the same in all scenarios. The same argument applies to the inventory generated through the "quick calculation" function of SPIK. For a real project of same size, the inventory might be slightly off compared to the scenarios, but when comparing the scenarios to each other no errors occurs as they are generated through the same method.

Arguably, the assembly process of CLT and prefabricated concrete are very similar. One of the shortcomings of Anavitor is however that no distinction is made between the different production methods of in-situ concrete, prefabricated concrete and CLT in terms of machinery used for assembly. These posts are secondary calculated based their cost, which in this study is set equal for all scenarios and include the assembly process and groundworks. As such, uncertainty of GWP regarding all scenarios are induced, especially for the CLT intensive scenarios where larger differences are expected to occur from the original values. As the value of this post is equal for all scenarios its relative importance grows as the GWP reduces throughout the scenarios. For the Reference case it is 7.8 % of the production phase while for Scenario E it accounts to 11.5 %.

The combined use of the software SPIK and Anavitor, using the IVL database, provide a strong platform for conducting an LCA. Anavitor, although under development, provide a simple and straightforward assessment process. Future updates including more accurate data regarding assembly, construction, maintenance, demolition and recycling possibilities would benefit the software greatly. The main strengths of the combined platform are the possibility to export bill of resources from SPIK and the IVL database. Using exports from SPIK allows LCAs to easily be carried out for any project within Skanska, as all projects by default have a SPIK cost calculation. The IVL database is regarded as trustworthy as it mainly includes national data from Sweden and in some cases Skanska specific data. Not using a generic database, covering for example European data, is considered a large benefit.

8.2 Discussion regarding the sensitivity analysis

The goal of the sensitivity analysis was primarily to add new insights to the research area rather than repeating previous studies. As such, further analysing regarding different energy scenarios and database choices was omitted. Firstly, the environmental potential of recycling CLT and using cement replacing materials in the concrete was studied. Secondly, EPD data from different European manufactures and the impact of transport distances was studied.

8.2.1 The potential of downcycling CLT and using cement replacing materials

CLT show a great potential in reducing GWP when being downcycled. As mentioned in Chapter 4 a young forest has the largest potential from a GWP perspective, as a tree absorb most CO_2 during its first 30 years. Downcycling of wood products can therefore be argued to promote a more GWP effective forestry while also increasing biogenic coal within society. Using a 50 % allocation between first and secondary product, half of the environmental benefit is given to the scenarios in the case study. From Section 7.1.1 the potential is clearly shown. However, how much of the benefit that is allocated to the primary of secondary products is a further discussion LCA policy makers

In order to be able to realistically account for downcycling of wood products in LCAs, reliable statistics on recycling rates and a strengthening of national policy for recycling old building material would be preferable. While, initiatives to collect statistics on recycling are at place (Naturvårdsverket 2014), statistics are far from being detailed enough to constitute any solid basis to use in the main LCA. Too many factors of uncertainties are otherwise playing a large part, such as: incentives of the last owner, the current economic situation and availability to recycle in the area.

Having such a policy would allow for LCA studies to account a certain degree of downcycling, effectively reducing the GWP related to wood products. Assuming that after a number of down cycles a wood product would need to be incinerated, due to quality flaws, a new equilibrium of forest rotations would theoretically be met. Where the inflow of carbon bound in wood products in society would equal the outflow. In such a state, where society is considered saturated with recycled wood products, the benefit of downcycling wood products would be gone. However, this scenario assumes no growth of the total building stock, allowing the inflow of wood products to be larger than the outflow. Similar findings were produced in a reforestation simulation done by (Lundgren 2014).

Also, the issues with global warming needs solutions and policy changes that are able to have impact quickly. The issue of reaching a new equilibrium of stored carbon for the building stock in the future should therefore not be seen as major issue. Instead all types of recycling, particularly of products including biogenic carbon, should be promoted and benefited.

The same type of discussion is valid for cement replacing materials in concrete. Currently fly-ash and ground-granulated blast-furnace slag (GGBS) are the most common materials to substitute cement in concrete. Fly-ash is a by-product from coal power plants and GGBS is a by-product obtained by quenching molten iron slag. For both products, an economic allocation is common, prescribing almost no environmental impact related to the primary process of the by-product to the concrete. For a project utilising fly-ash, such as Kurkinen et al. (2017), the question arises of how long such products will be available and to what extent such concrete can be widely available in the industry.

There is a clear trend towards less use of coal power plant, for example UK recently had their first 24 hours without using any electricity from coal (The Guardian 2017). Therefore, it is valid to question the motives of investing into a future technology of which the resource flow (fly-ash) is diminishing on a long term horizon. On the other hand, just as with downcycling of wood products, timing of dealing with the environmental issues at hand are more important than the longevity of the solutions.

Assuming that biogenic carbon of wood products cancel out itself in the wood products life cycle is the more common approach when calculating the GWP. However, Erlandsson and Holm (2015) argue that at a stage where demolished material become raw material of a new product, environmental loads should be assigned to the new product. Calculating in such a way would cause wood products in general to have a negative GWP, which would affect all hybrid scenarios significantly if environmental loads of incinerating the wood products would be assigned to electricity and heat production.

8.2.2 Sensitivity of result using other EPD data and transport distances

The possible sensitivity of a result by using different data sets was shown by Andersson and Barkander (2015), Larsson et al. (2016) and Liljenström et al. (2015). However, the sensitivity of EPD data from CLT suppliers and the impact of their transport distance has not been studied as extensively. Since the production of CLT have a small GWP relative to for example concrete, the GWP from transports rise in relative importance.

As seen Section 7.2 the potential of choosing a local producer is large, when aiming to minimize the impact from CLT in the production stage. For a CLT intensive building, for example Scenario E, the importance of choosing a fairly local supplier is also shown in absolute numbers.

As such, for organisations trying to minimize their environmental impact through timber construction the choice of supplier can be of great importance. Efforts should be made to promote and encourage local and sustainable forestry.

8.3 The relevance of building designed to last up to 100 years

In terms of GWP, the lifetime of the building is an important factor and the outcomes can vary depending on what life time that is assumed for a building. While it is technically feasible for concrete residential buildings to stand for 100 years, this is far from evident when it comes to timber residential buildings. A lifetime of a 100 years would benefit both concrete buildings and buildings with CLT components. Concrete benefits from the carbonation process over of a long time perspective and CLT become a carbon sink with time, due to forest rotations. Even so, the question arises how relevant and certain a 100-year time span is. Introducing 50 more years of technical and political development create a lot of uncertainty.

Regardless of lifetime, the technical development in the upcoming 50 years might have made today's technology obsolete. Perhaps a question whether it is more sustainable to demolish and rebuild will be even more relevant at such time. Exponentially technical development on a general level is arguable undisputable. Moore's law seems to be applicable to an increasingly number of fields than just transistors. Even though the construction industry is generally lacking behind in technical development it could be considered naive not to believe that major technical disruptions will take place in our buildings during a time span of 100 years. The differences between how we live and work will most likely be greater 2017-2117 compared to 1917-2017. Buildings designed with a technical life time of a 100 years should therefore be flexible and robust in their design, allowing for more easily made changes.

An argument can be made on when the emissions occur. While concrete GWP lay mainly in cement production initially, the main proportion of wood products emissions come at the end of the life cycle in terms of incineration. To counter climate change, reductions in global emissions are needed today. Therefore, systems that postpone emissions of GHG are highly relevant to discuss and develop. In this study, only timber fulfils such categories. The case of concrete carbonation can be considered invalid from such a view. Due to the imperativeness of rapidly reducing GHG emissions, improvements in recycling concrete are considered more important.

8.4 The case of hybrid structural system from a construction point of view

As seen by the result in Chapter 6, there is a clear correlation between the amount of CLT and reduced emissions of GHG. The potential of hybrid structural systems is therefore very much dependent on construction techniques. Although smaller CLT buildings are being built without weather protection, the majority of larger residential buildings have been erected using different weather protection systems (Larsson et al. 2016). In contrast, concrete buildings do not need any type of weather protection. As such, the question is raised whether a hybrid structure is the most economical alternative with the prerequisite that weather protection will be needed.

While there is research suggesting that the cost of weather protection might even pay back itself on a concrete structural building system (SBUF 2006), there is still a lack of empirical evidence regarding this matter. Such arguments are based on the notion of savings through efficiency improvements, where hidden cost for mainly labourers are reduced.

If there is a need for investing in a weather protection system, there might be less incentives to utilize a hybrid solution. Hybrid systems could induce more complicated production methods on site for residential buildings. However, due to certain qualitative aspects, such as the acoustic performance of concrete slabs, hybrid structures constructed with weather protection could still be an interesting idea. Consideration has to be taken to production times, as the CLT systems are naturally very quick to erect. For that reason, prefabricated concrete members are favourable over cast-on-site concrete due its similarities to CLT systems. In such a way, the benefits of using a weather protections system would be maximised.

Also, just as with a pure CLT systems, hybrid system needs extra consideration in design and construction to fulfil qualitative aspects such as fire safety and acoustic demands. As stated by Thorsson (2016) conventional concrete constructions techniques are not viable in order to reach good results for timber buildings

In the transition of the construction industry towards being more sustainable, residential buildings in timber most likely plays a future part. For an actor leading the change, there are large potential strategic benefits for future benefits, as client’s climate awareness constantly grows. However, such a strategy also has to mitigate the risk of developing timber construction for residential buildings on a larger scale. Production methods allowing reliable results and a high level of quality assurance needs to be developed within such an organisation.

8.5 Non-covered impact categories

When discussing environmental impact in the construction industry, GWP is the main focus. While GWP is perhaps the most easily related indicator due to the threat of global warming, there are many other categories of environmental impact that are of great importance not to neglect. As shown in Chapter 6 and 7 wood products are in general more environmental friendly than concrete in terms of GWP, but research in concrete products show potential in reducing GWP. However, the fact that wood products come from a renewable resource is often forgotten in a discussion where GWP is the main focus.

If decisions are based upon studies that solely consider GWP there is a large risk for sub-optimisation of systems. The Swedish Environmental Research Institute (IVL) promote a so called robust LCA application for buildings and the construction industry in (Erlandsson et al. 2014). In their report IVL state that LCAs only considering one impact category, most often GWP, should be avoided due to the risk of sub optimising. Further suggested categories to include are: water usage, material toxicity, resource use and biodiversity. A clear example of conflict is where young forest (promoted by a growing timber industry) is beneficial with regards to GWP but negative with regards to biodiversity.

The above given impact categories are labelled as midpoint indicators, as explained in Section 3.3. When communicating within the industry midpoint indicators, using a clear unit, is most likely the best choice. If a large enough amount of midpoint indicators is being calculated in a study the use of endpoint indicators for communication to end users or the general public could be an option. The most accepted endpoint indicators are human health, natural environment and natural resources. By only having three easily understood indicators, readability of the result by the general public could be increased thus improving communication. However, as endpoint indicators are based on a weighting of midpoint indicators the results are unavoidable diluted. Therefore, using a selection of midpoint indicator considered being most important for a project or organisation could be a better idea.

8.6 Key factors from a project development and construction company's perspective and key areas for future studies

From a developer and construction company's perspective, there are many possibilities to influence the environmental impact done by the construction of residential buildings, even without facility management. The transition towards a more "green" society is very clear in most industries and in the general sentiment of the public. Being a leading actor on the market regarding environmental issues in residential projects is undoubtedly strategic strength for future business, as clients' awareness and demands are growing.

Regarding development and construction of residential buildings the following areas have been identified as key aspects for future development and studies;

- Review the cost of construction with CLT for medium sized residential buildings and assess the cost saving potential as the technology matures.
- Assess what is needed to implement CLT construction techniques within an organisation that mainly build conventional buildings, including quality assurance to reach qualitative aspect demands
- Review the cost and benefits of using weather protection systems. Assess the potential of modular and reusable systems
- Development and assessment of concrete recipes including cement replacing materials.
- Study possible measures to reduce the number of early refurbishments of apartments, what is possible to implement without being a cost driver?
- Study the potential of reducing GWP from other components than structural element during the production phase, as their importance grow when the impact from the use phase reduces
- Develop knowledge on the environmental impact regarding other important impact categories for residential houses

9 CONCLUSIONS

There is a clear correlation between reduction of GWP and the reduction of concrete in the scenarios used in the case study. When replacing concrete for CLT components, apartment separating walls in CLT show the greatest reduction potential, followed by slabs and exterior walls. CLT balconies do not show any reduction potential, mainly due to the used bitumen based layer on top.

An absolute majority, 95% - 98%, of the buildings' weight could be identified by eleven categories of the heaviest material in Section 6.2.1. Further these material groups and products account for 64 % - 75 % of the GWP during the production phase of the scenarios. Identifying such material groups for individual projects is a natural step in order to reduce the GWP from the production phase of a construction project.

Downcycling of CLT and the use of cement replacing materials prove large improvement possibilities for both systems, although highly dependent on future development and policies. Although downcycling of CLT showed larger potential than using cement replacing materials, synergies of using both techniques yield the largest reduction. Therefore, hybrid solutions using concrete for technical requirement and advantages can benefit from such an approach.

The result from Section 7.2 show that transports of CLT products can have a large relative share of total emission during production of CLT, if not being produced in close proximity to project site.

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APPENDIX A – DESCRIPTION OF CLT

A CLT panel is made up of several layers of wooden boards stacked and glued crosswise (Gagnon & Pirvu, 2011). Between three and seven layers are typically used. Consecutive layers are most common placed orthogonally, but in some cases two layers may be put in the same direction to achieve certain properties. In vertical load bearing members, the outer layers usually run parallel to the load. Similar, the other layers of slabs usually run in the direction of the mayor span. In Figure A1 some examples of possible cross sections are presented. 3 There is a wide range of board and panel dimensions and most manufactures have the ability to meet specific demands. It is generally considered that the size of panels is mainly limited by transports regulations (Gagnon & Pirvu, 2011).

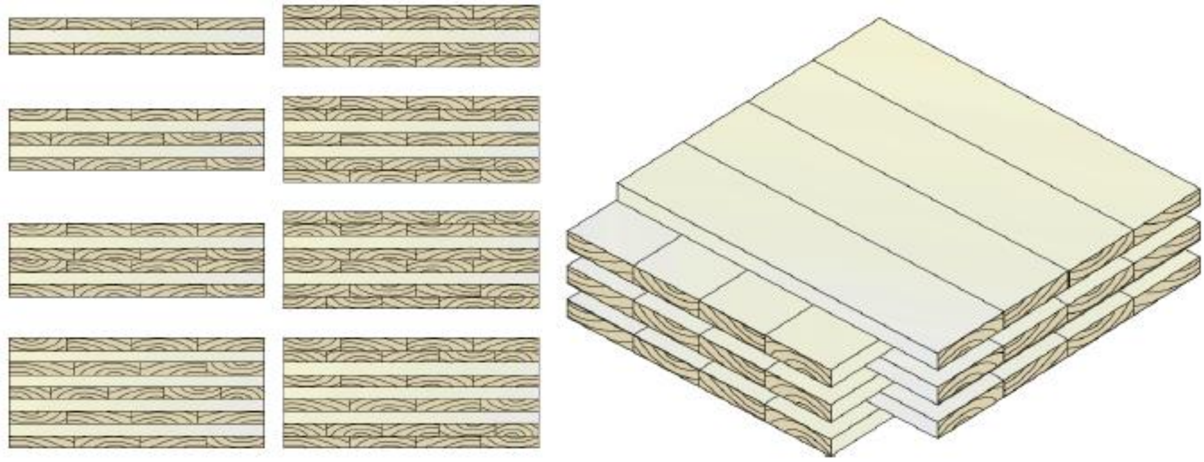


Figure A1: Examples of different cross sections and the general configuration of CLT-panels (Gagnon & Pirvu, 2011).

The large sized panels are mainly made possible by the fact that the boards are laminated crosswise. This creates great dimensional stability and out-of-plane stiffness (Gagnon & Pirvu, 2011). Further, it allows the panels to two work in a two-way action, similar to reinforced concrete.

The main advantage over prefabricated concrete panels are that CLT weigh much less (Schmidt & Griffin, 2013). The low weight allows for easy transportation, assembly and installation. Also, it lowers the self-weight of the building, making foundation work easier and less costly.

A.1 Manufacturing and assembly

A wide variety of wood can be used in the manufacturing process of CLT (Gagnon & Pirvu, 2011). Regarding adhesive there is a very wide variety to choose from which affects the properties of the product. Which is why CLT should not be compared to regular timber frame structures in that concern.

The durability and long term performance of CLT is, like all other wood products, highly dependent on not reaching a too high moisture content (Gagnon & Pirvu, 2011). Hence, the transportation, assembly and construction of the façade are critical stages for the long term structural performance of the load bearing system. Figure A2 provides examples of typical prefabricated wall and floor slab elements.

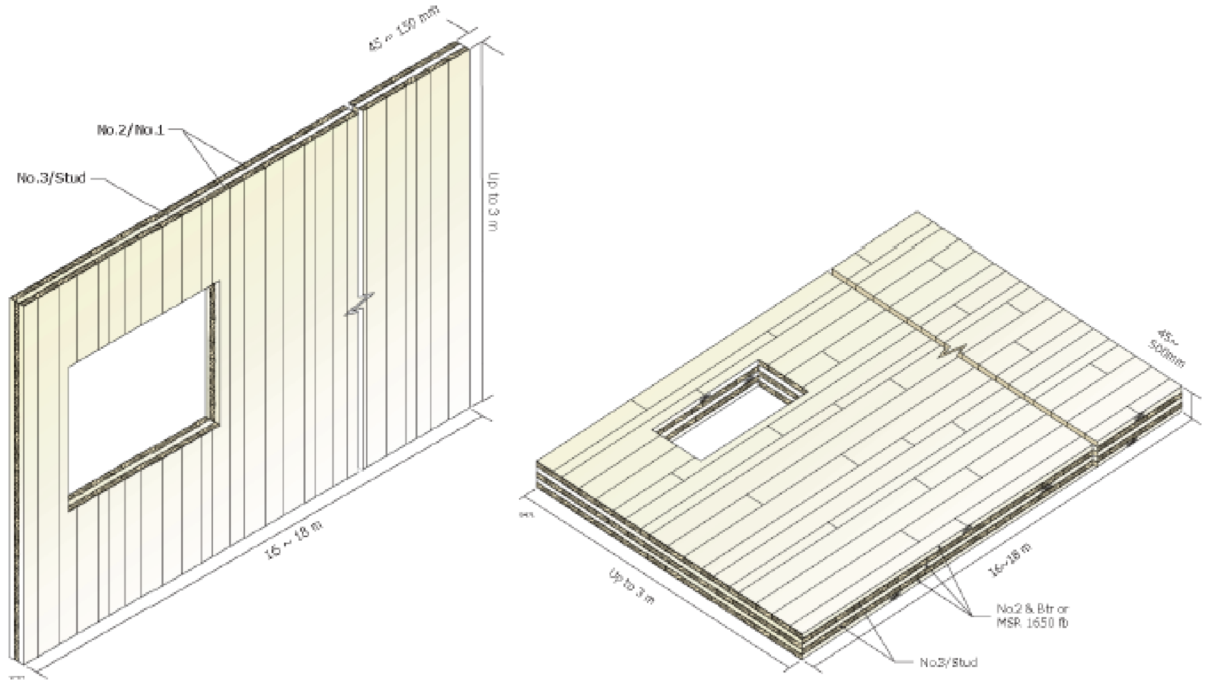


Figure A2: Examples of prefabricated wall and floor CLT elements (Gagnon & Pirvu, 2011).

Different suppliers offer various potential levels and types of prefabrication. Some suppliers focus on wall elements with different levels of prefabrication regarding façade and ready-made electricity and water pipes (Martinsons 2017). High levels of detail in production facilities opt for possibilities to tailor building elements in this case. There is also suppliers with a module focus (Trevita 2017).

A general approach to building with CLT in the Nordic countries involve using some sort of weather protection during the assembly stage. This involves production costs that are currently not affiliated when building with concrete. Weather protection, however, comes with benefits as well. The construction stage is relieved from most risks concerning weather and the protection also improve the working environment (SBUF 2006).

Another factor in construction that needs to be accounted for is the decrease in production time (Martinsons 2017). Compared to concrete structure, there is no dry-out time needed in wood production and as soon as a level has been assembled interior components can be installed.

APPENDIX B - BUILDING COMPONENTS

This appendix gives further description of all building components that have been replaced in the case study, except for the concrete balconies.

B.1 Concrete wall with brick façade

A structural concrete wall with dimensions 150 mm is insulated with 200 mm of mineral wool. The façade consists of a single layer brick façade, outside of a 30mm airgap. The wall is designed for any type of buildings. The wall is suitable for exposure for driving rain, due to its design with an air gap. An illustration of the wall can be seen in Figure B1.

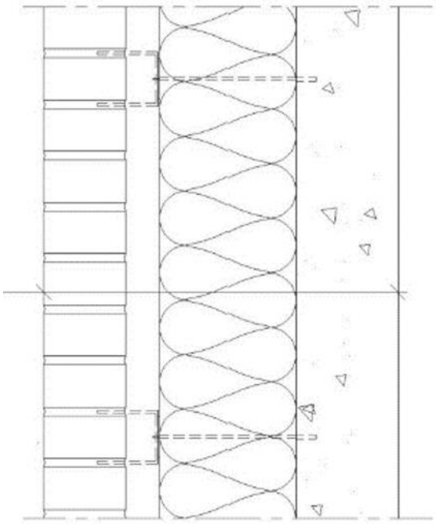


Figure B1: Illustration of the exterior concrete wall.

Included materials:

- 120 mm bricks - needs be resistant against frost damages
- 30 mm airgap - should be clean from mortar leftover
- 200 mm mineral wool
- 150 mm concrete – lowest quality C25/30

With 200 mm of insulation and concrete, the U-value has been calculated to 0,163 W/(m^2K) for this project. The fire safety of the wall has to be decided on project specific basis. Regarding the acoustic performance, the wall obtains $R'_w+C_{tr,50}>45$ dB(A).

B.2 Filigree slab

Filigree slabs is a common slab solution for residential buildings. It comes with a 45-mm prefabricated and reinforced concrete layer. On site it is complemented by installation and the upper reinforcement before a 200 mm concrete layer is added. Sound transmission through air is effectively reduced and with proper sound insulation for noise impact, sound class B in accordance with SS 25267:2015 can be obtained. The product generally provides a fire classification of R60. It is important that the concrete added on site is allowed enough time to dry on site before any flooring is installed. A schematic illustration of the slab is shown in Figure B2.

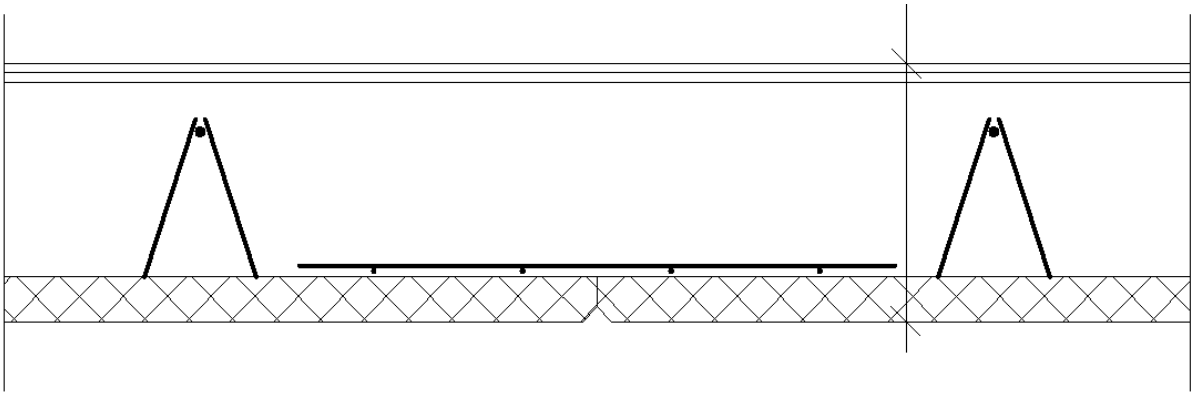


Figure B2: Illustration of a filigree slab.

B.3 Hollow core slab

The hollow core elements used in this study is HD/F 120/27, with an 85mm added layer of screed added on site. Sound class C is obtained through the system, although sound class B can be obtained during beneficial circumstances. Similarly, the elements generally provide a fire safety of R60, but can be designed to achieve R120. A vertical section of the slab can be seen in Figure B3.

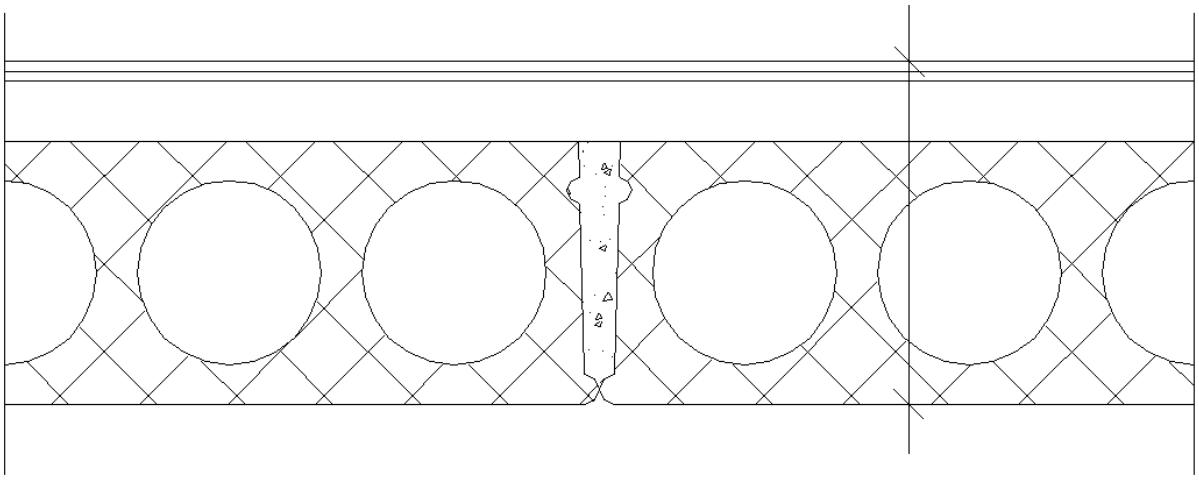
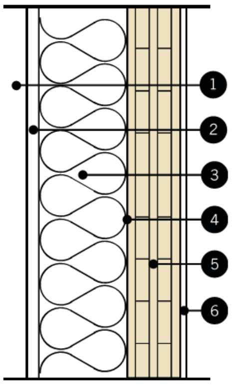


Figure B3: Illustration of a hollow core slab.

B.4 Exterior CLT wall (YV-22-01)

The exterior CLT wall chosen for the case study is labelled YV-22-01 in Martinsons product catalogue (Martinsons 2016). It achieves a sound insulating value of R'$_w$=52 dB(A) which corresponds to a sound class C. Further it achieves a U-value of 0,1629 W/(m^{2}K). See Figure B4 for an illustration of the wall.



1. Façade to be added
2. Standing lath
3. 235 mm insulation
4. 0,2 mm vapour barrier
5. 120 mm CLT element
6. 15 mm gypsum board

Figure B4: Illustration of the chosen exterior wall (Martinsons 2016).

B.5 Interior CLT walls (LS-11-01)

If CLT slabs are to be used in building projects there might be need for additional internal support, since the maximum span is generally smaller compared to filigree slabs and considerable smaller than hollow core elements. Also, interior CLT walls might be needed due to global stability issues. However, as the structural analysis carried out in this study only considers vertical loads, extra interior walls within apartments are omitted.

Generally, load bearing walls inside of apartments should be avoided if possible, due to less flexibility to future changes of the property use and layout.

A wall called LS-11-01 in Martinson's product catalogue will be the choice for apartment separating walls, due to its good sound insulating properties. An illustration is shown in Figure B5. It achieves a sound insulation value of R'_w=60 dB(A) and REI60 regarding fire safety.

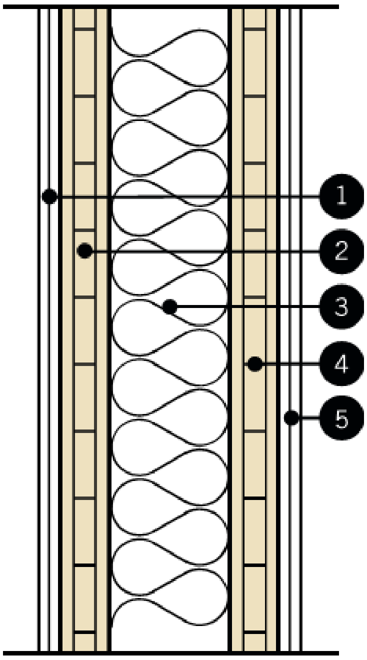


Figure B5: Illustration of LS-11-01 (Martinsons 2016)

1. 2*15 mm gypsum board
2. 80 mm CLT
3. 170 mm mineral wool
4. 80 mm CLT
5. 2*15 gypsum board

B.6 CLT slabs

Below are the chosen residential slab and balcony type for the project. Noticeable compared to concrete slabs are the thickness of the CLT slab, which is needed in order to obtain satisfactory sound insulation levels. MB-06-05 was chosen to use in the case study after consultation with structural engineers at Skanska.

B.6.1 MB-06-05

The slab obtains R60 and sound class C with regards air transmitted noise and noise impact (Martinsons 2016). In order to achieve a span of 7 meters a 240 mm thick CLT panel is needed. Figure B6 gives an illustration of the slab.

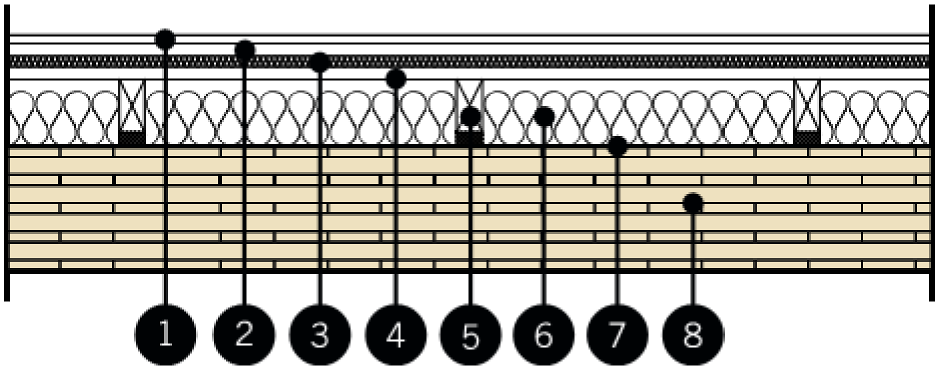


*Figure B6: Illustration of MB-06-05 (*Martinsons, 2016)

1. 14 mm parquet
2. 22 mm particle board
3. 20 mm noise impact reducing mat
4. 22 mm particle board
5. 95 mm wood studs
6. 100 mm mineral wool
7. 25 mm sylodyn
8. 240 mm CLT slab

B.6.2 CLT balcony

A predefined balcony design provided by Martinsons was chosen for the case study.

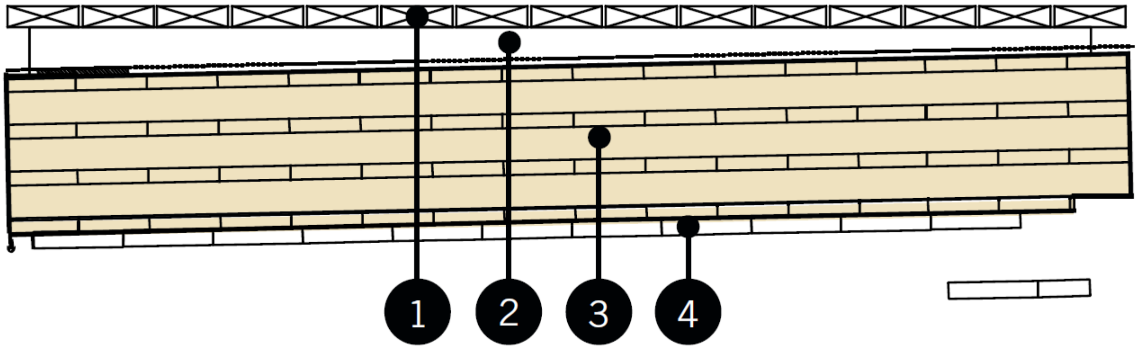


Figure B7: Illustration of the chosen balcony design (Martinsons, 2016)

1. 22 mm wood flooring
2. 22 bitumen
3. 208 CLT slab
4. 22 mm treated wood panel

APPENDIX C – QUALITATIVE FUNCTIONS CALCULATIONS

This appendix cover necessary calculations in order to provide the functional requirements set. It covers U-value calculations for the exterior walls and the structural analysis.

C.1 U-values for exterior walls

A simplified U-value calculation was carried out for the two types of exterior wall. The same amount and types of windows and doors are assumed for both cases and as such openings was omitted. In both cases the calculation are made up to the air gap.

The following input values were used:

- $\lambda_{gypsum} = 0{,}25\ W/(mK)$
- $\lambda_{CLT} = 0{,}12\ W/(mK)$
- $\lambda_{wood\ stud} = 0{,}14\ W/(mK)$
- $\lambda_{mineral\ wool} = 0{,}034\ W/(mK)$
- $\lambda_{concrete} = 1{,}7\ W/(mK)$
- $R_{se} = 0{,}04\ (m^2K)/W$
- $R_{si} = 0{,}13\ (m^2K)/W$

C.1.1 Concrete and brick wall

The following thicknesses were chosen:

- $d_{mineral\ wool} = 0{,}2\ m$
- $d_{concrete} = 0{,}15\ m$

Which provides the following U-value:

$$U_{concrete} = \frac{1}{R_{se} + \frac{d_{mineral\ wool}}{\lambda_{mineral\ wool}} + \frac{d_{concrete}}{\lambda_{concrete}} + R_{si}} = 0{,}1629\ W/(m^2K$$

C.1.2 CLT wall

The CLT wall was calculated for 1 m^2 to incorporate the wood studs. The following thicknesses were chosen for the wall:

- $d_{gypsum} = 0{,}015\ m$
- $d_{CLT} = 0{,}12\ m$
- $d_{mineral\ wool} = 0{,}235\ m$
- $d_{wood\ studs} = 0{,}095\ m$

Area of wood studs and insulation were calculated for each square meter. The wood studs are spaced 450 mm and have the dimension 45x95 mm.

$$A_{studs} = \frac{45}{450} = 0{,}1\ \frac{m^2}{m^2}$$

$$A_{mineral\ wool} = \frac{450 - 45}{450} = 0{,}9\ \frac{m^2}{m^2}$$

Thermal resistances for each material are as follows:

$$R_{gypsum} = \frac{d_{gypsum}}{\lambda_{gypsum}} = 0{,}06\ \frac{m^2K}{W}$$

$$R_{CLT} = \frac{d_{CLT}}{\lambda_{CLT}} = 1{,}00\ \frac{m^2K}{W}$$

$$R_{wood\ stud} = \frac{d_{wood\ stud}}{\lambda_{wood\ stud}} = 0{,}68\ \frac{m^2K}{W}$$

$$R_{mineral\ wool} = \frac{d_{mineral\ wool}}{\lambda_{mineral\ wool}} = 6{,}91\ \frac{m^2K}{W}$$

Total resistance through wood stud and insulation respectively:

$$R_{tot,stud} = R_{gypsum} + R_{CLT} + R_{wood\ stud} = 1{,}91\ \frac{m^2K}{W}$$

$$R_{tot,insulation} = R_{gypsum} + R_{CLT} + R_{mineral\ wool} = 8{,}14\ \frac{m^2K}{W}$$

Which provides the following U-value of the wall:

$$U_{CLT} = \frac{1}{R_{se} + \frac{1}{\frac{A_{stud}}{R_{tot,stud}} + \frac{A_{mineral\ wool}}{R_{tot,insulation}}} + R_{si}} = 0{,}1629\ W/(m^2K$$

C.2 Structural analysis

The objective of the structural analysis is only to prove the CLT design feasible with regards to vertical loads. It has been done with the help of the software 'Calculatis', provided by Stora Enso and design tables from Martinsons

The load derivations has been done in accordance with Eurocode, following the course work document Actions on Structures and Combinations of Loads (Engström 2015).

C.2.1 Vertical capacity of load bearing walls

The vertical capacity of the CLT walls was calculated by the help of the software 'Calculatis'. The only input values for the software are loads and product type. Correct partial factors and material factors for each load case are provided by 'Calculatis'.

For one meter of the load bearing wall on the bottom storey the residential load (main load) has been derived as follows:

- $Q_{res} = 2\frac{kN}{m^2}$
- $Span = l = 3{,}5\ m$
- $Width = b = 1\ m$
- $Number\ of\ storeys = n = 5$
- $Reduction\ for\ multiple\ storeys\ = \propto_n = \frac{2+(n-2)*0{,}7}{n} = 0{,}82$

$$P_{k,res} = Q_{res} * l * b * n * \propto_n = 28{,}7\ kN$$

For one meter of the load bearing wall on the bottom storey the snow load has been derived as follows:

- $Shape\ coefficent = \mu = 0{,}8 + 0{,}8 * \frac{20}{30} = 1{,}33$
- $Snow\ load\ based\ on\ geography\ =\ s_k = 1{,}5\ \frac{kN}{m^2}$
- $Specific\ snow\ load = s =\ \mu * s_k = 2\ \frac{kN}{m^2}$
- $l = 3{,}5\ m$
- $b = 1\ m$

$$P_{k,snow} = s * l * b = 7\ kN$$

For the self-weight of one meter of exterior the following assumptions have been made:

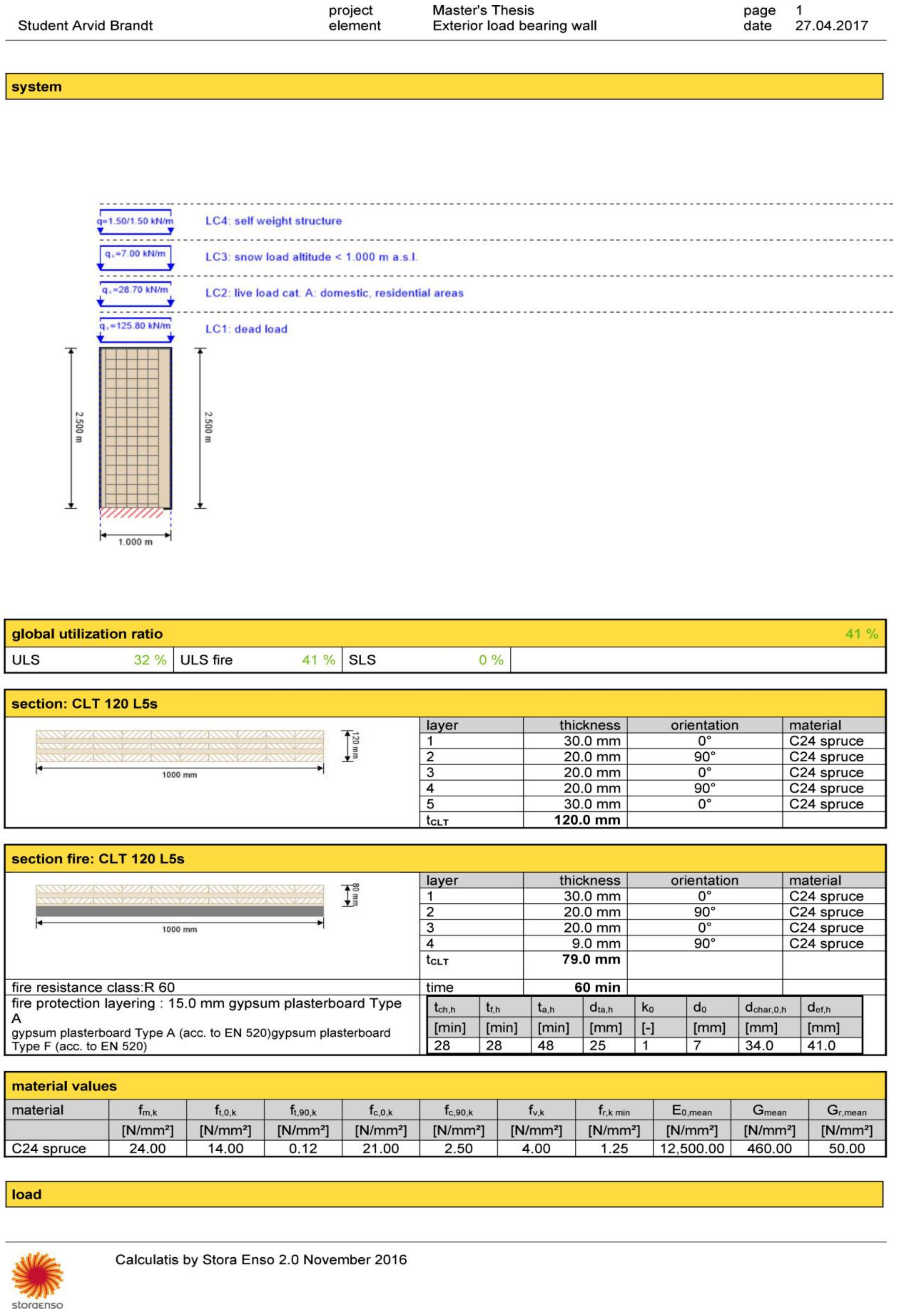
- $l = 3{,}5\ m$
- $b = 1\ m$
- $h = 2{,}77m$
- $Number\ of\ storeys = n = 5$
- $g_{k,roof} = 0{,}8\frac{kN}{m^2}$
- $g_{k,exterior\ wall} = 1{,}3\frac{kN}{m^2}$
- $g_{k,slabs} = 6\frac{kN}{m^2}$ (concrete)
- $$G_{k,exterior\ wall} = l * b * \left(g_{k,roof} + n * g_{k,slabs}\right) + b * h * n * g_{k,exterior\ wall} = 125{,}8\ kN$$

For the self-weight of one meter of interior wall the following assumptions have been made:

- $l = 3{,}5\ m$
- $b = 1\ m$
- $h = 2{,}77m$
- $Number\ of\ storeys = n = 5$
- $g_{k,roof} = 0{,}8\frac{kN}{m^2}$
- $g_{k,interior\ wall} = 0{,}05\frac{kN}{m^2}$
- $g_{k,slabs} = 6\frac{kN}{m^2}$ (concrete)

$$G_{k,interior\ wall} = l * b * \left(g_{k,roof} + n * g_{k,slabs}\right) + b * h * n * g_{k,interior\ wall} = 108{,}5\ kN$$

C.2.1.1 Exterior wall



	project	Master's Thesis	page	1
Student Arvid Brandt	element	Exterior load bearing wall	date	27.04.2017

system

global utilization ratio						41 %
ULS	32 %	ULS fire	41 %	SLS	0 %	

section: CLT 120 L5s

layer	thickness	orientation	material
1	30.0 mm	0°	C24 spruce
2	20.0 mm	90°	C24 spruce
3	20.0 mm	0°	C24 spruce
4	20.0 mm	90°	C24 spruce
5	30.0 mm	0°	C24 spruce
t_{CLT}	**120.0 mm**		

section fire: CLT 120 L5s

layer	thickness	orientation	material
1	30.0 mm	0°	C24 spruce
2	20.0 mm	90°	C24 spruce
3	20.0 mm	0°	C24 spruce
4	9.0 mm	90°	C24 spruce
t_{CLT}	**79.0 mm**		

fire resistance class:R 60

time **60 min**

fire protection layering : 15.0 mm gypsum plasterboard Type A
gypsum plasterboard Type A (acc. to EN 520)gypsum plasterboard Type F (acc. to EN 520)

$t_{ch,h}$	$t_{f,h}$	$t_{a,h}$	$d_{ta,h}$	k_0	d_0	$d_{char,0,h}$	$d_{ef,h}$
[min]	[min]	[min]	[mm]	[-]	[mm]	[mm]	[mm]
28	28	48	25	1	7	34.0	41.0

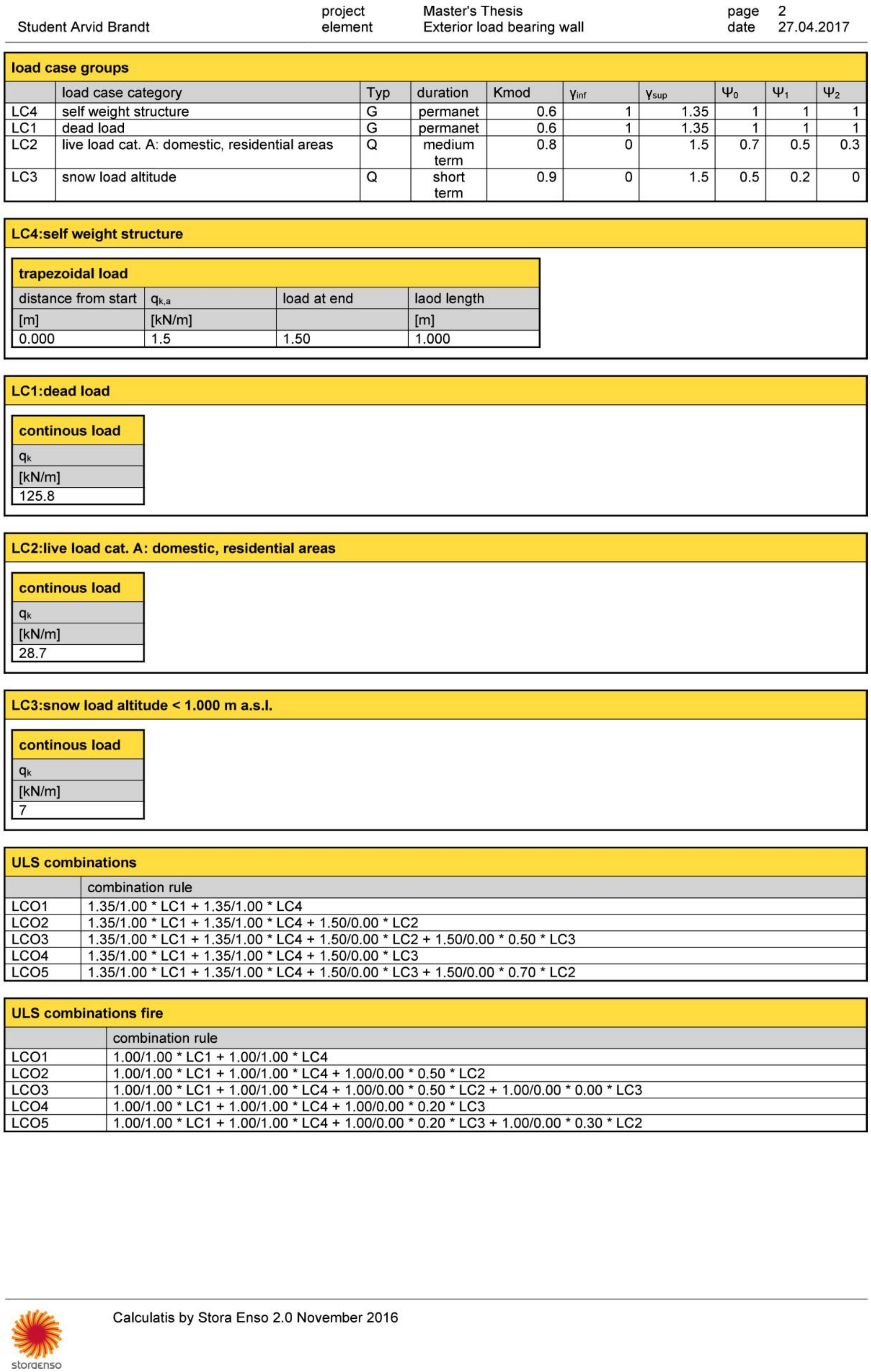
material values

material	$f_{m,k}$	$f_{t,0,k}$	$f_{t,90,k}$	$f_{c,0,k}$	$f_{c,90,k}$	$f_{v,k}$	$f_{r,k\ min}$	$E_{0,mean}$	G_{mean}	$G_{r,mean}$
	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]
C24 spruce	24.00	14.00	0.12	21.00	2.50	4.00	1.25	12,500.00	460.00	50.00

load

Calculatis by Stora Enso 2.0 November 2016

storaenso



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load case groups

	load case category	Typ	duration	Kmod	γ_{inf}	γ_{sup}	Ψ_0	Ψ_1	Ψ_2
LC4	self weight structure	G	permanet	0.6	1	1.35	1	1	1
LC1	dead load	G	permanet	0.6	1	1.35	1	1	1
LC2	live load cat. A: domestic, residential areas	Q	medium term	0.8	0	1.5	0.7	0.5	0.3
LC3	snow load altitude	Q	short term	0.9	0	1.5	0.5	0.2	0

LC4:self weight structure

trapezoidal load

distance from start	$q_{k,a}$	load at end	laod length
[m]	[kN/m]		[m]
0.000	1.5	1.50	1.000

LC1:dead load

continous load

q_k
[kN/m]
125.8

LC2:live load cat. A: domestic, residential areas

continous load

q_k
[kN/m]
28.7

LC3:snow load altitude < 1.000 m a.s.l.

continous load

q_k
[kN/m]
7

ULS combinations

	combination rule
LCO1	1.35/1.00 * LC1 + 1.35/1.00 * LC4
LCO2	1.35/1.00 * LC1 + 1.35/1.00 * LC4 + 1.50/0.00 * LC2
LCO3	1.35/1.00 * LC1 + 1.35/1.00 * LC4 + 1.50/0.00 * LC2 + 1.50/0.00 * 0.50 * LC3
LCO4	1.35/1.00 * LC1 + 1.35/1.00 * LC4 + 1.50/0.00 * LC3
LCO5	1.35/1.00 * LC1 + 1.35/1.00 * LC4 + 1.50/0.00 * LC3 + 1.50/0.00 * 0.70 * LC2

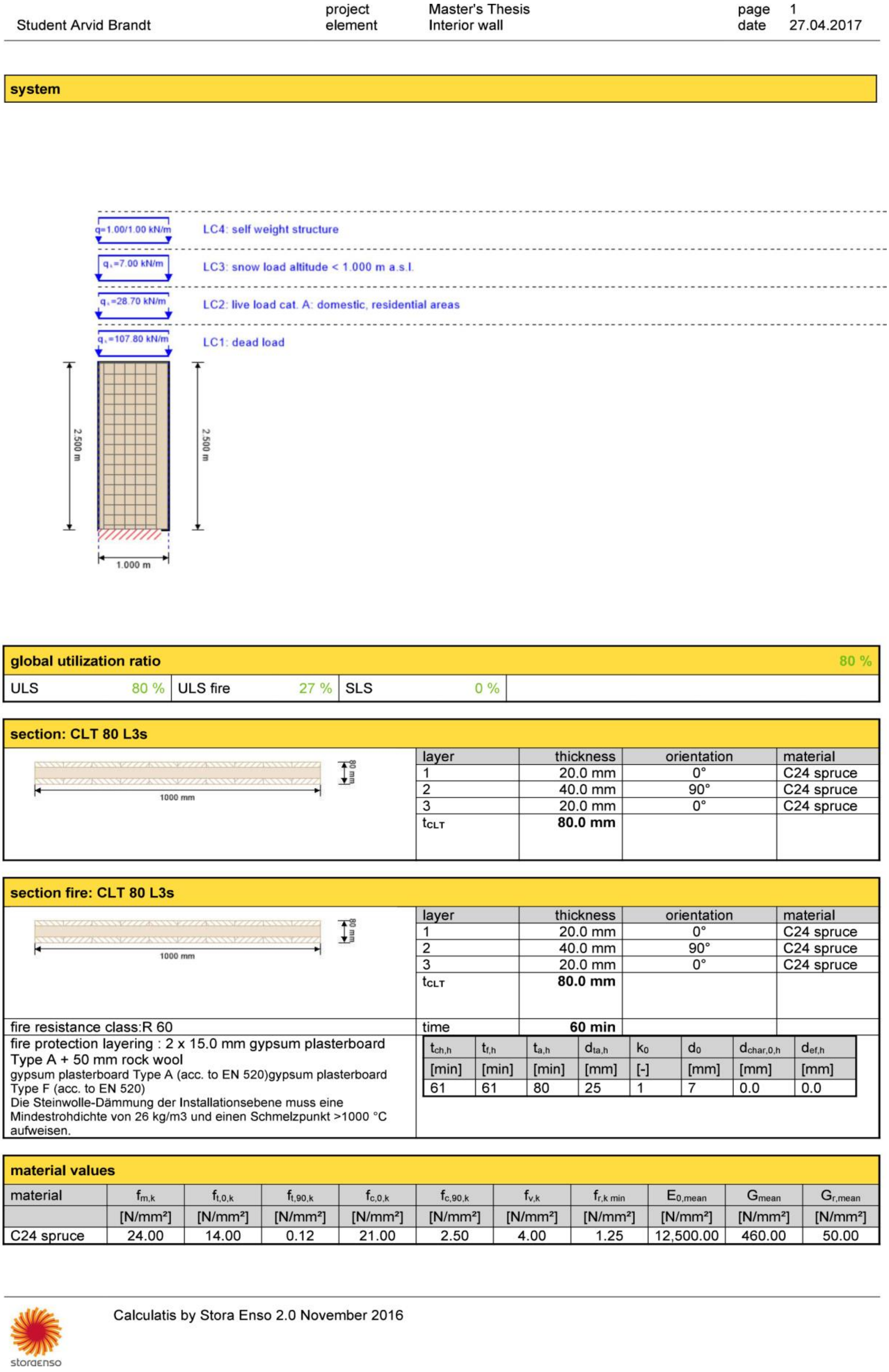
ULS combinations fire

	combination rule
LCO1	1.00/1.00 * LC1 + 1.00/1.00 * LC4
LCO2	1.00/1.00 * LC1 + 1.00/1.00 * LC4 + 1.00/0.00 * 0.50 * LC2
LCO3	1.00/1.00 * LC1 + 1.00/1.00 * LC4 + 1.00/0.00 * 0.50 * LC2 + 1.00/0.00 * 0.00 * LC3
LCO4	1.00/1.00 * LC1 + 1.00/1.00 * LC4 + 1.00/0.00 * 0.20 * LC3
LCO5	1.00/1.00 * LC1 + 1.00/1.00 * LC4 + 1.00/0.00 * 0.20 * LC3 + 1.00/0.00 * 0.30 * LC2

Calculatis by Stora Enso 2.0 November 2016

Figure C1: Excerpt from the structural analysis of the exterior wall done in the software Calculatis

C.2.1.2 Interior wall



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system

global utilization ratio						80 %
ULS	80 %	ULS fire	27 %	SLS	0 %	

section: CLT 80 L3s

layer	thickness	orientation	material
1	20.0 mm	0°	C24 spruce
2	40.0 mm	90°	C24 spruce
3	20.0 mm	0°	C24 spruce
t_{CLT}	**80.0 mm**		

section fire: CLT 80 L3s

layer	thickness	orientation	material
1	20.0 mm	0°	C24 spruce
2	40.0 mm	90°	C24 spruce
3	20.0 mm	0°	C24 spruce
t_{CLT}	**80.0 mm**		

fire resistance class:R 60

time **60 min**

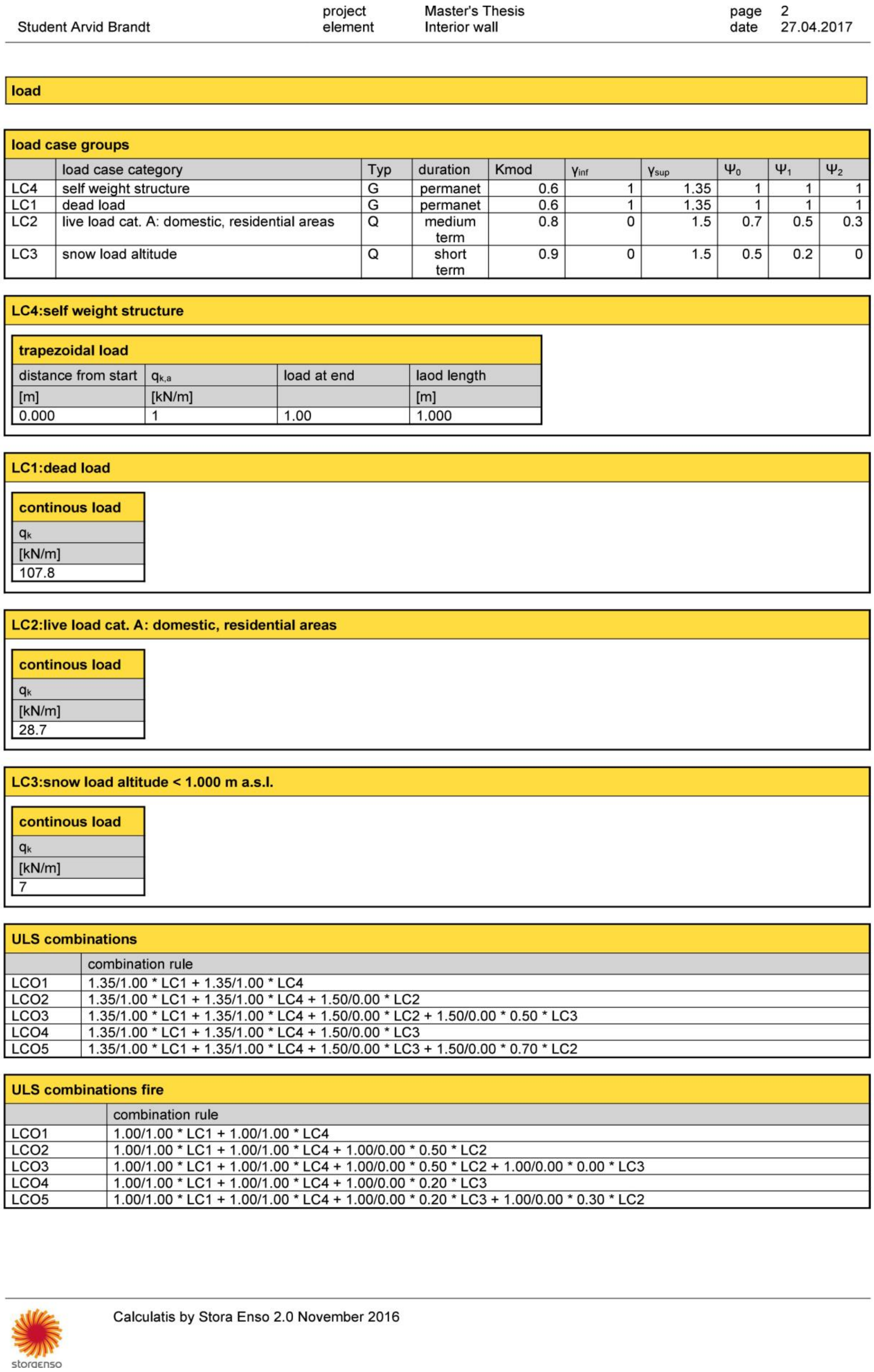
fire protection layering : 2 x 15.0 mm gypsum plasterboard Type A + 50 mm rock wool
gypsum plasterboard Type A (acc. to EN 520)gypsum plasterboard Type F (acc. to EN 520)
Die Steinwolle-Dämmung der Installationsebene muss eine Mindestrohdichte von 26 kg/m3 und einen Schmelzpunkt >1000 °C aufweisen.

$t_{ch,h}$	$t_{f,h}$	$t_{a,h}$	$d_{ta,h}$	k_0	d_0	$d_{char,0,h}$	$d_{ef,h}$
[min]	[min]	[min]	[mm]	[-]	[mm]	[mm]	[mm]
61	61	80	25	1	7	0.0	0.0

material values

material	$f_{m,k}$	$f_{t,0,k}$	$f_{t,90,k}$	$f_{c,0,k}$	$f_{c,90,k}$	$f_{v,k}$	$f_{r,k\ min}$	$E_{0,mean}$	G_{mean}	$G_{r,mean}$
	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]	[N/mm²]
C24 spruce	24.00	14.00	0.12	21.00	2.50	4.00	1.25	12,500.00	460.00	50.00

Calculatis by Stora Enso 2.0 November 2016



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project Master's Thesis
element Interior wall
page 2
date 27.04.2017

load

load case groups

	load case category	Typ	duration	Kmod	γ_{inf}	γ_{sup}	Ψ_0	Ψ_1	Ψ_2
LC4	self weight structure	G	permanet	0.6	1	1.35	1	1	1
LC1	dead load	G	permanet	0.6	1	1.35	1	1	1
LC2	live load cat. A: domestic, residential areas	Q	medium term	0.8	0	1.5	0.7	0.5	0.3
LC3	snow load altitude	Q	short term	0.9	0	1.5	0.5	0.2	0

LC4:self weight structure

trapezoidal load

distance from start	$q_{k,a}$	load at end	laod length
[m]	[kN/m]		[m]
0.000	1	1.00	1.000

LC1:dead load

continous load

q_k
[kN/m]
107.8

LC2:live load cat. A: domestic, residential areas

continous load

q_k
[kN/m]
28.7

LC3:snow load altitude < 1.000 m a.s.l.

continous load

q_k
[kN/m]
7

ULS combinations

	combination rule
LCO1	1.35/1.00 * LC1 + 1.35/1.00 * LC4
LCO2	1.35/1.00 * LC1 + 1.35/1.00 * LC4 + 1.50/0.00 * LC2
LCO3	1.35/1.00 * LC1 + 1.35/1.00 * LC4 + 1.50/0.00 * LC2 + 1.50/0.00 * 0.50 * LC3
LCO4	1.35/1.00 * LC1 + 1.35/1.00 * LC4 + 1.50/0.00 * LC3
LCO5	1.35/1.00 * LC1 + 1.35/1.00 * LC4 + 1.50/0.00 * LC3 + 1.50/0.00 * 0.70 * LC2

ULS combinations fire

	combination rule
LCO1	1.00/1.00 * LC1 + 1.00/1.00 * LC4
LCO2	1.00/1.00 * LC1 + 1.00/1.00 * LC4 + 1.00/0.00 * 0.50 * LC2
LCO3	1.00/1.00 * LC1 + 1.00/1.00 * LC4 + 1.00/0.00 * 0.50 * LC2 + 1.00/0.00 * 0.00 * LC3
LCO4	1.00/1.00 * LC1 + 1.00/1.00 * LC4 + 1.00/0.00 * 0.20 * LC3
LCO5	1.00/1.00 * LC1 + 1.00/1.00 * LC4 + 1.00/0.00 * 0.20 * LC3 + 1.00/0.00 * 0.30 * LC2

Calculatis by Stora Enso 2.0 November 2016

Figure C2: Excerpt from the structural analysis of the interior wall done in the software Calculatis

C.2.2 Residential slabs

The following design table from Martinsons was used when choosing CLT slab size.

Table C1: Martinsons' design table for residential slabs (Adapted from Martinsons 2017)

Load type 2)		Category A (Residential) 2,0 kN/m^2			
Slab 3)	Self-weight [kg/m^2]	Max span 4)	Deformation 6)	Max span 5)	Deformation 6)
L60-3s	24	2,3	L/315	2,0	L/465
L70-3s	28	2,6	L/321	2,6	L/321
L80-3s	32	3,1	L/304	3,0	L/333
L90-3s	36	3,4	L/312	3,4	L/312
L100-3s	40	3,7	L/316	3,7	L/316
L120-3s	48	4,5	L/302	4,3	L/341
L140-3s	56	5,1	L/313	4,7	L/395
L100-5s	40	3,5	L/318	3,5	L/318
L120-5s	48	4,0	L/317	3,9	L/315
L130-5s	52	4,6	L/319	4,4	L/336
L140-5s	56	4,5	L/308	4,3	L/350
L150-5s	60	5,2	L/302	4,6	L/397
L160-5s	64	5,7	L/311	5,0	L/420
L180-5s	72	5,7	L/335	5,0	L/446
L200-5s	80	6,3	L/368	5,6	L/514

L230-5s	92	6,8	L/422	6,0	L/594
L210-7s	84	6,3	L/380	5,6	L/528
L240-7s	96	7,1	L/455	6,3	L/643
L270-7s	108	7,4	L/500	6,5	L/722
L280-7s	112	7,4	L/493	6,6	L/673
L300-7s	120	7,7	L/538	6,9	L/726

1. EKS10, SS-EN1995-1-1, Safety class 3, Climate class 1, Self-weight = Self-weight slab + 50 kg/m^2
2. Imposed loads excl. partition walls according to 6.3.1.2(8) in SS-EN 1991-1-1 3)
3. ”L”=longitudinal outer lamella”60”=Thickness i mm.”3s”=Three lamellas.
4. Natural frequency min. demand ≥ 8 Hz, Deflection ≤ 1,3 mm at 3,0 m slab width
5. Natural frequency recommended for residential ≥ 10 Hz, Deflection ≤ 0,9 mm at 3,0 m slab width
6. Quasi permanent combination equation 6.16a & 6.16b (SS-EN 1990)

APPENDIX D – LIFE CYCLE INVENTORY ANALYSIS

Appendix D include the calculation regarding secondary effects and the complete inventory list for each scenario (exported in Swedish from Anavitor).

D.1 Secondary Effects

The following tables show the calculation of secondary effects for each scenario. X and Y reflects the length and width of the building and are changed due to increased size of interior load bearing walls.

D.1.1 Scenario A

Table D1: Calculated secondary effects for Scenario A.

	Insulation [m]	Foundation [m^2]	Roof [m^2]	A_{temp} [m^2]	Gross façade [m^2]
Original	0.2	512.5	546.0	2565.0	1415.5
New value	0.235	514.2	547.9	2571.0	1417.4
Relative change	117.5%	100.3%	100.3%	100.2%	100.1%

D.1.2 Scenario B

Table D2: Calculated secondary effects for Scenario B.

	X [m]	Y [m]	Foundation [m^2]	Roof [m^2]	A_{temp} [m^2]	Gross façade [m^2]
Original	35.1	14.6	512.5	546.0	2562.3	1415.5
New value	36.0	14.8	531.0	564.7	2654.9	1443.7
Relative change	102.4%	101.2%	103.6%	103.4%	103.6%	102.0%

D.1.3 Scenario C

Table D3: Calculated secondary effects for Scenario C.

	Insulation [m]	*X [m]*	*Y [m]*	*Foundation [m^2]*	*Roof [m^2]*	*A_{temp} [m^2]*	*Gross façade [m^2]*
Original	0.2	35.1	14.6	512.5	546.0	2565.0	1415.5
New value	0.235	36.0	14.8	534.5	568.5	2672.7	1447.6
Relative change	117.5%	102.6%	101.6%	104.3%	104.1%	104.2%	102.3%

D.1.4 Scenario D

Table D4: Calculated secondary effects for Scenario D.

	Insulation [m]	X [m]	Y [m]	Foundation [m^2]	Roof [m^2]	A_{temp} [m^2]	Slab thickness [m]	Gross façade [m^2]
Original	0.200	35.1	14.6	512.5	546.0	2562.3	0.250	1415.5

New value	0.235	36.0	14.8	534.5	568.5	2672.7	0.362	1504.6
Relative change	117.5%	102.6%	101.6%	104.3%	104.1%	104.3%	144.8%	106.3%

D.1.5 Scenario E

Table D5: Calculated secondary effects for Scenario E.

	Insulation [m]	X [m]	Y [m]	Foundation [m^2]	Roof [m^2]	A_{temp} [m^2]	Slab thickness [m]	Gross façade [m^2]
Original	0.200	35.1	14.6	512.5	546.0	2562.3	0.250	1415.5
New value	0.235	36.0	14.8	534.5	568.5	2672.7	0.438	1543.2
Relative change	117.5%	102.6%	101.6%	104.3%	104.1%	104.3%	175.2%	109.0%

D.2 Reference case

Product	**Weight [kg]**	**CO_2-eq. [kg]**
Skede: Produktion		
0-Projektdata		
Armering, skrotbaserat (IVL LCR)	78,9	68,5
Byggbetong Skanska C35/45 (IVL Skanska)	6412,5	1010,6
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	228,0	50,6
Planglas (IVL LCR)	12,0	6,9
Furu/gran, hyvlad & sågad (IVL LCR)	340,8	42,4
Skåpinrede i kök	194,2	65,5
Stålreglar (IVL LCR)	64,1	157,0
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	570,0	167,3
Fogmassa, silikon (IVL LCR)	273,6	501,0
Rostfritt stål, ospecificerat (IVL LCR)	3,3	8,6
Plåtdetaljer, målad (IVL LCR)	64,1	135,4
Snickerifärg inomhus, alkyd 70% TS (IVL LCR)	6,4	13,7
Lastbil 130-560 kW (IVL LCR)	0,0	0,0
Hjul- och Bandgrävmaskin 75-130 kW, 14-28 ton 21.1322 m fl (IVL LCR)	0,0	0,0
Dieselförbränning, produktion (IVL LCR)	0,0	0,0
Arbetsfordon, 75-130 (IVL LCR)	33,8	80974,7
01-Demontering		
Snickerifärg inomhus, alkyd 70% TS (IVL LCR)	394,8	847,6
01.SC-		
Mark och-murtegel (IVL LCR)	89694,3	21268,2
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	76507,2	16990,8
Armering, skrotbaserat (IVL LCR)	1104,0	957,8
Transport - avstånd	0,0	0,0
Furu/gran, hyvlad & sågad (IVL LCR)	4059,8	507,5
Rostfritt stål, ospecificerat (IVL LCR)	730,3	1899,5
Galvad spik, skruv och beslag (IVL LCR)	923,3	1379,5
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	3,7	6,9
Plastfolier (IVL LCR)	64,6	118,3
Mineralullsisolering (IVL LCR)	11638,8	15971,8
Pelare, balkar och stabiliserande väggar (IVL LCR)	498124,8	108577,5
Fogmassa, silikon (IVL LCR)	132,5	242,6
Takplåt, förzinkad (IVL LCR)	90,0	190,0
Underlagspapp bitumen (IVL LCR)	99,0	403,3
Formplywoodskivor (IVL LCR)	853,9	193,7
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	3353,4	986,1
Elförzinkad spik, skruv och beslag (IVL LCR)	10,8	52,3
01.SG-		
Ytpapp, ospecificerat (IVL LCR)	0,0	0,0
Underlagspapp bitumen (IVL LCR)	105,3	429,0
Galvad spik, skruv och beslag (IVL LCR)	106,4	159,0
Mineralullsisolering (IVL LCR)	1845,1	2532,0
Furu/gran, hyvlad & sågad (IVL LCR)	15457,7	1933,7
Träfiberskivor, hård board (IVL LCR)	298,1	95,5

Plastfolier (IVL LCR)	22,3	40,8
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	968,8	284,9
Elförzinkad spik, skruv och beslag (IVL LCR)	2,7	13,1
Takpanna, betong (IVL LCR)	17137,4	2720,9
15.A-		
Formolja, mineralisk (IVL LCR)	6,2	6,8
Armering, skrotbaserat (IVL LCR)	3361,1	2916,9
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	23,7	43,3
Byggbetong Skanska C25/30 (IVL Skanska)	138652,5	17698,2
15.S/11-		
Formplywoodskivor (IVL LCR)	130,9	29,7
Furu/gran, hyvlad & sågad (IVL LCR)	598,4	74,5
Galvad spik, skruv och beslag (IVL LCR)	8,6	12,8
Formolja, mineralisk (IVL LCR)	1,4	1,6
Armering, skrotbaserat (IVL LCR)	700,8	608,3
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	5,5	10,0
Byggbetong Skanska C25/30 (IVL Skanska)	15266,3	1947,9
Plastmatta	7,8	8,8
Plastprodukter av nylon/polyamid (PA) (IVL LCR)	10,2	18,7
15.SG/11-		
Armeringsnät (IVL LCR)	4899,5	4081,1
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	283,6	519,4
Armering, skrotbaserat (IVL LCR)	775,4	673,0
Byggbetong Skanska C28/35 (IVL Skanska)	202532,4	27364,6
Golvspackel, torrbruk (IVL LCR)	1004,9	222,8
Naturgrus, sand, grus, singel och kullersten (IVL LCR)	427,5	6,3
Cellplast, expanderad polystyren (EPS) (IVL LCR)	2470,1	9374,4
Byggbetong Skanska C25/30 (IVL Skanska)	35058,2	4482,3
Cellplast, extruderad polystyrene (XPS) (IVL LCR)	247,0	953,1
27.B/31-		
Betongelement	650950,0	173203,1
27.F/11-		
Formplywoodskivor (IVL LCR)	166,7	37,8
Furu/gran, hyvlad & sågad (IVL LCR)	1538,4	191,4
Galvad spik, skruv och beslag (IVL LCR)	22,7	33,9
Formolja, mineralisk (IVL LCR)	3,4	3,8
Armeringsnät (IVL LCR)	109,8	91,5
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	2,3	4,2
Armering, skrotbaserat (IVL LCR)	183,5	159,3
Ingjutenplast (IVL LCR)	2,4	2,7
Byggbetong Skanska C25/30 (IVL Skanska)	14035,1	1788,3
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	35,4	7,9
27.F/31-		
Högpresterande betongprefab, ospecificerad (IVL LCR)	38675,0	8305,7
Plattbärlag (IVL LCR)	221840,0	57492,1
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	6879,4	1530,0
Armeringsnät (IVL LCR)	1247,3	1039,2
Armering, skrotbaserat (IVL LCR)	22041,0	19130,7
Transport - avstånd	0,0	0,0
Ingjutenplast (IVL LCR)	292,5	330,1
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	8,5	15,5
Byggbetong Skanska C25/30 (IVL Skanska)	1241194,8	158147,0
27.Z-		
Armering, skrotbaserat (IVL LCR)	78,9	68,5
Byggbetong Skanska C35/45 (IVL Skanska)	6412,5	1010,6
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	228,0	50,6
Planglas (IVL LCR)	12,0	6,9
Furu/gran, hyvlad & sågad (IVL LCR)	340,8	42,4
Skåpinrede i kök	194,2	65,5
Stålreglar (IVL LCR)	64,1	157,0
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	570,0	167,3
Plåtdetaljer, målad (IVL LCR)	64,1	135,4
Fogmassa, silikon (IVL LCR)	311,2	569,9
Rostfritt stål, ospecificerat (IVL LCR)	3,3	8,6
Trälister, obehandlade (IVL LCR)	112,9	14,5
Elförzinkad spik, skruv och beslag (IVL LCR)	23,5	113,9
Galvad spik, skruv och beslag (IVL LCR)	320,6	479,0

Snickerifärg inomhus, alkyd 70% TS (IVL LCR)	7,0	15,0
41.B-		
Rör, elförzinkade (IVL LCR)	118,3	249,8
Takskyddsanordningar (IVL LCR)	84,6	126,4
Elförzinkad spik, skruv och beslag (IVL LCR)	5,9	28,6
Plåtdetaljer, målad (IVL LCR)	241,7	510,4
Furu/gran, hyvlad & sågad (IVL LCR)	1550,7	194,0
Glasfiber, ytskikt (IVL LCR)	57,4	94,6
Ytpapp, ospecificerat (IVL LCR)	0,0	0,0
Underlagspapp bitumen (IVL LCR)	9,8	40,1
Galvad spik, skruv och beslag (IVL LCR)	1,5	2,3
Plywoodskivor (IVL LCR)	50,5	11,5
41.C-		
Takskyddsanordningar (IVL LCR)	479,9	717,0
Furu/gran, hyvlad & sågad (IVL LCR)	15,3	1,9
Galvat stål och smide (IVL LCR)	6,4	11,6
Elförzinkad spik, skruv och beslag (IVL LCR)	21,2	102,8
Rör, elförzinkade (IVL LCR)	163,8	345,8
41.D-		
Mineralullsisolering (IVL LCR)	11550,0	15844,3
Glasull (IVL LCR)	33,8	46,4
Gjutrör, kartong (IVL LCR)	65,0	27,8
41.EF-		
Takskyddsanordningar (IVL LCR)	374,7	559,8
Galvat stål och smide (IVL LCR)	4,0	7,3
41.FB-		
Plåtdetaljer, målad (IVL LCR)	179,0	377,9
42.B-		
Cellplast, expanderad polystyren (EPS) (IVL LCR)	126,7	480,7
42.B/20-		
Tegelbalk	2003,0	43,7
42.D-		
Fönster, tre glas, trä-/aluminium (IVL LCR)	20997,5	23765,0
Elförzinkad spik, skruv och beslag (IVL LCR)	69,4	336,0
Skåp-, låd- och möbelbeslag (IVL LCR)	19,9	96,2
Galvad spik, skruv och beslag (IVL LCR)	10,1	15,1
Fogmassa, silikon (IVL LCR)	91,6	167,8
Mineralullsisolering (IVL LCR)	1061,1	1456,0
Skivmaterial övrigt, MDF (IVL LCR)	1526,4	639,6
Ytbehandlade trälister (IVL LCR)	251,9	32,5
Plåtdetaljer, målad (IVL LCR)	562,0	1186,5
Plastfolier (IVL LCR)	164,1	300,5
Fönster, trä, tre glas (IVL LCR)	2467,6	2101,9
Fönsterbänk, importerad natursten (IVL LCR)	2245,1	120,7
Aluminiumdörr (IVL LCR)	144,0	820,9
43.CB/41-		
Stålreglar (IVL LCR)	5199,5	12734,8
Elförzinkad spik, skruv och beslag (IVL LCR)	119,1	576,8
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	36642,5	10775,1
Mineralullsisolering (IVL LCR)	346,0	474,9
Plywoodskivor (IVL LCR)	5156,0	1169,6
Galvad spik, skruv och beslag (IVL LCR)	22,1	32,9
43.CC-		
Innerdörrar av trä (IVL LCR)	6384,0	2265,0
Galvad spik, skruv och beslag (IVL LCR)	9,6	14,3
Mässing, VVS-produkter (IVL LCR)	23,6	15,9
Ytbehandlade trälister (IVL LCR)	411,1	53,1
Elförzinkad spik, skruv och beslag (IVL LCR)	41,0	198,7
Skivmaterial övrigt, MDF (IVL LCR)	131,0	55,0
Kopplingar, mässing (IVL LCR)	6,1	29,3
Mineralullsisolering (IVL LCR)	20,4	28,1
Ståldörrar (IVL LCR)	4238,3	13994,1
Fogmassa, silikon (IVL LCR)	18,0	32,9
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	0,4	0,7
Aluminiumplåt (IVL LCR)	0,2	2,7
Plåtdetaljer, målad (IVL LCR)	151,2	319,2
43.DC-		
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	38940,0	8634,0
Naturgrus, sand, grus, singel och kullersten (IVL LCR)	1966,7	29,0
43.Z-		
Galvat stål och smide (IVL LCR)	798,0	1449,8

Elförzinkad spik, skruv och beslag (IVL LCR)	58,8	284,7
44.BB-		
Trägolv, lamellparkett (IVL LCR)	33457,7	7565,6
Transport - avstånd	0,0	0,0
Ytbehandlade trälister (IVL LCR)	681,9	88,0
Elförzinkad spik, skruv och beslag (IVL LCR)	1,7	8,2
Plastmatta	101,9	115,0
Klinkerplatta, klinker (IVL LCR)	14512,2	3375,5
Plastfolier (IVL LCR)	167,0	305,8
Fogmassa, silikon (IVL LCR)	11,5	21,1
Kakelplatta, kakel (IVL LCR)	243,1	56,5
44.C-		
Kakelplatta, kakel (IVL LCR)	24478,7	5691,9
Plastfolier (IVL LCR)	616,0	1128,0
Fogmassa, silikon (IVL LCR)	21,3	38,9
44.D-		
Undertaksystem Parafon Classic 18mm, 70 kg/m3, alubärverk (IVL Skanska)	176,4	812,7
Trälim/vitlim, PVAC (IVL LCR)	48,5	88,8
Undertaksplatta - mineralull	588,0	2040,6
45.BB-		
Aluminiumprofil (IVL LCR)	0,0	0,0
Konstruktionsstål, galvad (IVL LCR)	0,0	0,0
Konstruktionsstål, obelagd (IVL LCR)	3636,0	6304,1
45.BD-		
Konstruktionsstål, galvad (IVL LCR)	0,0	0,0
Konstruktionsstål, obelagd (IVL LCR)	285,3	494,7
45.CB-		
Byggbetong Skanska C25/30 (IVL Skanska)	35250,0	4478,7
Galvat stål och smide (IVL LCR)	500,0	908,4
46.A-		
Elförzinkad spik, skruv och beslag (IVL LCR)	519,6	2515,8
Kopplingar, mässing (IVL LCR)	10,9	52,2
Aluminiumprofil (IVL LCR)	16,4	222,5
Plåtdetaljer, målad (IVL LCR)	158,4	334,4
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	8,0	14,6
46.B-		
Melaminbelagd spånskiva	1160,1	390,9
Diskbänkar, tvättbänkar, utslagsbackar av rostfritt stål (IVL LCR)	223,8	473,5
Skåp-, låd- och möbelbeslag (IVL LCR)	17,7	85,9
Skivmaterial övrigt, MDF (IVL LCR)	2913,8	1223,2
Skåpinrede i kök	14937,1	5036,4
Bänkskiva, hötryckslaminat (typ HGP) (IVL LCR)	341,0	143,2
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	43,4	79,5
Kakelplatta, kakel (IVL LCR)	2298,1	534,4
Furu/gran, hyvlad & sågad (IVL LCR)	87,7	11,0
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	150,7	44,3
Elförzinkad spik, skruv och beslag (IVL LCR)	0,4	2,2
46.C-		
Tvättmaskin (IVL LCR)	2996,0	7639,2
Elförzinkad spik, skruv och beslag (IVL LCR)	378,0	1830,4
Bänkskiva, hötryckslaminat (typ HGP) (IVL LCR)	332,6	139,6
Spis med ugn (IVL LCR)	1820,0	4640,6
Kyl/sval och frys (IVL LCR)	3150,0	8031,9
Diskmaskin (IVL LCR)	1680,0	5392,5
Plåtdetaljer, målad (IVL LCR)	1,0	2,1
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	3,5	6,4
49.B-		
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	1281,5	377,0
Elförzinkad spik, skruv och beslag (IVL LCR)	2,0	9,8
Plastfolier (IVL LCR)	2,6	4,7
Stålreglar (IVL LCR)	92,5	226,6
Mineralullsisolering (IVL LCR)	80,5	110,5
Galvad spik, skruv och beslag (IVL LCR)	0,1	0,2
5-Fasader		
Rör, elförzinkade (IVL LCR)	76,8	162,1
Armaturer, förkromad mässing (IVL LCR)	336,6	7,3
Galvat stål och smide (IVL LCR)	1352,0	2456,3
Cellplast, expanderad polystyren (EPS) (IVL LCR)	8,5	32,2
Kopplingar, mässing (IVL LCR)	177,0	848,0
Mineralullsisolering (IVL LCR)	1918,2	2631,5
Plastprodukter av nylon/polyamid (PA) (IVL LCR)	138,0	252,7

Plåtdetaljer, målad (IVL LCR)	18,2	38,4
Radiator, vattenburen (IVL LCR)	1631,6	3444,7
Rör av rostfritt stål (IVL LCR)	920,2	2393,2
Rör och rörstolpar mm, galvat stål (IVL LCR)	389,3	698,8
Rör, förkromad koppar (IVL LCR)	1736,4	1170,0
Rör, gjutjärn (IVL LCR)	4105,5	9261,1
Rör, obelagd koppar (IVL LCR)	1865,2	40,7
Dränledningar, polyvinylklorid PVC (IVL LCR)	34,2	72,4
Rörisolering, NBR-cellgummi (svart) (IVL LCR)	1,8	3,3
Sanitetsporslin (IVL LCR)	389,3	170,8
Spånskiva (IVL LCR)	4,6	1,3
6-Stomkomplettering / rumsbildning		
Aluminiumprofil (IVL LCR)	15,7	212,9
Elförzinkad spik, skruv och beslag (IVL LCR)	1,4	6,9
Epoxifärg, tvåkomponentig vattenburen (IVL LCR)	0,0	0,5
Galvat stål och smide (IVL LCR)	590,1	1072,0
Kabelstegar, armaturrännor (IVL LCR)	521,3	1100,5
Kopplingar, mässing (IVL LCR)	65,1	311,9
Kopplingskabel, (FK, RK) (IVL LCR)	846,7	628,3
Plåtdetaljer, förzinkade (IVL LCR)	325,5	687,1
Rörkoppling, galvat stål (IVL LCR)	613,9	1115,3
71-		
Galvat stål och smide (IVL LCR)	1415,9	2572,4
Aluminiumprofil (IVL LCR)	42,9	582,2
Rör, gjutjärn (IVL LCR)	2688,8	6065,3
Planglas (IVL LCR)	71,5	41,1
Rör, obelagd koppar (IVL LCR)	64,4	1,4
Plastprodukter av polykarbonat (plexiglas), övrigt	57,2	445,1
Konstruktionsstål, obelagd (IVL LCR)	2459,9	4265,0
91//90-		
Plastfolier (IVL LCR)	25,9	47,5
Träfiberskivor, hård board (IVL LCR)	369,9	118,2
Galvad spik, skruv och beslag (IVL LCR)	3398,6	5077,8
Plywoodskivor (IVL LCR)	484,2	109,6
91//93-		
El, till byggarbetsplatsen (Nordenmix) (IVL LCR)	0,0	13348,4
Lastbil 130-560 kW (IVL LCR)	1,2	12410,9
Hjullastare 75-130 kW, 7-17 ton 22.1514; 22.2311 m fl (IVL LCR)	3,2	10613,6
91//96-		
Fjärrvärme till byggarbetsplatsen, ospecificerat (IVL LCR)	0,0	19342,5
Vägsalt (IVL LCR)	2270,0	694,2
Sorterat grus (IVL LCR)	22700,3	33,5
Ej påverkande tillfällig	0,0	0,0
Summa	***3697513***	***1039199***

Skede: Drift

-		
El, Nordenmix (IVL LCR)	0,0	1470980,4
Summa	***0***	***1470980***

Skede: Underhåll

-		
Tegelfasad	0,0	52003,3
Träfönster	0,0	65415,9
Betongpannetak	0,0	3472,7
Summa	***0***	***120892***

Skede: Rivning

-		
Rivningsentreprenad	1,0	51180,6
15.SG/11-		
Cellplast, expanderad polystyren (EPS) (IVL LCR)	2470,1	0,0
42.B-		
Cellplast, expanderad polystyren (EPS) (IVL LCR)	126,7	0,0
5-Fasader		
Cellplast, expanderad polystyren (EPS) (IVL LCR)	8,5	0,0
Summa	***2606***	***51181***

D.3 Scenario A

Product	**Weight [kg**	**CO_2-ekv. [kg]**
Skede: Produktion		
0-Projektdata		
Armering, skrotbaserat (IVL LCR)	79,1	68,6
Byggbetong Skanska C35/45 (IVL Skanska)	6427,5	1013,0
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	228,5	50,7
Planglas (IVL LCR)	12,0	6,9
Furu/gran, hyvlad & sågad (IVL LCR)	341,6	42,5
Skåpinrede i kök	194,6	65,6
Stålreglar (IVL LCR)	64,3	157,4
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	571,3	167,7
Fogmassa, silikon (IVL LCR)	274,2	502,2
Rostfritt stål, ospecificerat (IVL LCR)	3,3	8,6
Plåtdetaljer, målad (IVL LCR)	64,3	135,7
Snickerifärg inomhus, alkyd 70% TS (IVL LCR)	6,4	13,7
Lastbil 130-560 kW (IVL LCR)	0,0	0,0
Hjul- och Bandgrävmaskin 75-130 kW, 14-28 ton 21.1322 m fl (IVL LCR)	0,0	0,0
Dieselförbränning, produktion (IVL LCR)	0,0	0,0
Arbetsfordon, 75-130 (IVL LCR)	33,8	80967,1
01-Demontering		
Snickerifärg inomhus, alkyd 70% TS (IVL LCR)	395,8	849,6
01.SC-		
Takplåt, förzinkad (IVL LCR)	90,0	190,0
Underlagspapp bitumen (IVL LCR)	99,0	403,3
Galvad spik, skruv och beslag (IVL LCR)	18,1	27,0
Formplywoodskivor (IVL LCR)	853,9	193,7
Furu/gran, hyvlad & sågad (IVL LCR)	3458,3	432,6
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	3353,4	986,1
Elförzinkad spik, skruv och beslag (IVL LCR)	10,8	52,3
Mineralullsisolering (IVL LCR)	1007,3	1382,3
Plastfolier (IVL LCR)	60,2	110,2
01.SG-		
Ytpapp, ospecificerat (IVL LCR)	0,0	0,0
Underlagspapp bitumen (IVL LCR)	105,3	429,0
Galvad spik, skruv och beslag (IVL LCR)	106,9	159,7
Mineralullsisolering (IVL LCR)	1845,1	2532,0
Furu/gran, hyvlad & sågad (IVL LCR)	15544,1	1944,5
Träfiberskivor, hård board (IVL LCR)	298,1	95,5
Plastfolier (IVL LCR)	22,3	40,8
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	968,8	284,9
Elförzinkad spik, skruv och beslag (IVL LCR)	2,7	13,1
Takpanna, betong (IVL LCR)	17250,4	2738,9
15.A-		
Formolja, mineralisk (IVL LCR)	6,2	6,8
Armering, skrotbaserat (IVL LCR)	3361,1	2916,9
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	23,7	43,3
Byggbetong Skanska C25/30 (IVL Skanska)	138652,5	17698,2
15.S/11-		
Formplywoodskivor (IVL LCR)	130,9	29,7
Furu/gran, hyvlad & sågad (IVL LCR)	598,4	74,5
Galvad spik, skruv och beslag (IVL LCR)	8,6	12,8
Formolja, mineralisk (IVL LCR)	1,4	1,6
Armering, skrotbaserat (IVL LCR)	700,8	608,3
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	5,5	10,0
Byggbetong Skanska C25/30 (IVL Skanska)	15266,3	1947,9
Plastmatta	7,8	8,8
Plastprodukter av nylon/polyamid (PA) (IVL LCR)	10,2	18,7
15.SG/11-		
Armeringsnät (IVL LCR)	4909,0	4089,0
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	284,2	520,4
Armering, skrotbaserat (IVL LCR)	775,5	673,1
Byggbetong Skanska C28/35 (IVL Skanska)	202927,2	27417,9
Golvspackel, torrbruk (IVL LCR)	1006,8	223,2
Naturgrus, sand, grus, singel och kullersten (IVL LCR)	428,3	6,3
Cellplast, expanderad polystyren (EPS) (IVL LCR)	2474,9	9392,6
Byggbetong Skanska C25/30 (IVL Skanska)	35058,2	4482,3

Cellplast, extruderad polystyrene (XPS) (IVL LCR)	247,0	953,1
27.B/31-		
Betongelement	652360,0	173578,2
27.C/35-		
Mark och-murtegel (IVL LCR)	89856,7	21306,7
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	76645,8	17021,5
Armering, skrotbaserat (IVL LCR)	1106,0	959,6
Transport - avstånd	0,0	0,0
Furu/gran, hyvlad & sågad (IVL LCR)	9739,9	1218,0
Rostfritt stål, ospecificerat (IVL LCR)	731,6	1902,9
Galvat stål och smide (IVL LCR)	66,4	120,6
Plastfolier (IVL LCR)	301,1	551,6
Galvad spik, skruv och beslag (IVL LCR)	110,6	165,2
Mineralullsisolering (IVL LCR)	13209,4	18127,1
Elförzinkad spik, skruv och beslag (IVL LCR)	49,8	241,0
Korslimmat trä (KL-trä) (IVL LCR)	57069,6	13139,3
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	13736,5	4039,2
27.F/11-		
Formplywoodskivor (IVL LCR)	166,7	37,8
Furu/gran, hyvlad & sågad (IVL LCR)	1538,4	191,4
Galvad spik, skruv och beslag (IVL LCR)	22,7	33,9
Formolja, mineralisk (IVL LCR)	3,4	3,8
Armeringsnät (IVL LCR)	109,8	91,5
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	2,3	4,2
Armering, skrotbaserat (IVL LCR)	183,5	159,3
Ingjutenplast (IVL LCR)	2,4	2,7
Byggbetong Skanska C25/30 (IVL Skanska)	14035,1	1788,3
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	35,4	7,9
27.F/31-		
Plattbärlag (IVL LCR)	222310,0	57613,9
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	6894,0	1533,2
Armeringsnät (IVL LCR)	1250,0	1041,4
Armering, skrotbaserat (IVL LCR)	22087,7	19171,2
Transport - avstånd	0,0	0,0
Ingjutenplast (IVL LCR)	293,2	330,8
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	8,5	15,5
Byggbetong Skanska C25/30 (IVL Skanska)	1243824,5	158482,0
27.F/35-		
Tryckimpregnerat virke, NTR AB	4382,1	764,4
Transport - avstånd	0,0	0,0
Ytpapp, ospecificerat (IVL LCR)	982,8	4002,7
Underlagspapp bitumen (IVL LCR)	2,2	8,9
Korslimmat trä (KL-trä) (IVL LCR)	16278,1	3747,7
Furu/gran, hyvlad & sågad (IVL LCR)	4232,6	526,7
27.Z-		
Armering, skrotbaserat (IVL LCR)	79,1	68,6
Byggbetong Skanska C35/45 (IVL Skanska)	6427,5	1013,0
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	228,5	50,7
Planglas (IVL LCR)	12,0	6,9
Furu/gran, hyvlad & sågad (IVL LCR)	341,6	42,5
Skåpinrede i kök	194,6	65,6
Stålreglar (IVL LCR)	64,3	157,4
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	571,3	167,7
Plåtdetaljer, målad (IVL LCR)	64,3	135,7
Fogmassa, silikon (IVL LCR)	311,9	571,2
Rostfritt stål, ospecificerat (IVL LCR)	3,3	8,6
Trälister, obehandlade (IVL LCR)	113,1	14,6
Elförzinkad spik, skruv och beslag (IVL LCR)	23,6	114,1
Galvad spik, skruv och beslag (IVL LCR)	321,4	480,2
Snickerifärg inomhus, alkyd 70% TS (IVL LCR)	7,0	15,1
41.B-		
Rör, elförzinkade (IVL LCR)	118,3	249,8
Takskyddsanordningar (IVL LCR)	84,6	126,4
Elförzinkad spik, skruv och beslag (IVL LCR)	5,9	28,6
Plåtdetaljer, målad (IVL LCR)	241,7	510,4
Furu/gran, hyvlad & sågad (IVL LCR)	1550,7	194,0
Glasfiber, ytskikt (IVL LCR)	57,4	94,6
Ytpapp, ospecificerat (IVL LCR)	0,0	0,0
Underlagspapp bitumen (IVL LCR)	9,8	40,1
Galvad spik, skruv och beslag (IVL LCR)	1,5	2,3

Plywoodskivor (IVL LCR)	50,5	11,5
41.C-		
Takskyddsanordningar (IVL LCR)	482,2	720,4
Furu/gran, hyvlad & sågad (IVL LCR)	15,3	1,9
Galvat stål och smide (IVL LCR)	6,4	11,6
Elförzinkad spik, skruv och beslag (IVL LCR)	21,3	103,4
Rör, elförzinkade (IVL LCR)	164,7	347,7
41.D-		
Mineralullsisolering (IVL LCR)	11550,0	15844,3
Glasull (IVL LCR)	33,8	46,4
Gjutrör, kartong (IVL LCR)	65,0	27,8
41.EF-		
Takskyddsanordningar (IVL LCR)	374,7	559,8
Galvat stål och smide (IVL LCR)	4,0	7,3
41.FB-		
Plåtdetaljer, målad (IVL LCR)	179,0	377,9
42.B-		
Cellplast, expanderad polystyren (EPS) (IVL LCR)	126,7	480,7
42.B/20-		
Tegelbalk	2003,0	43,7
42.D-		
Fönster, tre glas, trä-/aluminium (IVL LCR)	20997,5	23765,0
Elförzinkad spik, skruv och beslag (IVL LCR)	69,4	336,0
Skåp-, låd- och möbelbeslag (IVL LCR)	19,9	96,2
Galvad spik, skruv och beslag (IVL LCR)	10,1	15,1
Fogmassa, silikon (IVL LCR)	91,6	167,8
Mineralullsisolering (IVL LCR)	1061,1	1456,0
Skivmaterial övrigt, MDF (IVL LCR)	1526,4	639,6
Ytbehandlade trälister (IVL LCR)	251,9	32,5
Plåtdetaljer, målad (IVL LCR)	562,0	1186,5
Plastfolier (IVL LCR)	164,1	300,5
Fönster, trä, tre glas (IVL LCR)	2467,6	2101,9
Fönsterbänk, importerad natursten (IVL LCR)	2245,1	120,7
Aluminiumdörr (IVL LCR)	144,0	820,9
43.CB/41-		
Stålreglar (IVL LCR)	5206,9	12753,2
Elförzinkad spik, skruv och beslag (IVL LCR)	119,3	577,8
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	36707,1	10794,1
Mineralullsisolering (IVL LCR)	346,9	476,1
Plywoodskivor (IVL LCR)	5156,0	1169,6
Galvad spik, skruv och beslag (IVL LCR)	22,1	32,9
43.CC-		
Innerdörrar av trä (IVL LCR)	6384,0	2265,0
Galvad spik, skruv och beslag (IVL LCR)	9,6	14,3
Mässing, VVS-produkter (IVL LCR)	23,6	15,9
Ytbehandlade trälister (IVL LCR)	411,1	53,1
Elförzinkad spik, skruv och beslag (IVL LCR)	41,0	198,7
Skivmaterial övrigt, MDF (IVL LCR)	131,0	55,0
Kopplingar, mässing (IVL LCR)	6,1	29,3
Mineralullsisolering (IVL LCR)	20,4	28,1
Ståldörrar (IVL LCR)	4238,3	13994,1
Fogmassa, silikon (IVL LCR)	18,0	32,9
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	0,4	0,7
Aluminiumplåt (IVL LCR)	0,2	2,7
Plåtdetaljer, målad (IVL LCR)	151,2	319,2
43.DC-		
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	39022,5	8652,3
Naturgrus, sand, grus, singel och kullersten (IVL LCR)	1970,8	29,1
43.Z-		
Galvat stål och smide (IVL LCR)	798,0	1449,8
Elförzinkad spik, skruv och beslag (IVL LCR)	58,8	284,7
44.BB-		
Trägolv, lamellparkett (IVL LCR)	33552,9	7587,1
Transport - avstånd	0,0	0,0
Ytbehandlade trälister (IVL LCR)	683,8	88,3
Elförzinkad spik, skruv och beslag (IVL LCR)	1,7	8,3
Plastmatta	101,9	115,0
Klinkerplatta, klinker (IVL LCR)	14514,7	3376,0
Plastfolier (IVL LCR)	167,0	305,8
Fogmassa, silikon (IVL LCR)	11,5	21,1
Kakelplatta, kakel (IVL LCR)	244,7	56,9

44.C-		
Kakelplatta, kakel (IVL LCR)	24478,7	5691,9
Plastfolier (IVL LCR)	616,0	1128,0
Fogmassa, silikon (IVL LCR)	21,3	38,9
44.D-		
Undertaksystem Parafon Classic 18mm, 70 kg/m3, alubärverk (IVL Skanska)	176,4	812,7
Trälim/vitlim, PVAC (IVL LCR)	48,5	88,8
Undertaksplatta - mineralull	588,0	2040,6
45.BB-		
Aluminiumprofil (IVL LCR)	0,0	0,0
Konstruktionsstål, galvad (IVL LCR)	0,0	0,0
Konstruktionsstål, obelagd (IVL LCR)	3636,0	6304,1
45.BD-		
Konstruktionsstål, galvad (IVL LCR)	0,0	0,0
Konstruktionsstål, obelagd (IVL LCR)	285,3	494,7
45.CB-		
Byggbetong Skanska C25/30 (IVL Skanska)	35250,0	4478,7
Galvat stål och smide (IVL LCR)	500,0	908,4
46.A-		
Elförzinkad spik, skruv och beslag (IVL LCR)	519,6	2515,8
Kopplingar, mässing (IVL LCR)	10,9	52,2
Aluminiumprofil (IVL LCR)	16,4	222,5
Plåtdetaljer, målad (IVL LCR)	158,4	334,4
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	8,0	14,6
46.B-		
Melaminbelagd spånskiva	1160,1	390,9
Diskbänkar, tvättbänkar, utslagsbackar av rostfritt stål (IVL LCR)	223,8	473,5
Skåp-, låd- och möbelbeslag (IVL LCR)	17,7	85,9
Skivmaterial övrigt, MDF (IVL LCR)	2913,8	1223,2
Skåpinrede i kök	14937,1	5036,4
Bänkskiva, hötryckslaminat (typ HGP) (IVL LCR)	341,0	143,2
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	43,4	79,5
Kakelplatta, kakel (IVL LCR)	2298,1	534,4
Furu/gran, hyvlad & sågad (IVL LCR)	87,7	11,0
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	150,7	44,3
Elförzinkad spik, skruv och beslag (IVL LCR)	0,4	2,2
46.C-		
Tvättmaskin (IVL LCR)	2996,0	7639,2
Elförzinkad spik, skruv och beslag (IVL LCR)	378,0	1830,4
Bänkskiva, hötryckslaminat (typ HGP) (IVL LCR)	332,6	139,6
Spis med ugn (IVL LCR)	1820,0	4640,6
Kyl/sval och frys (IVL LCR)	3150,0	8031,9
Diskmaskin (IVL LCR)	1680,0	5392,5
Plåtdetaljer, målad (IVL LCR)	1,0	2,1
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	3,5	6,4
49.B-		
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	1281,5	377,0
Elförzinkad spik, skruv och beslag (IVL LCR)	2,0	9,8
Plastfolier (IVL LCR)	2,6	4,7
Stålreglar (IVL LCR)	92,5	226,6
Mineralullsisolering (IVL LCR)	80,5	110,5
Galvad spik, skruv och beslag (IVL LCR)	0,1	0,2
5-Fasader		
Rör, elförzinkade (IVL LCR)	76,8	162,1
Armaturer, förkromad mässing (IVL LCR)	336,6	7,3
Galvat stål och smide (IVL LCR)	1352,0	2456,3
Cellplast, expanderad polystyren (EPS) (IVL LCR)	8,5	32,2
Kopplingar, mässing (IVL LCR)	177,0	848,0
Mineralullsisolering (IVL LCR)	1918,2	2631,5
Plastprodukter av nylon/polyamid (PA) (IVL LCR)	138,0	252,7
Plåtdetaljer, målad (IVL LCR)	18,2	38,4
Radiator, vattenburen (IVL LCR)	1631,6	3444,7
Rör av rostfritt stål (IVL LCR)	920,2	2393,2
Rör och rörstolpar mm, galvat stål (IVL LCR)	389,3	698,8
Rör, förkromad koppar (IVL LCR)	1736,4	1170,0
Rör, gjutjärn (IVL LCR)	4105,5	9261,1
Rör, obelagd koppar (IVL LCR)	1865,2	40,7
Dränledningar, polyvinylklorid PVC (IVL LCR)	34,2	72,4
Rörisolering, NBR-cellgummi (svart) (IVL LCR)	1,8	3,3
Sanitetsporslin (IVL LCR)	389,3	170,8
Spånskiva (IVL LCR)	4,6	1,3

6-Stomkomplettering / rumsbildning		
Aluminiumprofil (IVL LCR)	15,7	212,9
Elförzinkad spik, skruv och beslag (IVL LCR)	1,4	6,9
Epoxifärg, tvåkomponentig vattenburen (IVL LCR)	0,0	0,5
Galvat stål och smide (IVL LCR)	590,1	1072,0
Kabelstegar, armaturrännor (IVL LCR)	521,3	1100,5
Kopplingar, mässing (IVL LCR)	65,1	311,9
Kopplingskabel, (FK, RK) (IVL LCR)	846,7	628,3
Plåtdetaljer, förzinkade (IVL LCR)	325,5	687,1
Rörkoppling, galvat stål (IVL LCR)	613,9	1115,3
71-		
Galvat stål och smide (IVL LCR)	1415,9	2572,4
Aluminiumprofil (IVL LCR)	42,9	582,2
Rör, gjutjärn (IVL LCR)	2688,8	6065,3
Planglas (IVL LCR)	71,5	41,1
Rör, obelagd koppar (IVL LCR)	64,4	1,4
Plastprodukter av polykarbonat (plexiglas), övrigt	57,2	445,1
Konstruktionsstål, obelagd (IVL LCR)	2459,9	4265,0
91//90-		
Plastfolier (IVL LCR)	25,9	47,5
Träfiberskivor, hård board (IVL LCR)	369,9	118,2
Galvad spik, skruv och beslag (IVL LCR)	3406,6	5089,7
Plywoodskivor (IVL LCR)	484,2	109,6
91//93-		
El, till byggarbetsplatsen (Nordenmix) (IVL LCR)	0,0	13379,6
Lastbil 130-560 kW (IVL LCR)	1,2	12439,9
Hjullastare 75-130 kW, 7-17 ton 22.1514; 22.2311 m fl (IVL LCR)	3,2	10613,6
91//96-		
Fjärrvärme till byggarbetsplatsen, ospecificerat (IVL LCR)	0,0	19387,7
Vägsalt (IVL LCR)	2275,3	695,8
Sorterat grus (IVL LCR)	22753,4	33,6
Ej påverkande tillfällig	0,0	0,0
Summa	***3274458***	***953969***
Skede: Drift		
-		
El, Nordenmix (IVL LCR)	0,0	1474421,3
Summa	***0***	***1474421***
Skede: Underhåll		
-		
Tegelfasad	0,0	52097,5
Träfönster	0,0	67098,6
Betongpannetak	0,0	3491,8
Summa	***0***	***122688***
Skede: Rivning		
-		
Rivningsentreprenad	1,0	45662,7
15.SG/11-		
Cellplast, expanderad polystyren (EPS) (IVL LCR)	2474,9	0,0
42.B-		
Cellplast, expanderad polystyren (EPS) (IVL LCR)	126,7	0,0
5-Fasader		
Cellplast, expanderad polystyren (EPS) (IVL LCR)	8,5	0,0
Summa	***2611***	***45663***

D.4 Scenario B

Product	**Weight [kg]**	**CO$_2$-eq. [kg]**
Skede: Produktion		
0-Projektdata		
Armering, skrotbaserat (IVL LCR)	81,7	70,9
Byggbetong Skanska C35/45 (IVL Skanska)	6637,5	1046,1
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	236,0	52,3
Planglas (IVL LCR)	12,4	7,1
Furu/gran, hyvlad & sågad (IVL LCR)	352,7	43,9
Skåpinrede i kök	201,0	67,8
Stålreglar (IVL LCR)	66,4	162,5
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	590,0	173,2

Fogmassa, silikon (IVL LCR)	283,2	518,6
Rostfritt stål, ospecificerat (IVL LCR)	3,4	8,9
Plåtdetaljer, målad (IVL LCR)	66,4	140,1
Snickerifärg inomhus, alkyd 70% TS (IVL LCR)	6,6	14,2
Lastbil 130-560 kW (IVL LCR)	0,0	0,0
Hjul- och Bandgrävmaskin 75-130 kW, 14-28 ton 21.1322 m fl (IVL LCR)	0,0	0,0
Dieselförbränning, produktion (IVL LCR)	0,0	0,0
Arbetsfordon, 75-130 (IVL LCR)	33,7	80838,1
01-Demontering		
Snickerifärg inomhus, alkyd 70% TS (IVL LCR)	408,7	877,4
01.SC-		
Mark och-murtegel (IVL LCR)	91481,6	21692,0
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	78031,8	17329,3
Armering, skrotbaserat (IVL LCR)	1126,0	976,9
Transport - avstånd	0,0	0,0
Furu/gran, hyvlad & sågad (IVL LCR)	4071,7	508,9
Rostfritt stål, ospecificerat (IVL LCR)	744,8	1937,4
Galvad spik, skruv och beslag (IVL LCR)	941,4	1406,5
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	3,8	7,0
Plastfolier (IVL LCR)	64,7	118,5
Mineralullsisolering (IVL LCR)	11850,7	16262,5
Pelare, balkar och stabiliserande väggar (IVL LCR)	508051,2	110741,2
Fogmassa, silikon (IVL LCR)	135,1	247,4
Takplåt, förzinkad (IVL LCR)	90,0	190,0
Underlagspapp bitumen (IVL LCR)	99,0	403,3
Formplywoodskivor (IVL LCR)	853,9	193,7
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	3353,4	986,1
Elförzinkad spik, skruv och beslag (IVL LCR)	10,8	52,3
01.SG-		
Ytpapp, ospecificerat (IVL LCR)	0,0	0,0
Underlagspapp bitumen (IVL LCR)	105,3	429,0
Galvad spik, skruv och beslag (IVL LCR)	109,4	163,5
Mineralullsisolering (IVL LCR)	1845,1	2532,0
Furu/gran, hyvlad & sågad (IVL LCR)	16034,2	2005,8
Träfiberskivor, hård board (IVL LCR)	298,1	95,5
Plastfolier (IVL LCR)	22,3	40,8
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	968,8	284,9
Elförzinkad spik, skruv och beslag (IVL LCR)	2,7	13,1
Takpanna, betong (IVL LCR)	17890,7	2840,5
15.A-		
Formolja, mineralisk (IVL LCR)	6,4	7,0
Armering, skrotbaserat (IVL LCR)	3485,6	3024,9
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	24,5	44,9
Byggbetong Skanska C25/30 (IVL Skanska)	143787,8	18353,7
15.S/11-		
Formplywoodskivor (IVL LCR)	130,9	29,7
Furu/gran, hyvlad & sågad (IVL LCR)	598,4	74,5
Galvad spik, skruv och beslag (IVL LCR)	8,6	12,8
Formolja, mineralisk (IVL LCR)	1,4	1,6
Armering, skrotbaserat (IVL LCR)	700,8	608,3
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	5,5	10,0
Byggbetong Skanska C25/30 (IVL Skanska)	15266,3	1947,9
Plastmatta	7,8	8,8
Plastprodukter av nylon/polyamid (PA) (IVL LCR)	10,2	18,7
15.SG/11-		
Armeringsnät (IVL LCR)	5071,4	4224,3
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	293,6	537,7
Armering, skrotbaserat (IVL LCR)	803,3	697,2
Byggbetong Skanska C28/35 (IVL Skanska)	209638,8	28324,8
Golvspackel, torrbruk (IVL LCR)	1040,1	230,6
Naturgrus, sand, grus, singel och kullersten (IVL LCR)	442,5	6,5
Cellplast, expanderad polystyren (EPS) (IVL LCR)	2556,8	9703,3
Byggbetong Skanska C25/30 (IVL Skanska)	36321,6	4643,8
Cellplast, extruderad polystyrene (XPS) (IVL LCR)	255,9	987,5
27.B/35-		
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	71241,1	20948,3
Elförzinkad spik, skruv och beslag (IVL LCR)	172,1	833,2
Korslimmat trä (KL-trä) (IVL LCR)	86326,8	19875,2

Mineralullsisolering (IVL LCR)	7303,6	10022,7
27.F/11-		
Formplywoodskivor (IVL LCR)	166,7	37,8
Furu/gran, hyvlad & sågad (IVL LCR)	1538,4	191,4
Galvad spik, skruv och beslag (IVL LCR)	22,7	33,9
Formolja, mineralisk (IVL LCR)	3,4	3,8
Armeringsnät (IVL LCR)	109,8	91,5
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	2,3	4,2
Armering, skrotbaserat (IVL LCR)	183,5	159,3
Ingjutenplast (IVL LCR)	2,4	2,7
Byggbetong Skanska C25/30 (IVL Skanska)	14035,1	1788,3
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	35,4	7,9
27.F/31-		
Högpresterande betongprefab, ospecificerad (IVL LCR)	38675,0	8305,7
Plattbärlag (IVL LCR)	229642,0	59514,0
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	7121,3	1583,8
Armeringsnät (IVL LCR)	1291,2	1075,7
Armering, skrotbaserat (IVL LCR)	22816,2	19803,5
Transport - avstånd	0,0	0,0
Ingjutenplast (IVL LCR)	302,8	341,7
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	8,8	16,1
Byggbetong Skanska C25/30 (IVL Skanska)	1284847,0	163708,9
27.Z-		
Armering, skrotbaserat (IVL LCR)	81,7	70,9
Byggbetong Skanska C35/45 (IVL Skanska)	6637,5	1046,1
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	236,0	52,3
Planglas (IVL LCR)	12,4	7,1
Furu/gran, hyvlad & sågad (IVL LCR)	352,7	43,9
Skåpinrede i kök	201,0	67,8
Stålreglar (IVL LCR)	66,4	162,5
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	590,0	173,2
Plåtdetaljer, målad (IVL LCR)	66,4	140,1
Fogmassa, silikon (IVL LCR)	322,1	589,9
Rostfritt stål, ospecificerat (IVL LCR)	3,4	8,9
Trälister, obehandlade (IVL LCR)	116,8	15,0
Elförzinkad spik, skruv och beslag (IVL LCR)	24,3	117,8
Galvad spik, skruv och beslag (IVL LCR)	331,9	495,8
Snickerifärg inomhus, alkyd 70% TS (IVL LCR)	7,3	15,6
41.B-		
Rör, elförzinkade (IVL LCR)	122,4	258,4
Takskyddsanordningar (IVL LCR)	87,5	130,7
Elförzinkad spik, skruv och beslag (IVL LCR)	6,1	29,6
Plåtdetaljer, målad (IVL LCR)	248,2	524,1
Furu/gran, hyvlad & sågad (IVL LCR)	1590,9	199,0
Glasfiber, ytskikt (IVL LCR)	59,4	97,9
Ytpapp, ospecificerat (IVL LCR)	0,0	0,0
Underlagspapp bitumen (IVL LCR)	9,8	40,1
Galvad spik, skruv och beslag (IVL LCR)	1,5	2,3
Plywoodskivor (IVL LCR)	50,5	11,5
41.C-		
Takskyddsanordningar (IVL LCR)	495,1	739,7
Furu/gran, hyvlad & sågad (IVL LCR)	15,3	1,9
Galvat stål och smide (IVL LCR)	6,6	12,0
Elförzinkad spik, skruv och beslag (IVL LCR)	22,0	106,6
Rör, elförzinkade (IVL LCR)	169,8	358,5
41.D-		
Mineralullsisolering (IVL LCR)	11950,0	16393,0
Glasull (IVL LCR)	33,8	46,4
Gjutrör, kartong (IVL LCR)	67,3	28,7
41.EF-		
Takskyddsanordningar (IVL LCR)	374,7	559,8
Galvat stål och smide (IVL LCR)	4,0	7,3
41.FB-		
Plåtdetaljer, målad (IVL LCR)	179,0	377,9
42.B-		
Cellplast, expanderad polystyren (EPS) (IVL LCR)	131,4	498,5
42.B/20-		
Tegelbalk	2057,0	44,8
42.D-		
Fönster, tre glas, trä-/aluminium (IVL LCR)	21627,3	24477,8

Elförzinkad spik, skruv och beslag (IVL LCR)	70,3	340,2
Skåp-, låd- och möbelbeslag (IVL LCR)	20,4	98,7
Galvad spik, skruv och beslag (IVL LCR)	10,3	15,4
Fogmassa, silikon (IVL LCR)	93,9	171,9
Mineralullsisolering (IVL LCR)	1087,2	1491,9
Skivmaterial övrigt, MDF (IVL LCR)	1564,1	655,4
Ytbehandlade trälister (IVL LCR)	258,1	33,3
Plåtdetaljer, målad (IVL LCR)	577,7	1219,7
Plastfolier (IVL LCR)	168,2	308,0
Fönster, trä, tre glas (IVL LCR)	2467,6	2101,9
Fönsterbänk, importerad natursten (IVL LCR)	2313,3	124,4
Aluminiumdörr (IVL LCR)	144,0	820,9
43.CB/41-		
Stålreglar (IVL LCR)	5289,7	12955,7
Elförzinkad spik, skruv och beslag (IVL LCR)	121,7	589,4
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	37417,5	11003,0
Mineralullsisolering (IVL LCR)	357,7	490,9
Plywoodskivor (IVL LCR)	5156,0	1169,6
Galvad spik, skruv och beslag (IVL LCR)	22,1	32,9
43.CC-		
Innerdörrar av trä (IVL LCR)	6384,0	2265,0
Galvad spik, skruv och beslag (IVL LCR)	9,6	14,3
Mässing, VVS-produkter (IVL LCR)	23,6	15,9
Ytbehandlade trälister (IVL LCR)	411,1	53,1
Elförzinkad spik, skruv och beslag (IVL LCR)	41,0	198,7
Skivmaterial övrigt, MDF (IVL LCR)	131,0	55,0
Kopplingar, mässing (IVL LCR)	6,1	29,3
Mineralullsisolering (IVL LCR)	20,4	28,1
Ståldörrar (IVL LCR)	4238,3	13994,1
Fogmassa, silikon (IVL LCR)	18,0	32,9
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	0,4	0,7
Aluminiumplåt (IVL LCR)	0,2	2,7
Plåtdetaljer, målad (IVL LCR)	151,2	319,2
43.DC-		
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	40309,5	8937,7
Naturgrus, sand, grus, singel och kullersten (IVL LCR)	2035,8	30,1
43.Z-		
Galvat stål och smide (IVL LCR)	798,0	1449,8
Elförzinkad spik, skruv och beslag (IVL LCR)	58,8	284,7
44.BB-		
Trägolv, lamellparkett (IVL LCR)	34752,6	7858,4
Transport - avstånd	0,0	0,0
Ytbehandlade trälister (IVL LCR)	708,2	91,4
Elförzinkad spik, skruv och beslag (IVL LCR)	1,8	8,6
Plastmatta	102,1	115,2
Klinkerplatta, klinker (IVL LCR)	14526,8	3378,8
Plastfolier (IVL LCR)	167,0	305,8
Fogmassa, silikon (IVL LCR)	11,5	21,1
Kakelplatta, kakel (IVL LCR)	252,8	58,7
44.C-		
Kakelplatta, kakel (IVL LCR)	24478,7	5691,9
Plastfolier (IVL LCR)	616,0	1128,0
Fogmassa, silikon (IVL LCR)	21,3	38,9
44.D-		
Undertaksystem Parafon Classic 18mm, 70 kg/m3, alubärverk (IVL Skanska)	176,4	812,7
Trälim/vitlim, PVAC (IVL LCR)	48,5	88,8
Undertaksplatta - mineralull	588,0	2040,6
45.BB-		
Aluminiumprofil (IVL LCR)	0,0	0,0
Konstruktionsstål, galvad (IVL LCR)	0,0	0,0
Konstruktionsstål, obelagd (IVL LCR)	3636,0	6304,1
45.BD-		
Konstruktionsstål, galvad (IVL LCR)	0,0	0,0
Konstruktionsstål, obelagd (IVL LCR)	285,3	494,7
45.CB-		
Byggbetong Skanska C25/30 (IVL Skanska)	35250,0	4478,7
Galvat stål och smide (IVL LCR)	500,0	908,4
46.A-		
Elförzinkad spik, skruv och beslag (IVL LCR)	519,6	2515,8
Kopplingar, mässing (IVL LCR)	10,9	52,2
Aluminiumprofil (IVL LCR)	16,4	222,5

Plåtdetaljer, målad (IVL LCR)	158,4	334,4
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	8,0	14,6
46.B-		
Melaminbelagd spånskiva	1160,1	390,9
Diskbänkar, tvättbänkar, utslagsbackar av rostfritt stål (IVL LCR)	223,8	473,5
Skåp-, låd- och möbelbeslag (IVL LCR)	17,7	85,9
Skivmaterial övrigt, MDF (IVL LCR)	2913,8	1223,2
Skåpinrede i kök	14937,1	5036,4
Bänkskiva, hötryckslaminat (typ HGP) (IVL LCR)	341,0	143,2
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	43,4	79,5
Kakelplatta, kakel (IVL LCR)	2298,1	534,4
Furu/gran, hyvlad & sågad (IVL LCR)	87,7	11,0
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	150,7	44,3
Elförzinkad spik, skruv och beslag (IVL LCR)	0,4	2,2
46.C-		
Tvättmaskin (IVL LCR)	2996,0	7639,2
Elförzinkad spik, skruv och beslag (IVL LCR)	378,0	1830,4
Bänkskiva, hötryckslaminat (typ HGP) (IVL LCR)	332,6	139,6
Spis med ugn (IVL LCR)	1820,0	4640,6
Kyl/sval och frys (IVL LCR)	3150,0	8031,9
Diskmaskin (IVL LCR)	1680,0	5392,5
Plåtdetaljer, målad (IVL LCR)	1,0	2,1
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	3,5	6,4
49.B-		
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	1281,5	377,0
Elförzinkad spik, skruv och beslag (IVL LCR)	2,0	9,8
Plastfolier (IVL LCR)	2,6	4,7
Stålreglar (IVL LCR)	92,5	226,6
Mineralullsisolering (IVL LCR)	80,5	110,5
Galvad spik, skruv och beslag (IVL LCR)	0,1	0,2
5-Fasader		
Rör, elförzinkade (IVL LCR)	76,8	162,1
Armaturer, förkromad mässing (IVL LCR)	336,6	7,3
Galvat stål och smide (IVL LCR)	1352,0	2456,3
Cellplast, expanderad polystyren (EPS) (IVL LCR)	8,5	32,2
Kopplingar, mässing (IVL LCR)	177,0	848,0
Mineralullsisolering (IVL LCR)	1918,2	2631,5
Plastprodukter av nylon/polyamid (PA) (IVL LCR)	138,0	252,7
Plåtdetaljer, målad (IVL LCR)	18,2	38,4
Radiator, vattenburen (IVL LCR)	1631,6	3444,7
Rör av rostfritt stål (IVL LCR)	920,2	2393,2
Rör och rörstolpar mm, galvat stål (IVL LCR)	389,3	698,8
Rör, förkromad koppar (IVL LCR)	1736,4	1170,0
Rör, gjutjärn (IVL LCR)	4105,5	9261,1
Rör, obelagd koppar (IVL LCR)	1865,2	40,7
Dränledningar, polyvinylklorid PVC (IVL LCR)	34,2	72,4
Rörisolering, NBR-cellgummi (svart) (IVL LCR)	1,8	3,3
Sanitetsporslin (IVL LCR)	389,3	170,8
Spånskiva (IVL LCR)	4,6	1,3
6-Stomkomplettering / rumsbildning		
Aluminiumprofil (IVL LCR)	15,7	212,9
Elförzinkad spik, skruv och beslag (IVL LCR)	1,4	6,9
Epoxifärg, tvåkomponentig vattenburen (IVL LCR)	0,0	0,5
Galvat stål och smide (IVL LCR)	590,1	1072,0
Kabelstegar, armaturrännor (IVL LCR)	521,3	1100,5
Kopplingar, mässing (IVL LCR)	65,1	311,9
Kopplingskabel, (FK, RK) (IVL LCR)	846,7	628,3
Plåtdetaljer, förzinkade (IVL LCR)	325,5	687,1
Rörkoppling, galvat stål (IVL LCR)	613,9	1115,3
71-		
Galvat stål och smide (IVL LCR)	1415,9	2572,4
Aluminiumprofil (IVL LCR)	42,9	582,2
Rör, gjutjärn (IVL LCR)	2688,8	6065,3
Planglas (IVL LCR)	71,5	41,1
Rör, obelagd koppar (IVL LCR)	64,4	1,4
Plastprodukter av polykarbonat (plexiglas), övrigt	57,2	445,1
Konstruktionsstål, obelagd (IVL LCR)	2459,9	4265,0
91//90-		
Plastfolier (IVL LCR)	26,5	48,5
Träfiberskivor, hård board (IVL LCR)	378,0	120,8
Galvad spik, skruv och beslag (IVL LCR)	3517,9	5256,0

Plywoodskivor (IVL LCR)	484,2	109,6
91//93-		
El, till byggarbetsplatsen (Nordenmix) (IVL LCR)	0,0	13816,8
Lastbil 130-560 kW (IVL LCR)	1,3	12846,4
Hjullastare 75-130 kW, 7-17 ton 22.1514; 22.2311 m fl (IVL LCR)	3,2	10613,6
91//96-		
Fjärrvärme till byggarbetsplatsen, ospecificerat (IVL LCR)	0,0	20021,1
Vägsalt (IVL LCR)	2349,7	718,5
Sorterat grus (IVL LCR)	23496,8	34,7
Ej påverkande tillfällig	0,0	0,0
Summa	***3299580***	***936394***
Skede: Drift		
-		
El, Nordenmix (IVL LCR)	0,0	1522593,6
Summa	***0***	***1522594***
Skede: Underhåll		
-		
Tegelfasad	0,0	53039,6
Träfönster	0,0	67098,6
Betongpannetak	0,0	3600,1
Summa	***0***	***123738***
Skede: Rivning		
-		
Rivningsentreprenad	1,0	45907,4
Summa	***2698***	***45907***

D.5 Scenario C

Product	**Weight [kg]**	**CO$_2$-eq. [kg]**
Skede: Produktion		
0-Projektdata		
Armering, skrotbaserat (IVL LCR)	82,2	71,4
Byggbetong Skanska C35/45 (IVL Skanska)	6682,5	1053,1
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	237,6	52,7
Planglas (IVL LCR)	12,5	7,2
Furu/gran, hyvlad & sågad (IVL LCR)	355,1	44,2
Skåpinrede i kök	202,3	68,2
Stålreglar (IVL LCR)	66,8	163,6
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	594,0	174,3
Fogmassa, silikon (IVL LCR)	285,1	522,1
Rostfritt stål, ospecificerat (IVL LCR)	3,5	9,0
Plåtdetaljer, målad (IVL LCR)	66,8	141,1
Snickerifärg inomhus, alkyd 70% TS (IVL LCR)	6,6	14,2
Lastbil 130-560 kW (IVL LCR)	0,0	0,0
Hjul- och Bandgrävmaskin 75-130 kW, 14-28 ton 21.1322 m fl (IVL LCR)	0,0	0,0
Dieselförbränning, produktion (IVL LCR)	0,0	0,0
Arbetsfordon, 75-130 (IVL LCR)	33,7	80807,7
01-Demontering		
Snickerifärg inomhus, alkyd 70% TS (IVL LCR)	411,5	883,3
01.SC-		
Takplåt, förzinkad (IVL LCR)	90,0	190,0
Underlagspapp bitumen (IVL LCR)	99,0	403,3
Galvad spik, skruv och beslag (IVL LCR)	18,1	27,0
Formplywoodskivor (IVL LCR)	853,9	193,7
Furu/gran, hyvlad & sågad (IVL LCR)	3458,3	432,6
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	3353,4	986,1
Elförzinkad spik, skruv och beslag (IVL LCR)	10,8	52,3
Mineralullsisolering (IVL LCR)	1007,3	1382,3
Plastfolier (IVL LCR)	60,2	110,2
01.SG-		
Ytpapp, ospecificerat (IVL LCR)	0,0	0,0
Underlagspapp bitumen (IVL LCR)	105,3	429,0
Galvad spik, skruv och beslag (IVL LCR)	109,9	164,1
Mineralullsisolering (IVL LCR)	1845,1	2532,0
Furu/gran, hyvlad & sågad (IVL LCR)	16120,7	2016,6
Träfiberskivor, hård board (IVL LCR)	298,1	95,5

Plastfolier (IVL LCR)	22,3	40,8
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	968,8	284,9
Elförzinkad spik, skruv och beslag (IVL LCR)	2,7	13,1
Takpanna, betong (IVL LCR)	18003,7	2858,5
15.A-		
Formolja, mineralisk (IVL LCR)	6,4	7,0
Armering, skrotbaserat (IVL LCR)	3485,6	3024,9
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	24,5	44,9
Byggbetong Skanska C25/30 (IVL Skanska)	143787,8	18353,7
15.S/11-		
Formplywoodskivor (IVL LCR)	130,9	29,7
Furu/gran, hyvlad & sågad (IVL LCR)	598,4	74,5
Galvad spik, skruv och beslag (IVL LCR)	8,6	12,8
Formolja, mineralisk (IVL LCR)	1,4	1,6
Armering, skrotbaserat (IVL LCR)	700,8	608,3
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	5,5	10,0
Byggbetong Skanska C25/30 (IVL Skanska)	15266,3	1947,9
Plastmatta	7,8	8,8
Plastprodukter av nylon/polyamid (PA) (IVL LCR)	10,2	18,7
15.SG/11-		
Armeringsnät (IVL LCR)	5109,6	4256,1
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	295,8	541,8
Armering, skrotbaserat (IVL LCR)	810,2	703,2
Byggbetong Skanska C28/35 (IVL Skanska)	211218,0	28538,1
Golvspackel, torrbruk (IVL LCR)	1048,0	232,4
Naturgrus, sand, grus, singel och kullersten (IVL LCR)	445,8	6,6
Cellplast, expanderad polystyren (EPS) (IVL LCR)	2576,0	9776,4
Byggbetong Skanska C25/30 (IVL Skanska)	36637,4	4684,2
Cellplast, extruderad polystyrene (XPS) (IVL LCR)	258,2	996,1
27.B/35-		
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	71688,2	21079,7
Elförzinkad spik, skruv och beslag (IVL LCR)	173,2	838,5
Korslimmat trä (KL-trä) (IVL LCR)	86868,6	20000,0
Mineralullsisolering (IVL LCR)	7349,5	10085,6
27.C/35-		
Mark och-murtegel (IVL LCR)	91725,4	21749,8
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	78239,7	17375,5
Armering, skrotbaserat (IVL LCR)	1129,0	979,5
Transport - avstånd	0,0	0,0
Furu/gran, hyvlad & sågad (IVL LCR)	9942,5	1243,3
Rostfritt stål, ospecificerat (IVL LCR)	746,8	1942,5
Galvat stål och smide (IVL LCR)	67,7	123,1
Plastfolier (IVL LCR)	307,4	563,1
Galvad spik, skruv och beslag (IVL LCR)	112,9	168,7
Mineralullsisolering (IVL LCR)	13483,9	18503,7
Elförzinkad spik, skruv och beslag (IVL LCR)	50,8	246,0
Korslimmat trä (KL-trä) (IVL LCR)	58256,4	13412,5
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	14022,2	4123,2
27.F/11-		
Formplywoodskivor (IVL LCR)	166,7	37,8
Furu/gran, hyvlad & sågad (IVL LCR)	1538,4	191,4
Galvad spik, skruv och beslag (IVL LCR)	22,7	33,9
Formolja, mineralisk (IVL LCR)	3,4	3,8
Armeringsnät (IVL LCR)	109,8	91,5
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	2,3	4,2
Armering, skrotbaserat (IVL LCR)	183,5	159,3
Ingjutenplast (IVL LCR)	2,4	2,7
Byggbetong Skanska C25/30 (IVL Skanska)	14035,1	1788,3
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	35,4	7,9
27.F/31-		
Plattbärlag (IVL LCR)	231146,0	59903,8
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	7168,0	1594,2
Armeringsnät (IVL LCR)	1299,6	1082,7
Armering, skrotbaserat (IVL LCR)	22965,6	19933,2
Transport - avstånd	0,0	0,0
Ingjutenplast (IVL LCR)	304,8	344,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	8,8	16,2

Byggbetong Skanska C25/30 (IVL Skanska)	1293261,9	164781,1
27.F/35-		
Tryckimpregnerat virke, NTR AB	4382,1	764,4
Transport - avstånd	0,0	0,0
Ytpapp, ospecificerat (IVL LCR)	982,8	4002,7
Underlagspapp bitumen (IVL LCR)	2,2	8,9
Korslimmat trä (KL-trä) (IVL LCR)	16278,1	3747,7
Furu/gran, hyvlad & sågad (IVL LCR)	4232,6	526,7
27.Z-		
Armering, skrotbaserat (IVL LCR)	82,2	71,4
Byggbetong Skanska C35/45 (IVL Skanska)	6682,5	1053,1
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	237,6	52,7
Planglas (IVL LCR)	12,5	7,2
Furu/gran, hyvlad & sågad (IVL LCR)	355,1	44,2
Skåpinrede i kök	202,3	68,2
Stålreglar (IVL LCR)	66,8	163,6
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	594,0	174,3
Plåtdetaljer, målad (IVL LCR)	66,8	141,1
Fogmassa, silikon (IVL LCR)	324,3	593,9
Rostfritt stål, ospecificerat (IVL LCR)	3,5	9,0
Trälister, obehandlade (IVL LCR)	117,6	15,1
Elförzinkad spik, skruv och beslag (IVL LCR)	24,5	118,6
Galvad spik, skruv och beslag (IVL LCR)	334,1	499,2
Snickerifärg inomhus, alkyd 70% TS (IVL LCR)	7,3	15,7
41.B-		
Rör, elförzinkade (IVL LCR)	123,8	261,3
Takskyddsanordningar (IVL LCR)	88,5	132,2
Elförzinkad spik, skruv och beslag (IVL LCR)	6,2	30,0
Plåtdetaljer, målad (IVL LCR)	250,4	528,6
Furu/gran, hyvlad & sågad (IVL LCR)	1604,3	200,7
Glasfiber, ytskikt (IVL LCR)	60,1	99,0
Ytpapp, ospecificerat (IVL LCR)	0,0	0,0
Underlagspapp bitumen (IVL LCR)	9,8	40,1
Galvad spik, skruv och beslag (IVL LCR)	1,5	2,3
Plywoodskivor (IVL LCR)	50,5	11,5
41.C-		
Takskyddsanordningar (IVL LCR)	497,4	743,1
Furu/gran, hyvlad & sågad (IVL LCR)	15,3	1,9
Galvat stål och smide (IVL LCR)	6,6	12,1
Elförzinkad spik, skruv och beslag (IVL LCR)	22,1	107,1
Rör, elförzinkade (IVL LCR)	170,7	360,4
41.D-		
Mineralullsisolering (IVL LCR)	12050,0	16530,2
Glasull (IVL LCR)	33,8	46,4
Gjutrör, kartong (IVL LCR)	68,0	29,0
41.EF-		
Takskyddsanordningar (IVL LCR)	374,7	559,8
Galvat stål och smide (IVL LCR)	4,0	7,3
41.FB-		
Plåtdetaljer, målad (IVL LCR)	179,0	377,9
42.B-		
Cellplast, expanderad polystyren (EPS) (IVL LCR)	131,4	498,5
42.B/20-		
Tegelbalk	2057,0	44,8
42.D-		
Fönster, tre glas, trä-/aluminium (IVL LCR)	21627,3	24477,8
Elförzinkad spik, skruv och beslag (IVL LCR)	70,3	340,2
Skåp-, låd- och möbelbeslag (IVL LCR)	20,4	98,7
Galvad spik, skruv och beslag (IVL LCR)	10,3	15,4
Fogmassa, silikon (IVL LCR)	93,9	171,9
Mineralullsisolering (IVL LCR)	1087,2	1491,9
Skivmaterial övrigt, MDF (IVL LCR)	1564,1	655,4
Ytbehandlade trälister (IVL LCR)	258,1	33,3
Plåtdetaljer, målad (IVL LCR)	577,7	1219,7
Plastfolier (IVL LCR)	168,2	308,0
Fönster, trä, tre glas (IVL LCR)	2467,6	2101,9
Fönsterbänk, importerad natursten (IVL LCR)	2313,3	124,4
Aluminiumdörr (IVL LCR)	144,0	820,9
43.CB/41-		
Stålreglar (IVL LCR)	5307,3	12999,0
Elförzinkad spik, skruv och beslag (IVL LCR)	122,2	591,9

Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	37568,2	11047,3
Mineralullsisolering (IVL LCR)	360,4	494,6
Plywoodskivor (IVL LCR)	5156,0	1169,6
Galvad spik, skruv och beslag (IVL LCR)	22,1	32,9
43.CC-		
Innerdörrar av trä (IVL LCR)	6384,0	2265,0
Galvad spik, skruv och beslag (IVL LCR)	9,6	14,3
Mässing, VVS-produkter (IVL LCR)	23,6	15,9
Ytbehandlade trälister (IVL LCR)	411,1	53,1
Elförzinkad spik, skruv och beslag (IVL LCR)	41,0	198,7
Skivmaterial övrigt, MDF (IVL LCR)	131,0	55,0
Kopplingar, mässing (IVL LCR)	6,1	29,3
Mineralullsisolering (IVL LCR)	20,4	28,1
Ståldörrar (IVL LCR)	4238,3	13994,1
Fogmassa, silikon (IVL LCR)	18,0	32,9
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	0,4	0,7
Aluminiumplåt (IVL LCR)	0,2	2,7
Plåtdetaljer, målad (IVL LCR)	151,2	319,2
43.DC-		
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	40573,5	8996,2
Naturgrus, sand, grus, singel och kullersten (IVL LCR)	2049,2	30,3
43.Z-		
Galvat stål och smide (IVL LCR)	798,0	1449,8
Elförzinkad spik, skruv och beslag (IVL LCR)	58,8	284,7
44.BB-		
Trägolv, lamellparkett (IVL LCR)	35000,1	7914,4
Transport - avstånd	0,0	0,0
Ytbehandlade trälister (IVL LCR)	713,3	92,1
Elförzinkad spik, skruv och beslag (IVL LCR)	1,8	8,6
Plastmatta	102,1	115,2
Klinkerplatta, klinker (IVL LCR)	14529,2	3379,4
Plastfolier (IVL LCR)	167,0	305,8
Fogmassa, silikon (IVL LCR)	11,5	21,1
Kakelplatta, kakel (IVL LCR)	254,4	59,1
44.C-		
Kakelplatta, kakel (IVL LCR)	24478,7	5691,9
Plastfolier (IVL LCR)	616,0	1128,0
Fogmassa, silikon (IVL LCR)	21,3	38,9
44.D-		
Undertaksystem Parafon Classic 18mm, 70 kg/m3, alubärverk (IVL Skanska)	176,4	812,7
Trälim/vitlim, PVAC (IVL LCR)	48,5	88,8
Undertaksplatta - mineralull	588,0	2040,6
45.BB-		
Aluminiumprofil (IVL LCR)	0,0	0,0
Konstruktionsstål, galvad (IVL LCR)	0,0	0,0
Konstruktionsstål, obelagd (IVL LCR)	3636,0	6304,1
45.BD-		
Konstruktionsstål, galvad (IVL LCR)	0,0	0,0
Konstruktionsstål, obelagd (IVL LCR)	285,3	494,7
45.CB-		
Byggbetong Skanska C25/30 (IVL Skanska)	35250,0	4478,7
Galvat stål och smide (IVL LCR)	500,0	908,4
46.A-		
Elförzinkad spik, skruv och beslag (IVL LCR)	519,6	2515,8
Kopplingar, mässing (IVL LCR)	10,9	52,2
Aluminiumprofil (IVL LCR)	16,4	222,5
Plåtdetaljer, målad (IVL LCR)	158,4	334,4
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	8,0	14,6
46.B-		
Melaminbelagd spånskiva	1160,1	390,9
Diskbänkar, tvättbänkar, utslagsbackar av rostfritt stål (IVL LCR)	223,8	473,5
Skåp-, låd- och möbelbeslag (IVL LCR)	17,7	85,9
Skivmaterial övrigt, MDF (IVL LCR)	2913,8	1223,2
Skåpinrede i kök	14937,1	5036,4
Bänkskiva, hötryckslaminat (typ HGP) (IVL LCR)	341,0	143,2
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	43,4	79,5
Kakelplatta, kakel (IVL LCR)	2298,1	534,4
Furu/gran, hyvlad & sågad (IVL LCR)	87,7	11,0
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	150,7	44,3
Elförzinkad spik, skruv och beslag (IVL LCR)	0,4	2,2
46.C-		

Tvättmaskin (IVL LCR)	2996,0	7639,2
Elförzinkad spik, skruv och beslag (IVL LCR)	378,0	1830,4
Bänkskiva, hötryckslaminat (typ HGP) (IVL LCR)	332,6	139,6
Spis med ugn (IVL LCR)	1820,0	4640,6
Kyl/sval och frys (IVL LCR)	3150,0	8031,9
Diskmaskin (IVL LCR)	1680,0	5392,5
Plåtdetaljer, målad (IVL LCR)	1,0	2,1
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	3,5	6,4
49.B-		
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	1281,5	377,0
Elförzinkad spik, skruv och beslag (IVL LCR)	2,0	9,8
Plastfolier (IVL LCR)	2,6	4,7
Stålreglar (IVL LCR)	92,5	226,6
Mineralullsisolering (IVL LCR)	80,5	110,5
Galvad spik, skruv och beslag (IVL LCR)	0,1	0,2
5-Fasader		
Rör, elförzinkade (IVL LCR)	76,8	162,1
Armaturer, förkromad mässing (IVL LCR)	336,6	7,3
Galvat stål och smide (IVL LCR)	1352,0	2456,3
Cellplast, expanderad polystyren (EPS) (IVL LCR)	8,5	32,2
Kopplingar, mässing (IVL LCR)	177,0	848,0
Mineralullsisolering (IVL LCR)	1918,2	2631,5
Plastprodukter av nylon/polyamid (PA) (IVL LCR)	138,0	252,7
Plåtdetaljer, målad (IVL LCR)	18,2	38,4
Radiator, vattenburen (IVL LCR)	1631,6	3444,7
Rör av rostfritt stål (IVL LCR)	920,2	2393,2
Rör och rörstolpar mm, galvat stål (IVL LCR)	389,3	698,8
Rör, förkromad koppar (IVL LCR)	1736,4	1170,0
Rör, gjutjärn (IVL LCR)	4105,5	9261,1
Rör, obelagd koppar (IVL LCR)	1865,2	40,7
Dränledningar, polyvinylklorid PVC (IVL LCR)	34,2	72,4
Rörisolering, NBR-cellgummi (svart) (IVL LCR)	1,8	3,3
Sanitetsporslin (IVL LCR)	389,3	170,8
Spånskiva (IVL LCR)	4,6	1,3
6-Stomkomplettering / rumsbildning		
Aluminiumprofil (IVL LCR)	15,7	212,9
Elförzinkad spik, skruv och beslag (IVL LCR)	1,4	6,9
Epoxifärg, tvåkomponentig vattenburen (IVL LCR)	0,0	0,5
Galvat stål och smide (IVL LCR)	590,1	1072,0
Kabelstegar, armaturrännor (IVL LCR)	521,3	1100,5
Kopplingar, mässing (IVL LCR)	65,1	311,9
Kopplingskabel, (FK, RK) (IVL LCR)	846,7	628,3
Plåtdetaljer, förzinkade (IVL LCR)	325,5	687,1
Rörkoppling, galvat stål (IVL LCR)	613,9	1115,3
71-		
Galvat stål och smide (IVL LCR)	1415,9	2572,4
Aluminiumprofil (IVL LCR)	42,9	582,2
Rör, gjutjärn (IVL LCR)	2688,8	6065,3
Planglas (IVL LCR)	71,5	41,1
Rör, obelagd koppar (IVL LCR)	64,4	1,4
Plastprodukter av polykarbonat (plexiglas), övrigt	57,2	445,1
Konstruktionsstål, obelagd (IVL LCR)	2459,9	4265,0
91//90-		
Plastfolier (IVL LCR)	26,5	48,5
Träfiberskivor, hård board (IVL LCR)	378,0	120,8
Galvad spik, skruv och beslag (IVL LCR)	3541,7	5291,6
Plywoodskivor (IVL LCR)	484,2	109,6
91//93-		
El, till byggarbetsplatsen (Nordenmix) (IVL LCR)	0,0	13910,4
Lastbil 130-560 kW (IVL LCR)	1,3	12933,5
Hjullastare 75-130 kW, 7-17 ton 22.1514; 22.2311 m fl (IVL LCR)	3,2	10613,6
91//96-		
Fjärrvärme till byggarbetsplatsen, ospecificerat (IVL LCR)	0,0	20156,9
Vägsalt (IVL LCR)	2365,6	723,4
Sorterat grus (IVL LCR)	23656,1	34,9
Ej påverkande tillfällig	0,0	0,0
Summa	***2877394***	***851373***

Skede: Drift

-		
El, Nordenmix (IVL LCR)	0,0	1532916,3

Summa	***0***	***1532916***
Skede: Underhåll		
-		
Tegelfasad	0,0	53180,9
Träfönster	0,0	67098,6
Betongpannetak	0,0	3619,3
Summa	***0***	***123899***
Skede: Rivning		
-		
Rivningsentreprenad	1,0	40250,5
Summa	***2717***	***40251***

D.6 Scenario D

Product	**Weight [kg]**	**CO_2-eq. [kg]**
Skede: Produktion		
0-Projektdata		
Armering, skrotbaserat (IVL LCR)	82,2	71,4
Byggbetong Skanska C35/45 (IVL Skanska)	6682,5	1053,1
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	237,6	52,7
Planglas (IVL LCR)	12,5	7,2
Furu/gran, hyvlad & sågad (IVL LCR)	355,1	44,2
Skåpinrede i kök	202,3	68,2
Stålreglar (IVL LCR)	66,8	163,6
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	594,0	174,3
Fogmassa, silikon (IVL LCR)	285,1	522,1
Rostfritt stål, ospecificerat (IVL LCR)	3,5	9,0
Plåtdetaljer, målad (IVL LCR)	66,8	141,1
Snickerifärg inomhus, alkyd 70% TS (IVL LCR)	6,6	14,2
Lastbil 130-560 kW (IVL LCR)	0,0	0,0
Hjul- och Bandgrävmaskin 75-130 kW, 14-28 ton 21.1322 m fl (IVL LCR)	0,0	0,0
Dieselförbränning, produktion (IVL LCR)	0,0	0,0
Arbetsfordon, 75-130 (IVL LCR)	33,7	80807,7
01-Demontering		
Snickerifärg inomhus, alkyd 70% TS (IVL LCR)	411,5	883,3
01.SC-		
Takplåt, förzinkad (IVL LCR)	90,0	190,0
Underlagspapp bitumen (IVL LCR)	99,0	403,3
Galvad spik, skruv och beslag (IVL LCR)	18,1	27,0
Formplywoodskivor (IVL LCR)	853,9	193,7
Furu/gran, hyvlad & sågad (IVL LCR)	3458,3	432,6
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	3353,4	986,1
Elförzinkad spik, skruv och beslag (IVL LCR)	10,8	52,3
Mineralullsisolering (IVL LCR)	1007,3	1382,3
Plastfolier (IVL LCR)	60,2	110,2
01.SG-		
Ytpapp, ospecificerat (IVL LCR)	0,0	0,0
Underlagspapp bitumen (IVL LCR)	105,3	429,0
Galvad spik, skruv och beslag (IVL LCR)	109,9	164,1
Mineralullsisolering (IVL LCR)	1845,1	2532,0
Furu/gran, hyvlad & sågad (IVL LCR)	16120,7	2016,6
Träfiberskivor, hård board (IVL LCR)	298,1	95,5
Plastfolier (IVL LCR)	22,3	40,8
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	968,8	284,9
Elförzinkad spik, skruv och beslag (IVL LCR)	2,7	13,1
Takpanna, betong (IVL LCR)	18003,7	2858,5
15.A-		
Formolja, mineralisk (IVL LCR)	6,4	7,0
Armering, skrotbaserat (IVL LCR)	3485,6	3024,9
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	24,5	44,9
Byggbetong Skanska C25/30 (IVL Skanska)	143787,8	18353,7
15.S/11-		
Formplywoodskivor (IVL LCR)	130,9	29,7
Furu/gran, hyvlad & sågad (IVL LCR)	598,4	74,5
Galvad spik, skruv och beslag (IVL LCR)	8,6	12,8
Formolja, mineralisk (IVL LCR)	1,4	1,6
Armering, skrotbaserat (IVL LCR)	700,8	608,3

Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	5,5	10,0
Byggbetong Skanska C25/30 (IVL Skanska)	15266,3	1947,9
Plastmatta	7,8	8,8
Plastprodukter av nylon/polyamid (PA) (IVL LCR)	10,2	18,7
15.SG/11-		
Armeringsnät (IVL LCR)	5109,6	4256,1
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	295,8	541,8
Armering, skrotbaserat (IVL LCR)	810,2	703,2
Byggbetong Skanska C28/35 (IVL Skanska)	211218,0	28538,1
Golvspackel, torrbruk (IVL LCR)	1048,0	232,4
Naturgrus, sand, grus, singel och kullersten (IVL LCR)	445,8	6,6
Cellplast, expanderad polystyren (EPS) (IVL LCR)	2576,0	9776,4
Byggbetong Skanska C25/30 (IVL Skanska)	36637,4	4684,2
Cellplast, extruderad polystyrene (XPS) (IVL LCR)	258,2	996,1
27.B/35-		
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	71688,2	21079,7
Elförzinkad spik, skruv och beslag (IVL LCR)	173,2	838,5
Korslimmat trä (KL-trä) (IVL LCR)	86868,6	20000,0
Mineralullsisolering (IVL LCR)	7349,5	10085,6
27.C/35-		
Mark och-murtegel (IVL LCR)	95381,4	22616,7
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	81358,2	18068,1
Armering, skrotbaserat (IVL LCR)	1174,0	1018,6
Transport - avstånd	0,0	0,0
Furu/gran, hyvlad & sågad (IVL LCR)	10338,8	1292,9
Rostfritt stål, ospecificerat (IVL LCR)	776,6	2019,9
Galvat stål och smide (IVL LCR)	70,4	128,0
Plastfolier (IVL LCR)	319,6	585,5
Galvad spik, skruv och beslag (IVL LCR)	117,4	175,4
Mineralullsisolering (IVL LCR)	14022,6	19243,1
Elförzinkad spik, skruv och beslag (IVL LCR)	52,8	255,8
Korslimmat trä (KL-trä) (IVL LCR)	60578,4	13947,1
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	14581,1	4287,5
27.F/11-		
Formplywoodskivor (IVL LCR)	166,7	37,8
Furu/gran, hyvlad & sågad (IVL LCR)	1538,4	191,4
Galvad spik, skruv och beslag (IVL LCR)	22,7	33,9
Formolja, mineralisk (IVL LCR)	3,4	3,8
Armeringsnät (IVL LCR)	109,8	91,5
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	2,3	4,2
Armering, skrotbaserat (IVL LCR)	183,5	159,3
Ingjutenplast (IVL LCR)	2,4	2,7
Byggbetong Skanska C25/30 (IVL Skanska)	14035,1	1788,3
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	35,4	7,9
27.F/31-		
HD/F Plattor 270 mm	806552,0	182764,7
Byggbetong Skanska C35/45 (IVL Skanska)	491185,3	77409,7
Betongpump 130-560 kW (IVL LCR)	0,3	823,2
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	28401,5	6297,3
Naturgrus, sand, grus, singel och kullersten (IVL LCR)	2049,2	30,3
27.F/35-		
Tryckimpregnerat virke, NTR AB	4382,1	764,4
Transport - avstånd	0,0	0,0
Ytpapp, ospecificerat (IVL LCR)	982,8	4002,7
Underlagspapp bitumen (IVL LCR)	2,2	8,9
Korslimmat trä (KL-trä) (IVL LCR)	16278,1	3747,7
Furu/gran, hyvlad & sågad (IVL LCR)	4232,6	526,7
27.Z-		
Armering, skrotbaserat (IVL LCR)	82,2	71,4
Byggbetong Skanska C35/45 (IVL Skanska)	6682,5	1053,1
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	237,6	52,7
Planglas (IVL LCR)	12,5	7,2
Furu/gran, hyvlad & sågad (IVL LCR)	355,1	44,2
Skåpinrede i kök	202,3	68,2
Stålreglar (IVL LCR)	66,8	163,6
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	594,0	174,3
Plåtdetaljer, målad (IVL LCR)	66,8	141,1
Fogmassa, silikon (IVL LCR)	324,3	593,9

Rostfritt stål, ospecificerat (IVL LCR)	3,5	9,0
Trälister, obehandlade (IVL LCR)	117,6	15,1
Elförzinkad spik, skruv och beslag (IVL LCR)	24,5	118,6
Galvad spik, skruv och beslag (IVL LCR)	334,1	499,2
Snickerifärg inomhus, alkyd 70% TS (IVL LCR)	7,3	15,7
41.B-		
Rör, elförzinkade (IVL LCR)	123,8	261,3
Takskyddsanordningar (IVL LCR)	88,5	132,2
Elförzinkad spik, skruv och beslag (IVL LCR)	6,2	30,0
Plåtdetaljer, målad (IVL LCR)	250,4	528,6
Furu/gran, hyvlad & sågad (IVL LCR)	1604,3	200,7
Glasfiber, ytskikt (IVL LCR)	60,1	99,0
Ytpapp, ospecificerat (IVL LCR)	0,0	0,0
Underlagspapp bitumen (IVL LCR)	9,8	40,1
Galvad spik, skruv och beslag (IVL LCR)	1,5	2,3
Plywoodskivor (IVL LCR)	50,5	11,5
41.C-		
Takskyddsanordningar (IVL LCR)	497,4	743,1
Furu/gran, hyvlad & sågad (IVL LCR)	15,3	1,9
Galvat stål och smide (IVL LCR)	6,6	12,1
Elförzinkad spik, skruv och beslag (IVL LCR)	22,1	107,1
Rör, elförzinkade (IVL LCR)	170,7	360,4
41.D-		
Mineralullsisolering (IVL LCR)	12050,0	16530,2
Glasull (IVL LCR)	33,8	46,4
Gjutrör, kartong (IVL LCR)	68,0	29,0
41.EF-		
Takskyddsanordningar (IVL LCR)	374,7	559,8
Galvat stål och smide (IVL LCR)	4,0	7,3
41.FB-		
Plåtdetaljer, målad (IVL LCR)	179,0	377,9
42.B-		
Cellplast, expanderad polystyren (EPS) (IVL LCR)	131,4	498,5
42.B/20-		
Tegelbalk	2126,0	46,3
42.D-		
Fönster, tre glas, trä-/aluminium (IVL LCR)	22424,3	25379,8
Elförzinkad spik, skruv och beslag (IVL LCR)	71,3	345,4
Skåp-, låd- och möbelbeslag (IVL LCR)	21,0	101,7
Galvad spik, skruv och beslag (IVL LCR)	10,6	15,9
Fogmassa, silikon (IVL LCR)	96,7	177,1
Mineralullsisolering (IVL LCR)	1120,2	1537,1
Skivmaterial övrigt, MDF (IVL LCR)	1611,5	675,2
Ytbehandlade trälister (IVL LCR)	265,9	34,3
Plåtdetaljer, målad (IVL LCR)	597,5	1261,6
Plastfolier (IVL LCR)	173,4	317,5
Fönster, trä, tre glas (IVL LCR)	2467,6	2101,9
Fönsterbänk, importerad natursten (IVL LCR)	2400,2	129,1
Aluminiumdörr (IVL LCR)	144,0	820,9
43.CB/41-		
Stålreglar (IVL LCR)	5307,3	12999,0
Elförzinkad spik, skruv och beslag (IVL LCR)	122,2	591,9
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	37568,2	11047,3
Mineralullsisolering (IVL LCR)	360,4	494,6
Plywoodskivor (IVL LCR)	5156,0	1169,6
Galvad spik, skruv och beslag (IVL LCR)	22,1	32,9
43.CC-		
Innerdörrar av trä (IVL LCR)	6384,0	2265,0
Galvad spik, skruv och beslag (IVL LCR)	9,6	14,3
Mässing, VVS-produkter (IVL LCR)	23,6	15,9
Ytbehandlade trälister (IVL LCR)	411,1	53,1
Elförzinkad spik, skruv och beslag (IVL LCR)	41,0	198,7
Skivmaterial övrigt, MDF (IVL LCR)	131,0	55,0
Kopplingar, mässing (IVL LCR)	6,1	29,3
Mineralullsisolering (IVL LCR)	20,4	28,1
Ståldörrar (IVL LCR)	4238,3	13994,1
Fogmassa, silikon (IVL LCR)	18,0	32,9
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	0,4	0,7
Aluminiumplåt (IVL LCR)	0,2	2,7
Plåtdetaljer, målad (IVL LCR)	151,2	319,2
43.DC-		

Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	40573,5	8996,2
Naturgrus, sand, grus, singel och kullersten (IVL LCR)	2049,2	30,3
43.Z-		
Galvat stål och smide (IVL LCR)	798,0	1449,8
Elförzinkad spik, skruv och beslag (IVL LCR)	58,8	284,7
44.BB-		
Trägolv, lamellparkett (IVL LCR)	35000,1	7914,4
Transport - avstånd	0,0	0,0
Ytbehandlade trälister (IVL LCR)	713,3	92,1
Elförzinkad spik, skruv och beslag (IVL LCR)	1,8	8,6
Plastmatta	102,1	115,2
Klinkerplatta, klinker (IVL LCR)	14529,2	3379,4
Plastfolier (IVL LCR)	167,0	305,8
Fogmassa, silikon (IVL LCR)	11,5	21,1
Kakelplatta, kakel (IVL LCR)	254,4	59,1
44.C-		
Kakelplatta, kakel (IVL LCR)	24478,7	5691,9
Plastfolier (IVL LCR)	616,0	1128,0
Fogmassa, silikon (IVL LCR)	21,3	38,9
44.D-		
Undertaksystem Parafon Classic 18mm, 70 kg/m3, alubärverk (IVL Skanska)	176,4	812,7
Trälim/vitlim, PVAC (IVL LCR)	48,5	88,8
Undertaksplatta - mineralull	588,0	2040,6
45.BB-		
Aluminiumprofil (IVL LCR)	0,0	0,0
Konstruktionsstål, galvad (IVL LCR)	0,0	0,0
Konstruktionsstål, obelagd (IVL LCR)	3636,0	6304,1
45.BD-		
Konstruktionsstål, galvad (IVL LCR)	0,0	0,0
Konstruktionsstål, obelagd (IVL LCR)	285,3	494,7
45.CB-		
Byggbetong Skanska C25/30 (IVL Skanska)	35250,0	4478,7
Galvat stål och smide (IVL LCR)	500,0	908,4
46.A-		
Elförzinkad spik, skruv och beslag (IVL LCR)	519,6	2515,8
Kopplingar, mässing (IVL LCR)	10,9	52,2
Aluminiumprofil (IVL LCR)	16,4	222,5
Plåtdetaljer, målad (IVL LCR)	158,4	334,4
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	8,0	14,6
46.B-		
Melaminbelagd spånskiva	1160,1	390,9
Diskbänkar, tvättbänkar, utslagsbackar av rostfritt stål (IVL LCR)	223,8	473,5
Skåp-, låd- och möbelbeslag (IVL LCR)	17,7	85,9
Skivmaterial övrigt, MDF (IVL LCR)	2913,8	1223,2
Skåpinrede i kök	14937,1	5036,4
Bänkskiva, hötryckslaminat (typ HGP) (IVL LCR)	341,0	143,2
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	43,4	79,5
Kakelplatta, kakel (IVL LCR)	2298,1	534,4
Furu/gran, hyvlad & sågad (IVL LCR)	87,7	11,0
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	150,7	44,3
Elförzinkad spik, skruv och beslag (IVL LCR)	0,4	2,2
46.C-		
Tvättmaskin (IVL LCR)	2996,0	7639,2
Elförzinkad spik, skruv och beslag (IVL LCR)	378,0	1830,4
Bänkskiva, hötryckslaminat (typ HGP) (IVL LCR)	332,6	139,6
Spis med ugn (IVL LCR)	1820,0	4640,6
Kyl/sval och frys (IVL LCR)	3150,0	8031,9
Diskmaskin (IVL LCR)	1680,0	5392,5
Plåtdetaljer, målad (IVL LCR)	1,0	2,1
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	3,5	6,4
49.B-		
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	1281,5	377,0
Elförzinkad spik, skruv och beslag (IVL LCR)	2,0	9,8
Plastfolier (IVL LCR)	2,6	4,7
Stålreglar (IVL LCR)	92,5	226,6
Mineralullsisolering (IVL LCR)	80,5	110,5
Galvad spik, skruv och beslag (IVL LCR)	0,1	0,2
5-Fasader		
Rör, elförzinkade (IVL LCR)	76,8	162,1
Armaturer, förkromad mässing (IVL LCR)	336,6	7,3
Galvat stål och smide (IVL LCR)	1352,0	2456,3

Cellplast, expanderad polystyren (EPS) (IVL LCR)	8,5	32,2
Kopplingar, mässing (IVL LCR)	177,0	848,0
Mineralullsisolering (IVL LCR)	1918,2	2631,5
Plastprodukter av nylon/polyamid (PA) (IVL LCR)	138,0	252,7
Plåtdetaljer, målad (IVL LCR)	18,2	38,4
Radiator, vattenburen (IVL LCR)	1631,6	3444,7
Rör av rostfritt stål (IVL LCR)	920,2	2393,2
Rör och rörstolpar mm, galvat stål (IVL LCR)	389,3	698,8
Rör, förkromad koppar (IVL LCR)	1736,4	1170,0
Rör, gjutjärn (IVL LCR)	4105,5	9261,1
Rör, obelagd koppar (IVL LCR)	1865,2	40,7
Dränledningar, polyvinylklorid PVC (IVL LCR)	34,2	72,4
Rörisolering, NBR-cellgummi (svart) (IVL LCR)	1,8	3,3
Sanitetsporslin (IVL LCR)	389,3	170,8
Spånskiva (IVL LCR)	4,6	1,3
6-Stomkomplettering / rumsbildning		
Aluminiumprofil (IVL LCR)	15,7	212,9
Elförzinkad spik, skruv och beslag (IVL LCR)	1,4	6,9
Epoxifärg, tvåkomponentig vattenburen (IVL LCR)	0,0	0,5
Galvat stål och smide (IVL LCR)	590,1	1072,0
Kabelstegar, armaturrännor (IVL LCR)	521,3	1100,5
Kopplingar, mässing (IVL LCR)	65,1	311,9
Kopplingskabel, (FK, RK) (IVL LCR)	846,7	628,3
Plåtdetaljer, förzinkade (IVL LCR)	325,5	687,1
Rörkoppling, galvat stål (IVL LCR)	613,9	1115,3
71-		
Galvat stål och smide (IVL LCR)	1415,9	2572,4
Aluminiumprofil (IVL LCR)	42,9	582,2
Rör, gjutjärn (IVL LCR)	2688,8	6065,3
Planglas (IVL LCR)	71,5	41,1
Rör, obelagd koppar (IVL LCR)	64,4	1,4
Plastprodukter av polykarbonat (plexiglas), övrigt	57,2	445,1
Konstruktionsstål, obelagd (IVL LCR)	2459,9	4265,0
91//90-		
Plastfolier (IVL LCR)	26,5	48,5
Träfiberskivor, hård board (IVL LCR)	378,0	120,8
Galvad spik, skruv och beslag (IVL LCR)	3541,7	5291,6
Plywoodskivor (IVL LCR)	484,2	109,6
91//93-		
El, till byggarbetsplatsen (Nordenmix) (IVL LCR)	0,0	13910,4
Lastbil 130-560 kW (IVL LCR)	1,3	12933,5
Hjullastare 75-130 kW, 7-17 ton 22.1514; 22.2311 m fl (IVL LCR)	3,2	10613,6
91//96-		
Fjärrvärme till byggarbetsplatsen, ospecificerat (IVL LCR)	0,0	20156,9
Vägsalt (IVL LCR)	2365,6	723,4
Sorterat grus (IVL LCR)	23656,1	34,9
Ej påverkande tillfällig	0,0	0,0
Summa	***2661185***	***875290***
Skede: Drift		
-		
El, Nordenmix (IVL LCR)	0,0	1532916,3
Summa	***0***	***1532916***
Skede: Underhåll		
-		
Tegelfasad	0,0	70892,2
Träfönster	0,0	69202,1
Betongpannetak	0,0	3619,3
Summa	***0***	***143713***
Skede: Rivning		
-		
Rivningsentreprenad	1,0	39049,1
Summa	***2717***	***39049***

D.7 Scenario E

Product	**Weight [kg]**	**CO$_2$-eq. [kg]**
Skede: Produktion		

0-Projektdata		
Armering, skrotbaserat (IVL LCR)	82,2	71,4
Byggbetong Skanska C35/45 (IVL Skanska)	6682,5	1053,1
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	237,6	52,7
Planglas (IVL LCR)	12,5	7,2
Furu/gran, hyvlad & sågad (IVL LCR)	355,1	44,2
Skåpinrede i kök	202,3	68,2
Stålreglar (IVL LCR)	66,8	163,6
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	594,0	174,3
Fogmassa, silikon (IVL LCR)	285,1	522,1
Rostfritt stål, ospecificerat (IVL LCR)	3,5	9,0
Plåtdetaljer, målad (IVL LCR)	66,8	141,1
Snickerifärg inomhus, alkyd 70% TS (IVL LCR)	6,6	14,2
Lastbil 130-560 kW (IVL LCR)	0,0	0,0
Hjul- och Bandgrävmaskin 75-130 kW, 14-28 ton 21.1322 m fl (IVL LCR)	0,0	0,0
Dieselförbränning, produktion (IVL LCR)	0,0	0,0
Arbetsfordon, 75-130 (IVL LCR)	33,7	80807,7
01-Demontering		
Snickerifärg inomhus, alkyd 70% TS (IVL LCR)	411,5	883,3
01.SC-		
Takplåt, förzinkad (IVL LCR)	90,0	190,0
Underlagspapp bitumen (IVL LCR)	99,0	403,3
Galvad spik, skruv och beslag (IVL LCR)	18,1	27,0
Formplywoodskivor (IVL LCR)	853,9	193,7
Furu/gran, hyvlad & sågad (IVL LCR)	3458,3	432,6
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	3353,4	986,1
Elförzinkad spik, skruv och beslag (IVL LCR)	10,8	52,3
Mineralullsisolering (IVL LCR)	1007,3	1382,3
Plastfolier (IVL LCR)	60,2	110,2
01.SG-		
Ytpapp, ospecificerat (IVL LCR)	0,0	0,0
Underlagspapp bitumen (IVL LCR)	105,3	429,0
Galvad spik, skruv och beslag (IVL LCR)	109,9	164,1
Mineralullsisolering (IVL LCR)	1845,1	2532,0
Furu/gran, hyvlad & sågad (IVL LCR)	16120,7	2016,6
Träfiberskivor, hård board (IVL LCR)	298,1	95,5
Plastfolier (IVL LCR)	22,3	40,8
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	968,8	284,9
Elförzinkad spik, skruv och beslag (IVL LCR)	2,7	13,1
Takpanna, betong (IVL LCR)	18003,7	2858,5
15.A-		
Formolja, mineralisk (IVL LCR)	6,4	7,0
Armering, skrotbaserat (IVL LCR)	3485,6	3024,9
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	24,5	44,9
Byggbetong Skanska C25/30 (IVL Skanska)	143787,8	18353,7
15.S/11-		
Formplywoodskivor (IVL LCR)	130,9	29,7
Furu/gran, hyvlad & sågad (IVL LCR)	598,4	74,5
Galvad spik, skruv och beslag (IVL LCR)	8,6	12,8
Formolja, mineralisk (IVL LCR)	1,4	1,6
Armering, skrotbaserat (IVL LCR)	700,8	608,3
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	5,5	10,0
Byggbetong Skanska C25/30 (IVL Skanska)	15266,3	1947,9
Plastmatta	7,8	8,8
Plastprodukter av nylon/polyamid (PA) (IVL LCR)	10,2	18,7
15.SG/11-		
Armeringsnät (IVL LCR)	5109,6	4256,1
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	295,8	541,8
Armering, skrotbaserat (IVL LCR)	810,2	703,2
Byggbetong Skanska C28/35 (IVL Skanska)	211218,0	28538,1
Golvspackel, torrbruk (IVL LCR)	1048,0	232,4
Naturgrus, sand, grus, singel och kullersten (IVL LCR)	445,8	6,6
Cellplast, expanderad polystyren (EPS) (IVL LCR)	2576,0	9776,4
Byggbetong Skanska C25/30 (IVL Skanska)	36637,4	4684,2
Cellplast, extruderad polystyrene (XPS) (IVL LCR)	258,2	996,1
27.B/35-		
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	71688,2	21079,7
Elförzinkad spik, skruv och beslag (IVL LCR)	173,2	838,5

Korslimmat trä (KL-trä) (IVL LCR)	86868,6	20000,0
Mineralullsisolering (IVL LCR)	7349,5	10085,6
27.C/35-		
Mark och-murtegel (IVL LCR)	96762,6	22944,2
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	82536,3	18329,7
Armering, skrotbaserat (IVL LCR)	1191,0	1033,3
Transport - avstånd	0,0	0,0
Furu/gran, hyvlad & sågad (IVL LCR)	10488,5	1311,6
Rostfritt stål, ospecificerat (IVL LCR)	787,8	2049,2
Galvat stål och smide (IVL LCR)	71,5	129,8
Plastfolier (IVL LCR)	324,2	594,0
Galvad spik, skruv och beslag (IVL LCR)	119,1	177,9
Mineralullsisolering (IVL LCR)	14225,9	19522,0
Elförzinkad spik, skruv och beslag (IVL LCR)	53,6	259,5
Korslimmat trä (KL-trä) (IVL LCR)	61455,6	14149,1
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	14792,2	4349,6
27.F/11-		
Formplywoodskivor (IVL LCR)	166,7	37,8
Furu/gran, hyvlad & sågad (IVL LCR)	1538,4	191,4
Galvad spik, skruv och beslag (IVL LCR)	22,7	33,9
Formolja, mineralisk (IVL LCR)	3,4	3,8
Armeringsnät (IVL LCR)	109,8	91,5
Transport - avstånd	0,0	0,0
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	2,3	4,2
Armering, skrotbaserat (IVL LCR)	183,5	159,3
Ingjutenplast (IVL LCR)	2,4	2,7
Byggbetong Skanska C25/30 (IVL Skanska)	14035,1	1788,3
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	35,4	7,9
27.F/35-		
Tryckimpregnerat virke, NTR AB	4382,1	764,4
Transport - avstånd	0,0	0,0
Ytpapp, ospecificerat (IVL LCR)	982,8	4002,7
Underlagspapp bitumen (IVL LCR)	2,2	8,9
Korslimmat trä (KL-trä) (IVL LCR)	270034,0	62170,6
Furu/gran, hyvlad & sågad (IVL LCR)	10037,0	1252,8
Trägolv, lamellparkett (IVL LCR)	0,0	0,0
Spånskiva (IVL LCR)	83365,0	24145,4
Galvad spik, skruv och beslag (IVL LCR)	368,9	551,1
Mineralullsisolering (IVL LCR)	12174,5	16704,6
Gjutjärn, invändigt VA (IVL LCR)	4918,0	11094,0
27.Z-		
Armering, skrotbaserat (IVL LCR)	82,2	71,4
Byggbetong Skanska C35/45 (IVL Skanska)	6682,5	1053,1
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	237,6	52,7
Planglas (IVL LCR)	12,5	7,2
Furu/gran, hyvlad & sågad (IVL LCR)	355,1	44,2
Skåpinrede i kök	202,3	68,2
Stålreglar (IVL LCR)	66,8	163,6
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	594,0	174,3
Plåtdetaljer, målad (IVL LCR)	66,8	141,1
Fogmassa, silikon (IVL LCR)	324,3	593,9
Rostfritt stål, ospecificerat (IVL LCR)	3,5	9,0
Trälister, obehandlade (IVL LCR)	117,6	15,1
Elförzinkad spik, skruv och beslag (IVL LCR)	24,5	118,6
Galvad spik, skruv och beslag (IVL LCR)	334,1	499,2
Snickerifärg inomhus, alkyd 70% TS (IVL LCR)	7,3	15,7
41.B-		
Rör, elförzinkade (IVL LCR)	123,8	261,3
Takskyddsanordningar (IVL LCR)	88,5	132,2
Elförzinkad spik, skruv och beslag (IVL LCR)	6,2	30,0
Plåtdetaljer, målad (IVL LCR)	250,4	528,6
Furu/gran, hyvlad & sågad (IVL LCR)	1604,3	200,7
Glasfiber, ytskikt (IVL LCR)	60,1	99,0
Ytpapp, ospecificerat (IVL LCR)	0,0	0,0
Underlagspapp bitumen (IVL LCR)	9,8	40,1
Galvad spik, skruv och beslag (IVL LCR)	1,5	2,3
Plywoodskivor (IVL LCR)	50,5	11,5
41.C-		
Takskyddsanordningar (IVL LCR)	497,4	743,1
Furu/gran, hyvlad & sågad (IVL LCR)	15,3	1,9
Galvat stål och smide (IVL LCR)	6,6	12,1

Elförzinkad spik, skruv och beslag (IVL LCR)	22,1	107,1
Rör, elförzinkade (IVL LCR)	170,7	360,4
41.D-		
Mineralullsisolering (IVL LCR)	12050,0	16530,2
Glasull (IVL LCR)	33,8	46,4
Gjutrör, kartong (IVL LCR)	68,0	29,0
41.EF-		
Takskyddsanordningar (IVL LCR)	374,7	559,8
Galvat stål och smide (IVL LCR)	4,0	7,3
41.FB-		
Plåtdetaljer, målad (IVL LCR)	179,0	377,9
42.B-		
Cellplast, expanderad polystyren (EPS) (IVL LCR)	131,4	498,5
42.B/20-		
Tegelbalk	2180,0	47,5
42.D-		
Fönster, tre glas, trä-/aluminium (IVL LCR)	23054,1	26092,6
Elförzinkad spik, skruv och beslag (IVL LCR)	72,2	349,6
Skåp-, låd- och möbelbeslag (IVL LCR)	21,5	104,1
Galvad spik, skruv och beslag (IVL LCR)	10,9	16,3
Fogmassa, silikon (IVL LCR)	99,0	181,3
Mineralullsisolering (IVL LCR)	1146,3	1573,0
Skivmaterial övrigt, MDF (IVL LCR)	1649,1	691,0
Ytbehandlade trälister (IVL LCR)	272,1	35,1
Plåtdetaljer, målad (IVL LCR)	613,3	1294,8
Plastfolier (IVL LCR)	177,5	325,0
Fönster, trä, tre glas (IVL LCR)	2467,6	2101,9
Fönsterbänk, importerad natursten (IVL LCR)	2468,4	132,7
Aluminiumdörr (IVL LCR)	144,0	820,9
43.CB/41-		
Stålreglar (IVL LCR)	5307,3	12999,0
Elförzinkad spik, skruv och beslag (IVL LCR)	122,2	591,9
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	37568,2	11047,3
Mineralullsisolering (IVL LCR)	360,4	494,6
Plywoodskivor (IVL LCR)	5156,0	1169,6
Galvad spik, skruv och beslag (IVL LCR)	22,1	32,9
43.CC-		
Innerdörrar av trä (IVL LCR)	6384,0	2265,0
Galvad spik, skruv och beslag (IVL LCR)	9,6	14,3
Mässing, VVS-produkter (IVL LCR)	23,6	15,9
Ytbehandlade trälister (IVL LCR)	411,1	53,1
Elförzinkad spik, skruv och beslag (IVL LCR)	41,0	198,7
Skivmaterial övrigt, MDF (IVL LCR)	131,0	55,0
Kopplingar, mässing (IVL LCR)	6,1	29,3
Mineralullsisolering (IVL LCR)	20,4	28,1
Ståldörrar (IVL LCR)	4238,3	13994,1
Fogmassa, silikon (IVL LCR)	18,0	32,9
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	0,4	0,7
Aluminiumplåt (IVL LCR)	0,2	2,7
Plåtdetaljer, målad (IVL LCR)	151,2	319,2
43.DC-		
Mur- och putsbruk, färdigblandat torrbruk (IVL LCR)	40573,5	8996,2
Naturgrus, sand, grus, singel och kullersten (IVL LCR)	2049,2	30,3
43.Z-		
Galvat stål och smide (IVL LCR)	798,0	1449,8
Elförzinkad spik, skruv och beslag (IVL LCR)	58,8	284,7
44.BB-		
Trägolv, lamellparkett (IVL LCR)	35000,1	7914,4
Transport - avstånd	0,0	0,0
Ytbehandlade trälister (IVL LCR)	713,3	92,1
Elförzinkad spik, skruv och beslag (IVL LCR)	1,8	8,6
Plastmatta	102,1	115,2
Klinkerplatta, klinker (IVL LCR)	14529,2	3379,4
Plastfolier (IVL LCR)	167,0	305,8
Fogmassa, silikon (IVL LCR)	11,5	21,1
Kakelplatta, kakel (IVL LCR)	254,4	59,1
44.C-		
Kakelplatta, kakel (IVL LCR)	24478,7	5691,9
Plastfolier (IVL LCR)	616,0	1128,0
Fogmassa, silikon (IVL LCR)	21,3	38,9
44.D-		

Undertaksystem Parafon Classic 18mm, 70 kg/m3, alubärverk (IVL Skanska)	176,4	812,7
Trälim/vitlim, PVAC (IVL LCR)	48,5	88,8
Undertaksplatta - mineralull	588,0	2040,6
45.BB-		
Aluminiumprofil (IVL LCR)	0,0	0,0
Konstruktionsstål, galvad (IVL LCR)	0,0	0,0
Konstruktionsstål, obelagd (IVL LCR)	3636,0	6304,1
45.BD-		
Konstruktionsstål, galvad (IVL LCR)	0,0	0,0
Konstruktionsstål, obelagd (IVL LCR)	285,3	494,7
45.CB-		
Byggbetong Skanska C25/30 (IVL Skanska)	35250,0	4478,7
Galvat stål och smide (IVL LCR)	500,0	908,4
46.A-		
Elförzinkad spik, skruv och beslag (IVL LCR)	519,6	2515,8
Kopplingar, mässing (IVL LCR)	10,9	52,2
Aluminiumprofil (IVL LCR)	16,4	222,5
Plåtdetaljer, målad (IVL LCR)	158,4	334,4
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	8,0	14,6
46.B-		
Melaminbelagd spånskiva	1160,1	390,9
Diskbänkar, tvättbänkar, utslagsbackar av rostfritt stål (IVL LCR)	223,8	473,5
Skåp-, låd- och möbelbeslag (IVL LCR)	17,7	85,9
Skivmaterial övrigt, MDF (IVL LCR)	2913,8	1223,2
Skåpinrede i kök	14937,1	5036,4
Bänkskiva, hötryckslaminat (typ HGP) (IVL LCR)	341,0	143,2
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	43,4	79,5
Kakelplatta, kakel (IVL LCR)	2298,1	534,4
Furu/gran, hyvlad & sågad (IVL LCR)	87,7	11,0
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	150,7	44,3
Elförzinkad spik, skruv och beslag (IVL LCR)	0,4	2,2
46.C-		
Tvättmaskin (IVL LCR)	2996,0	7639,2
Elförzinkad spik, skruv och beslag (IVL LCR)	378,0	1830,4
Bänkskiva, hötryckslaminat (typ HGP) (IVL LCR)	332,6	139,6
Spis med ugn (IVL LCR)	1820,0	4640,6
Kyl/sval och frys (IVL LCR)	3150,0	8031,9
Diskmaskin (IVL LCR)	1680,0	5392,5
Plåtdetaljer, målad (IVL LCR)	1,0	2,1
Plastprodukter övrigt ospecificerat, polyolefin (PP/PE) (IVL LCR)	3,5	6,4
49.B-		
Gipsskivor, kartonggipsskivor ospecificerat (IVL LCR)	1281,5	377,0
Elförzinkad spik, skruv och beslag (IVL LCR)	2,0	9,8
Plastfolier (IVL LCR)	2,6	4,7
Stålreglar (IVL LCR)	92,5	226,6
Mineralullsisolering (IVL LCR)	80,5	110,5
Galvad spik, skruv och beslag (IVL LCR)	0,1	0,2
5-Fasader		
Rör, elförzinkade (IVL LCR)	76,8	162,1
Armaturer, förkromad mässing (IVL LCR)	336,6	7,3
Galvat stål och smide (IVL LCR)	1352,0	2456,3
Cellplast, expanderad polystyren (EPS) (IVL LCR)	8,5	32,2
Kopplingar, mässing (IVL LCR)	177,0	848,0
Mineralullsisolering (IVL LCR)	1918,2	2631,5
Plastprodukter av nylon/polyamid (PA) (IVL LCR)	138,0	252,7
Plåtdetaljer, målad (IVL LCR)	18,2	38,4
Radiator, vattenburen (IVL LCR)	1631,6	3444,7
Rör av rostfritt stål (IVL LCR)	920,2	2393,2
Rör och rörstolpar mm, galvat stål (IVL LCR)	389,3	698,8
Rör, förkromad koppar (IVL LCR)	1736,4	1170,0
Rör, gjutjärn (IVL LCR)	4105,5	9261,1
Rör, obelagd koppar (IVL LCR)	1865,2	40,7
Dränledningar, polyvinylklorid PVC (IVL LCR)	34,2	72,4
Rörisolering, NBR-cellgummi (svart) (IVL LCR)	1,8	3,3
Sanitetsporslin (IVL LCR)	389,3	170,8
Spånskiva (IVL LCR)	4,6	1,3
6-Stomkomplettering / rumsbildning		
Aluminiumprofil (IVL LCR)	15,7	212,9
Elförzinkad spik, skruv och beslag (IVL LCR)	1,4	6,9
Epoxifärg, tvåkomponentig vattenburen (IVL LCR)	0,0	0,5
Galvat stål och smide (IVL LCR)	590,1	1072,0

Kabelstegar, armaturrännor (IVL LCR)	521,3	1100,5
Kopplingar, mässing (IVL LCR)	65,1	311,9
Kopplingskabel, (FK, RK) (IVL LCR)	846,7	628,3
Plåtdetaljer, förzinkade (IVL LCR)	325,5	687,1
Rörkoppling, galvat stål (IVL LCR)	613,9	1115,3
71-		
Galvat stål och smide (IVL LCR)	1415,9	2572,4
Aluminiumprofil (IVL LCR)	42,9	582,2
Rör, gjutjärn (IVL LCR)	2688,8	6065,3
Planglas (IVL LCR)	71,5	41,1
Rör, obelagd koppar (IVL LCR)	64,4	1,4
Plastprodukter av polykarbonat (plexiglas), övrigt	57,2	445,1
Konstruktionsstål, obelagd (IVL LCR)	2459,9	4265,0
91//90-		
Plastfolier (IVL LCR)	26,5	48,5
Träfiberskivor, hård board (IVL LCR)	378,0	120,8
Galvad spik, skruv och beslag (IVL LCR)	3541,7	5291,6
Plywoodskivor (IVL LCR)	484,2	109,6
91//93-		
El, till byggarbetsplatsen (Nordenmix) (IVL LCR)	0,0	13910,4
Lastbil 130-560 kW (IVL LCR)	1,3	12933,5
Hjullastare 75-130 kW, 7-17 ton 22.1514; 22.2311 m fl (IVL LCR)	3,2	10613,6
91//96-		
Fjärrvärme till byggarbetsplatsen, ospecificerat (IVL LCR)	0,0	20156,9
Vägsalt (IVL LCR)	2365,6	723,4
Sorterat grus (IVL LCR)	23656,1	34,9
Ej påverkande tillfällig	0,0	0,0
Summa	***1698266***	***721643***
Skede: Drift		
-		
El, Nordenmix (IVL LCR)	0,0	1532916,3
Summa	***0***	***1532916***
Skede: Underhåll		
-		
Tegelfasad	0,0	56855,0
Träfönster	0,0	70674,4
Betongpannetak	0,0	3619,3
Summa	***0***	***131149***
Skede: Rivning		
-		
Rivningsentreprenad	1,0	25239,3
Summa	***2717***	***25239***