CHALMERS
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Assessing the Climate Impact of the Gothenburg Cable Car

A Comparison of Two Alternatives Before and After Design Revision

Master’s thesis in Industrial Ecology

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DIVISION OF BUILDING TECHNOLOGY

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MASTER’S THESIS ACEX30

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ABSTRACT

In 2019, the previously planned Gothenburg cable car, including towers and stations, was redesigned to cut costs since the project had proved more expensive than previously expected. This thesis compares the climate impact of the two designs before and after the design revision by investigating whether the revision had a positive effect on the climate impact and identifies which parameters of the current design that contributes the most to the climate impact. The materials and amounts in the bill of quantities of stations and towers were used as a basis for a life cycle assessment performed in the tool Klimatkalkyl, developed by the Swedish Transport Administration. A third objective was to see how well the tool Klimatkalkyl can be used for unusual constructions without all material being included in the tool. It was found that the second design alternative had a smaller climate impact than the first. During the redesign the climate impact of the assessed parameters decreased from 37 096 tCO_2 eq. to 30 704 tCO_2 eq. Not all parts of the stations could be included due to lack of data. Steel and concrete were the materials that contributed most to the climate impact. Important parameters included tower design, geotechnical conditions for foundations and amount of concrete in the stations. It was also found that Klimatkalkyl could be used for assessing the climate impact of the cable car when material quantities were known but that complementary data was needed in cases where specific material quantities were not known. This case study showed that an increased life cycle perspective in the design phase of buildings and infrastructure may help identify climate hotspots and serve as a basis for comparisons and selection between different design alternatives. However, missing or average data are an uncertainty that needs to be considered as project specific data is not always known or available in the design phase, especially for more unusual projects like the Gothenburg cable car.

Key words: Cable car, Gothenburg, Klimatkalkyl, Life cycle assessment, LCA, sustainable design, Transportation infrastructure

Bedömning av klimatpåverkan från Göteborgs stadslinbana

En jämförelse av två alternativ före och efter designrevision

Examensarbete inom masterprogrammet Industriell Ekologi

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SAMMANFATTNING

Under 2019 designades den före detta planerade stadslinbanan i Göteborg, inklusive torn och stationer, om eftersom projektet hade visat sig vara dyrare än vad som tidigare förväntats. Det här examensarbetet jämför klimatpåverkan mellan de två designalternativen före och efter designrevisionen genom att undersöka om förändringarna i utformning hade en positiv effekt på klimatpåverkan och identifierar vilka parametrar i den nuvarande designen som bidrar mest till klimatpåverkan. Material och mängder in mängdförteckningen för stationer och torn användes som underlag för en livscykelanalys genomförd i verktyget Klimatkalkyl, utvecklat av Trafikverket. Ett tredje mål var att se hur väl Klimatkalkyl kan användas för ovanliga byggnader då inte alla material finns med i modellen. Resultaten visade att det andra designalternativet hade en lägre klimatpåverkan än det första. Under designförändringen minskades klimatpåverkan från de undersökta parametrarna från 37 096 tCO_2 ekv. till 30 704 tCO_2 ekv. Alla delar av stationerna kunde inte inkluderas på grund av avsaknad av data. Stål och betong var de material som bidrog mest till klimatpåverkan. Viktiga parametrar inkluderade torndesign, geotekniska förutsättningar för grundläggning, och mängden betong i stationerna. Resultaten visade även att Klimatkalkyl kunde användas för att uppskatta linbanans klimatpåverkan när materialmängderna var kända, men att kompletterande data krävdes i de fall då specifika materialmängder inte var kända. Den här fallstudien visade att ett ökat livscykelperspektiv i designfasen för byggnader och infrastruktur kan hjälpa till att identifiera områden som bidrar till klimatpåverkan och tjäna som underlag för jämförelser och val mellan alternativa designutformningar. Saknade eller genomsnittliga data är dock en osäkerhet som måste beaktas då projektspecifika data inte alltid är känd eller tillgänglig i designfasen, speciellt för mer ovanliga projekt som Göteborgs stadslinbana.

Nyckelord: Linbana, Göteborg, Klimatkalkyl, Livscykelanalys, LCA, hållbar design, transportinfrastruktur

Contents

Preface

This master's thesis is written as the conclusion of my studies in the master's programme Industrial Ecology at Chalmers University of Technology. The thesis was written based on an idea from the company Tyréns that became involved in the Gothenburg cable car project during the design revision. There are several people that have helped me throughout the work on this report.

I would like to thank Tyréns, and especially my supervisors Sandra Sjökvist and Patricia Heller, for the opportunity to write my thesis in collaboration with Tyréns and for the support with both the work itself and practical matters related to writing the thesis. Another big thank you should go to my supervisor at Chalmers, Assistant Professor Alexander Hollberg at the Sustainable Building group at the Division for Building Technology, Department of Architecture and Civil Engineering, for helping me with advice throughout the entire work process. Thank you also to Professor Holger Wallbaum for serving as examiner for the project.

Thanks also to NCC for sharing the bill of quantities for both cable car designs which was the main source for the climate impact assessment in the report. A special thanks should go to Jakob Persson at NCC who compiled the bills of quantities and helped interpreting and explaining them.

In addition, I have gotten the opportunity to meet many friendly people at Tyréns during the spring. Thanks to Jessica Ekberg who shared her knowledge about the cable car project, and to Amber Cottis for reading the draft report and giving valuable feedback.

In summary, thank you all for your help and support!

Göteborg, June 2020

Erik Larsson

Notations

Abbreviations

BoQ	Bill of Quantities
CO_2 eq.	Carbon dioxide equivalents
GWP	Global Warming Potential
ISO	International Organisation for Standardization
LCA	Life Cycle Assessment
p/dir,h	Persons per direction and hour
PE	Polyethylene
PEM	Medium-Density Polyethylene
PP	Polypropylene
SEK	Swedish Kronor (currency)
SP	Standard Pile (Swedish: standardpåle, a type of concrete piles)

Translations of terms in Klimatkalkyl from Swedish to English

Typåtgärder	Type measures
Byggdelar	Building parts

1 Introduction

Climate change is a global issue with the possibility of causing significant damage to future generations. An increased focus on decreasing emissions and monitoring the climate impact of products and services over their entire life cycle is thus needed. The need to address emissions of greenhouse gases applies to many different sectors, one of which is infrastructure.

In an article, Müller et al. (2013) estimated the carbon footprint of global infrastructure stocks in 2008 to be approximately 102-137 $GtCO_2$. It was also concluded that the carbon footprint in developed and developing countries on a per capita basis was approximately 53 (+/-6) tCO_2 and 10 (+/-1) tCO_2 respectively (Müller et al., 2013). If infrastructure corresponding to the Western nations' stock levels were to be spread over the world it would give rise to emissions of 350 $GtCO_2$ caused by materials production, which in turn would take up 35-60 % of the remaining 2 °C degree target carbon budget up to 2050 (Müller et al., 2013). One option to counteract this is to use less carbon-intensive material and another is that infrastructure needs to be included when addressing climate change, for example in future climate agreements (Müller et al., 2013). At the same time, the building industry causes up to 30 % of the global emissions of greenhouse gases and consumes up to 40 % of global energy (UNEP, 2009). These numbers highlight the need to take climate impact into account when constructing and maintaining infrastructure projects and buildings related to transportation.

When looking at a national, rather than global level, Sweden has a goal to be climate neutral by 2045 and the Swedish Environmental Protection Agency (Naturvårdsverket) also states that Sweden "has declared its ambition to be a pioneer in building sustainable societies" (Naturvårdsverket, 2018a). Currently 5-10 % of the carbon footprint from the transport sector originates from construction, operation and maintenance of infrastructure, however the goal of the Swedish Transport Administration (Trafikverket) is that the net emissions should be zero by 2045 (Naturvårdsverket, 2018a). The Swedish Transport Administration has also set certain milestones and goals during the time leading up to 2045. Compared to 2015, the climate impact originating from construction, operation and maintenance of all infrastructure should be reduced by 15 % to 2020 and by 30 % to 2025 (Naturvårdsverket, 2018b). Transportation infrastructure can be connected to both the transport sector itself and the construction sector. From a construction perspective, the greenhouse gas emissions from transport infrastructure currently constitute about a third of total Swedish construction-related greenhouse gas emissions (Krantz, 2019).

An infrastructure project entails energy use and emissions during its life cycle and the choices made during the design-phase influence the entire life cycle of the infrastructure in question. Given the need to address global emissions from infrastructure it is thus important to take an increased life cycle perspective into account when designing new infrastructure projects. Also, considering the stated ambitions from Swedish authorities to be a frontrunner in reducing the environmental and climate impact from infrastructure (Naturvårdsverket, 2018a) and the fact that Sweden is a developed country (which on average causes more emissions and also has more resources to address them), there is a need to assess the climate impact of current and future infrastructure projects in Sweden.

Using Life Cycle Assessment (LCA) and similar approaches early in the design and planning phases, can provide a way for architects or construction engineers to get an overview of a project’s climate impact during its entire life cycle. This can also provide comparative values for different design alternatives, which can then be used as a basis for decision-making when choosing between different material or design alternatives for example. This can add a complementary perspective in contrast to exclusively looking at economic costs. There might also, for example, be the possibility to achieve synergies in both saving money and decreasing climate impact by reducing the amount of material. It is also possible to get an overview over which factors cause the most climate impact and the potential for increased implementation of sustainable design principles, like reduction of materials or selection of the material with the least climate impact.

The specific infrastructure project to be studied in this thesis is the previously proposed Gothenburg cable car. In preparation for the city of Gothenburg’s 400-year anniversary in 2021, a suggestion from citizens about establishing a cable car across the Göta Älv river was proposed to the City of Gothenburg in 2013. The Gothenburg region is expected to continue to grow in the future and there is a wish to improve connections between different parts of the city. The cable car promised a sustainable and innovative way of travelling that would be connected to the rest of the public transport system in the city, thus decreasing congestion and breaking physical barriers like roads and the river between the stations. Other values, such as serving as a tourist attraction, were also identified. The suggestion continued to develop and a conceptual design of four stations (Järntorget, Lindholmen, Västra Ramberget and Wieselgrensplatsen) was proposed.

The cost of the project was to be paid by the City of Gothenburg, The Västra Götaland Region and the Swedish state (Trafikkontoret Göteborgs Stad, 2019). An initial estimate placed the cost of the cable car at 1.1 billion Swedish Kronor (SEK). However, an updated estimate made in early 2019 instead placed the cost at approximately 4 billion SEK (Trafikkontoret Göteborgs Stad, 2019). In order to reduce costs, a design revision of the cable car was initiated and performed during 2019, leading to a new proposed design of the stations and towers. In the original design, the stations were similar to travelling centres with stores and cafés proposed as part of the stations. After the design revision, the stations were simpler and more like ordinary stops in their function as no additional services apart from transportation were to be provided. However, the cable car technology itself and the main function of transporting passengers were similar between the two alternatives.

The driving factor for the redesign was to cut costs. But even though there are cost estimates for the alternatives before and after the design revision there are no calculations or estimates of the climate impact of neither of the alternatives. The cable car may be considered a sustainable alternative during use as it is driven by electricity but knowing the climate impact of the infrastructure itself and the materials used to construct it could be a good complement to this from a life cycle perspective. In November 2019, the political majority in Gothenburg decided to stop the cable car project. Despite this, this study may serve as a case study on the use of a life cycle perspective when comparing different design alternatives of infrastructure.

1.1 Aim and Objectives

The overall aim of this thesis is to produce and compare two climate calculations on the proposed cable car designs, before and after design revision respectively. This overall aim includes several objectives. The first objective is to see if the design revision made in 2019 has had a positive effect on the project's climate impact. The second objective is to assess the climate impact of the current design and which parameters contribute to the greatest climate impact.

The main tool used to assess the climate impact of both alternatives will be the tool Klimatkalkyl developed by the Swedish Transport Administration (Trafikverket). This tool is based on LCA methodology and contains a range of parameters for materials, building parts and construction and maintenance activities. In addition to the above objectives, a third objective is to investigate how well Klimatkalkyl can be used to assess the climate impact of the cable car despite all activities and materials not being included in the model since urban cable cars are unusual in Sweden. This will potentially give an insight into the tool’s usefulness for other more unusual projects and structures in the future, and in turn also on how the model might be improved. This objective is achieved while working on the climate calculations and the first two objectives and is addressed through a discussion on the chosen methodology.

Thus, apart from assessing the cable car specifically, this thesis aims to serve as a case study for comparison of design alternatives with the help of Klimatkalkyl. This is especially relevant because an increased life cycle perspective is needed to address many environmental problems. If climate assessments are incorporated at an earlier stage in a project’s life cycle, i.e. the design phase, there is a potential for providing architects and construction engineers with increased decision-support in this area.

1.2 Report Outline

Following the introduction, Chapter 2 describes theory related to LCA methodology including using LCA in connection to design and infrastructure. The Klimatkalkyl model is described and the context of the Gothenburg cable car and the two assessed alternatives are explained. Using LCA terminology, the goal and scope definition, inventory analysis and impact assessment are presented as sub-categories under the methodology in Chapter 3. The results are shown in Chapter 4 and further analysed in Chapter 5. Chapter 6 discusses the results, including implications and other insights gained during the study. Chapter 7 presents a conclusion of the study.

Data serving as a basis for the study, and the specific calculation methodology are presented in the appendix. In the report, the term *design alternative 1* refers to the original concept design before the design revision, while *design alternative 2* refers to the alternative after the design revision (these may also be referred to as alternatives A and B respectively in programme documents about the cable car). Most of the sources for the specific cable car project, as well as Klimatkalkyl are in Swedish. For this reason, some of the data in the appendix, and figures showing the interface of Klimatkalkyl, are also in Swedish. Aggregated data in the main report has been translated to English by the author.

2 Theory and Background

In this section, theory connecting to LCA and Klimatkalkyl is described. Furthermore, the context of the object under study, the Gothenburg cable car, is explained and the two studied design alternatives are presented.

2.1 Life Cycle Assessment

The methodology and tool (Klimatkalkyl) used for calculating the climate impact in this report is based on life cycle thinking, and more specifically the method of life cycle assessment (LCA). In short, LCA is a method that can be used to quantify and analyse environmental impacts over the entire life cycle of a product or service (Baumann, 2013). The life cycle of a product can consist of several stages, for example raw material extraction, production, use, and disposal as well as transports between different processes or life cycle stages. One way of referring to, and distinguishing between, different life cycle stages is through nomenclature defined in the European standard *EN15978* as shown in Table 2.1. Here, each phase or stage in the life cycle of a building or construction work can also be designated by a letter and a number. For example, the construction phase is the first phase (A). It can be further subdivided into the production phase A1-A3 and the building and installation phase A4-A5 (Boverket, 2019).

Table 2.1 Life cycle stages as specified by the European standard EN15978 "Sustainability of construction works – Assessment of environmental performance of buildings" (Swedish Institute for Standards, 2011).

A1-A5. Construction stage		
A1-A3. Product stage	A1	Raw material supply
	A2	Transport
	A3	Manufacturing
A4-A5. Construction process stage	A4	Transport
	A5	Construction-installation process
B1-B7. Use stage	B1	Use
	B2	Maintenance
	B3	Repair
	B4	Refurbishment
	B5	Replacement
	B6	Operational energy use
	B7	Operational water use
C1-C4. End-of-life stage	C1	De-construction/demolition
	C2	Transport
	C3	Waste processing
	C4	Disposal
D. Benefits and loads outside of the system boundary		

2.1.1 LCA Methodology

LCAs are divided into four specific main steps: goal and scope definition, inventory analysis, impact assessment and interpretation of the results (Baumann & Tillman, 2004). Guidelines on how to perform an LCA can be found in international standards, for example those issued by the International Organisation for Standardization (ISO). ISO 14040 defines and describes the framework and principles of the different steps and their connection to each other, as well as reporting, critical reviewing and limitations of LCA methodology (ISO 14040, 2006). ISO 14044 states requirements and guidelines on how to perform the steps (ISO 14044, 2006). A brief description of each of the four steps will be presented below, including some other relevant terms of importance to the study.

Goal and Scope Definition

This first step has to do with specifying the context of the LCA by stating the goal of the study and defining the scope by describing the options to model and deciding on system boundaries by setting delimitations for the study (Baumann & Tillman, 2004).

System boundaries and delimitations

Delimitations may include choosing which impact categories to include in the study, which options to model, which steps or parts of the life cycle to include and which to exclude etc. (Baumann & Tillman, 2004). The system boundaries of an LCA study can greatly affect the results depending on which processes that are included or excluded. LCAs can vary in scope. For example, a cradle-to-grave study covers the whole life cycle of a product, whilst a cradle-to-gate study only include processes before the product has reached the factory gate (Baumann & Tillman, 2004).

Functional Unit

Objects under study may fulfil more than one specific function but one specific function should be chosen to relate to the results of the LCA calculations. This function can be described by a so-called *functional unit* and is used as a basis for calculations and for comparing different assessed alternatives based on them providing the same function (Baumann & Tillman, 2004). An example of a functional unit from the transport sector is person-km, describing the function of transporting people a certain distance. The results of an LCA investigating different transport alternatives may then be compared based on this function by reporting the environmental impacts per person-km.

Choosing impact categories and method of impact assessment

The actual impact assessment is one of the subsequent steps in the LCA but defining what method to use and which environmental impacts to assess are already part of the goal and scope definition. One reason for this is that the choice of impact categories may influence what data needs to be found during the inventory analysis step. It is also possible to exclude the impact assessment completely and stop after the inventory analysis. Such a study is called a life cycle inventory analysis (LCIA) (Baumann & Tillman, 2004). For example, in this study the impact category was chosen to be global warming potential (GWP).

Inventory Analysis

In this step, The LCA model is created based on the goal and scope defined in the previous step. Data is collected, calculations are made and an inventory of the resources used during the life cycle, such as materials and energy, and the emissions that they generate is created (Boverket, 2019). Ideally, all environmentally relevant flows and processes that are not outside the system boundaries should be included (Baumann & Tillman, 2004). Calculation of material and environmental loads is done in relation to the chosen functional unit. An important part of the inventory analysis is collection of the necessary data and information needed to carry out the study. This may include both qualitative and quantitative data. Quantitative data may include such categories as inputs of materials and energy, data on products and objects included in the life cycle, or output of emissions from activities and materials. Qualitative data may include which system boundaries the gathered data applies to, or qualitative descriptions of processes and objects for instance (Baumann & Tillman, 2004).

Impact Assessment

In the impact assessment step, emissions and resource use are related to different environmental impacts (Boverket, 2019). The environmental impact of the inventory identified in the previous step is quantified and translated into environmental consequences (Baumann & Tillman, 2004). Generally, this is done by multiplying parameters and amounts found in the inventory analysis by the emission factor for each parameter (emission per unit of material). For example, an inventory parameter may give rise to a certain amount of greenhouse gases which is then translated into global warming potential that describes the climate impact of the inventory parameter. The impact assessment step can also be seen as an aggregation of data from the inventory analysis as the life cycle inventory may contain many different objects and parameters that are compiled into a smaller number of environmental impact categories in the impact assessment (Baumann & Tillman, 2004; Baumann, 2013). LCA's may include one or several different impact categories. In this study, the main impact category used when calculating the climate impact is global warming potential (GWP). For this reason, a brief explanation to this metric is given below.

Global warming potential (GWP)

GWP is a measurement that describes a material's or product's contribution to climate change and is thus a measurement of their climate impact. One definition of the GWP of a substance is "the ratio between the increased infrared absorption it causes and the increased infrared absorption caused by 1 kg of CO_2" (Baumann & Tillman, 2004, p. 149). If a substance absorbs more radiation it thereby contributes more to global warming. Greenhouse gases absorb different amounts of infrared radiation and thus contribute to climate change to different extents depending on the gas. The climate impact of different greenhouse gases can be expressed relative to carbon dioxide which is why the unit of GWP is expressed in carbon dioxide equivalents (CO_2 eq.). For example, methane (CH_4) contribute 25 times more to the greenhouse effect per kg compared to CO_2 (over a 100-year period) and thus have a GWP(100) of 25 kg CO_2 eq./kg (Forster et al., 2007).

Interpretation

In the interpretation step, the results found in the inventory analysis, impact assessment, or both are analysed and interpreted (Baumann & Tillman, 2004). Interpretation is an iterative process that occurs in connection with the other three steps (Baumann, 2013). For instance, new results may be found during the working process that changes the focus or delimitations of the study. The interpretation may also include different types of assessments such as sensitivity analysis. In a sensitivity analysis, the influence of uncertain data on the results of the study may be investigated. Data for input parameters may be changed and if a small change in the data leads to large changes in the results, such as if the order of environmental impact between assessed alternatives is changed, there might be a need to find more accurate data in order to draw clear conclusions (Baumann & Tillman, 2004).

2.1.2 LCA in Connection to Design and Infrastructure

This study aims to make a comparison of two different design alternatives. One important property of using LCA in development of products and designs is the holistic environmental assessment that is made possible (Baumann & Tillman, 2004). The design phase influences the climate impact during the whole life cycle of a product, building or infrastructure object. The structures of infrastructure and buildings are decided, including choice of materials, amounts of materials etc. This has an impact through the extraction and production of materials and the construction process. But the design also determines how a facility will be used and will thus impact emissions during the use stage of the facility. Furthermore, the choice of materials affects the end-of-life stage depending on whether the materials can be reused or recycled in some way, or if they cannot be reused at all.

Many of the decisions that are the most impactful are decided early in the phase of a building project, consequently the possibility to influence the climate impact is also bigger in earlier phases (Kanafani et al., 2019). In general, during product development there is also a higher flexibility in changing the design at an early stage, while the cost of changing the design rises as the design process progresses (Baumann & Tillman, 2004). As the design progresses, there is thus a lock-in effect of the climate impact as more and more factors in the design are determined (Baumann & Tillman, 2004). At the same time, there are also many other parameters than environmental that are considered during the design phase. Trade-offs and synergies may thus also need to be addressed.

But although there is a greater opportunity to influence earlier in the design process, more is uncertain so it may be harder to accurately assess the final results. For instance, Kanafani et al. (2019) state that the knowledge of the specific LCA data required moves from a high degree of generic “fill-in” data based on similar previous projects (if such data exists) early in the design process of a construction to more and more project-specific data later in the process. As will be seen below, this is also relevant for the cable car and this study. For the assessed alternatives, exact lists of how the station buildings would look in different areas or parts had not always been made or finalised for all areas of the buildings. For instance, specific room descriptions were lacking (Jakob Persson (engineer, NCC), personal communication[1]). In some places, there is no specific information on materials and amounts since the project did not reach a stage where this needed to be decided. That the cable car project has now been put on hold also means that some of these parameters will likely never be decided exactly, unless the project is taken up again in the future.

LCA of infrastructure is not very common in all areas. There is a lack of LCA studies and inventory data on cable cars (Biberos-Bendezú & Vázquez-Rowe, 2020). In connection to energy use of cable cars, Clément-Werny et al. (2011) argue that global LCA studies, or similar, need to be conducted for lists of itemized elements used in cable car infrastructure. Even where there is data, it is sometimes hard to compare designs of stations and towers between different cable cars and some data is approximated. For example, Messmer & Frischknecht (2016) have made an inventory representative for Swiss mountainous regions. The towers and stations were

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[1] Personal communication with Jakob Persson occurred in the time span February to April, 2020. This is the case for the whole report but will be omitted in the text below.

significantly smaller than the Gothenburg cable car and only two stations were part of the system. More assessments of different kinds of stations, designs and cable car technologies are thus needed.

2.2 Klimatkalkyl

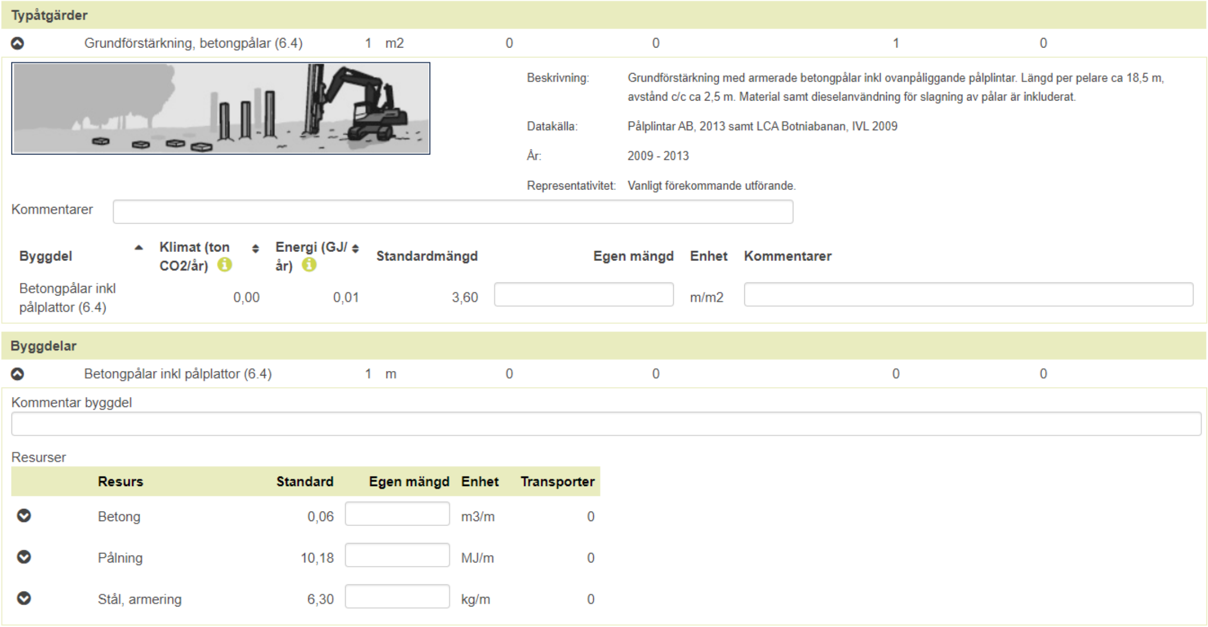
The main tool used in answering the aim and objectives of this thesis is Klimatkalkyl which is developed by The Swedish Transport Administration (Trafikverket). The tool is based on LCA methodology and can be used to calculate the climate impact (expressed in GWP) and the primary energy consumption over the life cycle of infrastructure related to transportation (Toller, 2018). Construction and maintenance of infrastructure are included in the model, as well as raw materials and products and transports in connection to extraction and processing of raw materials (Toller, 2018). Klimatkalkyl is available online via Trafikverket (link available in the reference list). The model is in Swedish and translations of terms from the model in this work has been done by the author.

Some of the goals of the tool is to include the climate impact and energy use of infrastructure as a basis for decision-making by Trafikverket, to make continuous improvements during planning and implementation possible, to follow up results, and use for specifying climate requirements in procurements (Toller, 2018). Its main scope is intended to be infrastructure, but it can also be used for other projects since new objects, materials and emission factors can be added by the user. In addition to adding new data, it is also possible for the user to change and modify existing emission factors and material amounts within the model. This allows project specific data to be used if such data is available to the user. In this way, the model and data can be adapted to suit specific projects if needed.

In the model, templates for different resources, emission factors and project specific input data are used. The model contains different kinds of categories that are structured in a hierarchical manner and can be described as follows (Toller, 2018):

- Type measures (Swedish: *typåtgärder*) are parts of a facility that the assessed infrastructure consist of.
- Building parts (Swedish: *byggdelar*) are sub-parts that the type measures consist of, and in turn contains materials and/or work processes (Swedish: *arbetsmoment*).
- Resources are the smallest hierarchical unit and can be either materials or work processes.

A type measure can contain several building parts and these can contain several different resources. For an example, see Figure 2.1 where the building part *concrete piles* include the materials concrete and steel rebars and the work process *piling*.



Typåtgärder

	Grundförstärkning, betongpålar (6.4)	1	m2	0	0	1	0

Beskrivning: Grundförstärkning med armerade betongpålar inkl ovanpåliggande pålplintar. Längd per pelare ca 18,5 m, avstånd c/c ca 2,5 m. Material samt dieselanvändning för slagning av pålar är inkluderat.
Datakälla: Pålplintar AB, 2013 samt LCA Botniabanan, IVL 2009
År: 2009 - 2013
Representativitet: Vanligt förekommande utförande.

Kommentarer

Byggdel	Klimat (ton CO2/år)	Energi (GJ/ år)	Standardmängd	Egen mängd	Enhet	Kommentarer
Betongpålar inkl pålplattor (6.4)	0,00	0,01	3,60		m/m2	

Byggdelar

	Betongpålar inkl pålplattor (6.4)	1	m	0	0	0	0

Kommentar byggdel

Resurser

	Resurs	Standard	Egen mängd	Enhet	Transporter
	Betong	0,06		m3/m	0
	Pålning	10,18		MJ/m	0
	Stål, armering	6,30		kg/m	0

Figure 2.1 Screenshot from Klimatkalkyl showing an example of the structure of type measures, building parts and resources. The type measure "foundation reinforcement, concrete piles" [m^2] consists of the building part "concrete piles" [m] which in turn consists of the resources, concrete, steel and the work process of carrying out the piling. Source: Klimatkalkyl (retrieved May, 2020).

It is also possible to include operation and maintenance activities in the model but because no templates for this matched the cable car, this was not relevant for the scope of this thesis. When using the model, the different type measures, building parts and maintenance activities are found in an inventory within the model. The input is required to be given in certain predefined units depending on the material. For example, steel needs to be in tonnes, wood in cubic meters, layers of geotextile in m^2 etc. The inventory of each amount is multiplied by corresponding emission factors in the model. Examples of emission factors can be found in Trafikverket (2017). Regarding data for emission factors, the aim is that it should correspond to conservative and representative average values (Toller, 2018).

Information with the results from the impact assessment is generated within the tool. Klimatkalkyl presents the results in different ways. One category called "construction total" shows the total climate impact or primary energy consumption of the assessed parameters. Another chart called "construction and reinvestment" shows the results per year that the assessed construction or infrastructure will continue to operate or fulfil its function. This is calculated based on pre-set lifetimes for all components and materials in the model and it is assumed that each component is replaced at different points in time based on their lifetimes (Norberg & Toller, 2018). This means that it is not necessary to know the lifetime of the main construction (the cable car in this case) since the climate impact per year is based on the lifetime of each component included in the assessment.

The Klimatkalkyl tool is developed continuously. During the work on this report, the latest finalised version was 6.1 which is used in the method. Version 7.0 was under development during this time but it was only possible to search for objects within version 7.0 and see their names but not view any information in depth. It was thus not possible to work in the 7.0 model. It should be noted that Trafikverket published version 7.0 in June 2020. However, at this point the climate calculations in this study had already been completed. In version 7.0, several building part and type measures were updated or added. Another important change is that transports to the construction site are included in version 7.0 (Trafikverket, 2020).

The tool sets certain delimitations in the life cycle. In the construction stage, version 6.1 of Klimatkalkyl includes raw materials extraction, production and construction (Toller, 2018), corresponding to A1-A3 and A5 in *EN15978* (see Table 2.1). Transport to the construction site (A4) is not included in version 6.1 as it usually contributes to only a small share of the total climate impact (Toller, 2018). This is different in version 7.0 where transports to the construction site has been added (Trafikverket, 2020). Operation and maintenance are included, but the use from traffic on the infrastructure is not included. The end-of-life stage is also excluded (Toller, 2018). Klimatkalkyl in general uses average values which sometimes may be criticised for not being detailed enough to capture details in specific projects (Krantz, 2019). The inventory is also smaller than some other LCA software. This may be connected to the use of average data for some materials rather than many different variants. The option to add own material creates the possibility to expand the model to include project specific values. Further information about how the tool is used in this study is found in Section 3.4.1.

2.3 The Gothenburg Cable Car

In this section, the Gothenburg cable car is explained further to give an overview of the project under study. First, a brief history of the project explains how the cable car project has evolved over time and how it led up to the two different alternative designs. These designs are subsequently described and some main differences are identified. The designing architects for the first design was UNStudios in design 1 and Kanozi in alternative 2. NCC was a contractor, and Leitner ropeways the cable car manufacturer, for both alternatives. Tyréns was involved in the design revision as a construction and project leader.

2.3.1 Brief History of the Project

In 2013, the city of Gothenburg began investigating the possibility of establishing a cable car in the city. The original proposal of a cable car was submitted as an idea from citizens of something that the city could do in connection to Gothenburg’s 400-year anniversary celebration in 2021 (Lindeberg et al. 2018).

Work on investigating the possibility of establishing a cable car progressed from 2013 onwards and the project continued to develop. All steps in the project’s history will not be described here, but in 2016 the Gothenburg city council decided that the city would plan for building the cable car (Trafikkontoret Göteborgs Stad, 2019). Several *statements* served as a basis for the planning, one of which was the maximum cost of 1,1 billion SEK.

In the end of 2016, a procurement strategy was chosen where the contractor and the cable car manufacturer would work together in planning how to carry out the project.

The bidding for the project was initiated in 2017 and won by NCC as a contractor and Leitner ropeways as the cable car manufacturer. The decision was appealed by another company and because of this it took until august 2018 before the contract was signed (Trafikkontoret Göteborgs Stad, 2019).

An updated cost estimate made in February 2019 showed that the new projected cost would be too high (4.1 billion SEK) compared to the originally estimated cost and allowed budget of 1.1 billion SEK. In retrospect, the Gothenburg traffic office states that there are several reasons that the new estimate proved so much higher. At the time of the original estimate, not all costs were possible to calculate. Several costs were based on templates as, for example, neither the location or design of stations or towers were decided at this stage (Trafikkontoret Göteborgs Stad, 2019). Other uncertainties were that it was not possible to give a cost estimate including aesthetic design other than for standard cable cars, that commercial facilities or costs for land or adaptation of surrounding areas were not possible to assess and that several adjustments had not yet been completed at this stage (Trafikkontoret Göteborgs Stad, 2019).

In April 2019, a redesign of the cable car was initiated with goals to halve the investment cost and lower maintenance and operation costs (Trafikkontoret Göteborgs Stad, 2019). The aim to lower costs resulted in changed designs for both stations and towers. NCC created bid item lists, also called bills of quantities, for both this new design alternative and the original first concept design. The first list being from February 2019 and the second from October the same year. Tyréns was also involved in the design revision resulting in the second design as a construction and process leader. Several variants were proposed for the new design (hereafter called *design 2*). The overall design of the stations was the same between these alternatives of design 2 but the number of stations as well as the type of towers differed between them. One of these variants is chosen to represent alternative 2 in this study. This is further discussed and motivated below in Section 2.3.4. The cost was lowered to 2.1 billion SEK for the assessed alternative and maintenance costs were also lowered (Tyréns, 2019).

Despite the lowered costs, the politicians in the Gothenburg traffic board (Trafiknämnden) voted to stop the cable car project in the autumn of 2019. On November 28th a decision was taken by the board to pass on the matter to final decision in the city council with the stated position that the cable car project should be declared as stopped. (Göteborgs Stad Trafiknämnden, 2019). The cable car project is thus not active anymore and there are currently no longer any plans for building, or continue to plan for, the cable car.

2.3.2 Common Basis for the Alternatives

Several parameters were left unchanged during the redesign and is thus the same in the first and second design alternative. One important parameter is the placement of stations and towers where alternatives were not considered during the design revision because of cost and time perspectives (Trafikkontoret Göteborgs Stad, 2019). The four stations are Järntorget, Lindholmen, Västra Ramberget and Wieselgrensplatsen. The placement of the stations, towers and the cable between them can be seen in Figure 2.2. Six towers (referred to as towers A-F) of different heights are placed between the stations as support and part of the cable car construction.

Earlier studies showed that the cable car technology “3S” was the only option that would allow for a sufficient altitude above the river and provide the required passenger capacity, thus no changes in the cable car technology itself was made during the design revision (Tyréns, 2019). The 3S technology means that the cable car has three cables (also known as tricable). One cable is the haul rope on which the cable car gondolas are moved forward while the other two cables are carrying ropes which grant increased strength and stability allowing for a higher capacity as well as increased resistance to wind (Leitner ropeways, 2017). The cable car is driven by electricity and connected to the electricity grid. A depot for gondolas is placed at Västra Ramberget as part of the station there (Lindeberg et al., 2018; Tyréns, 2019).

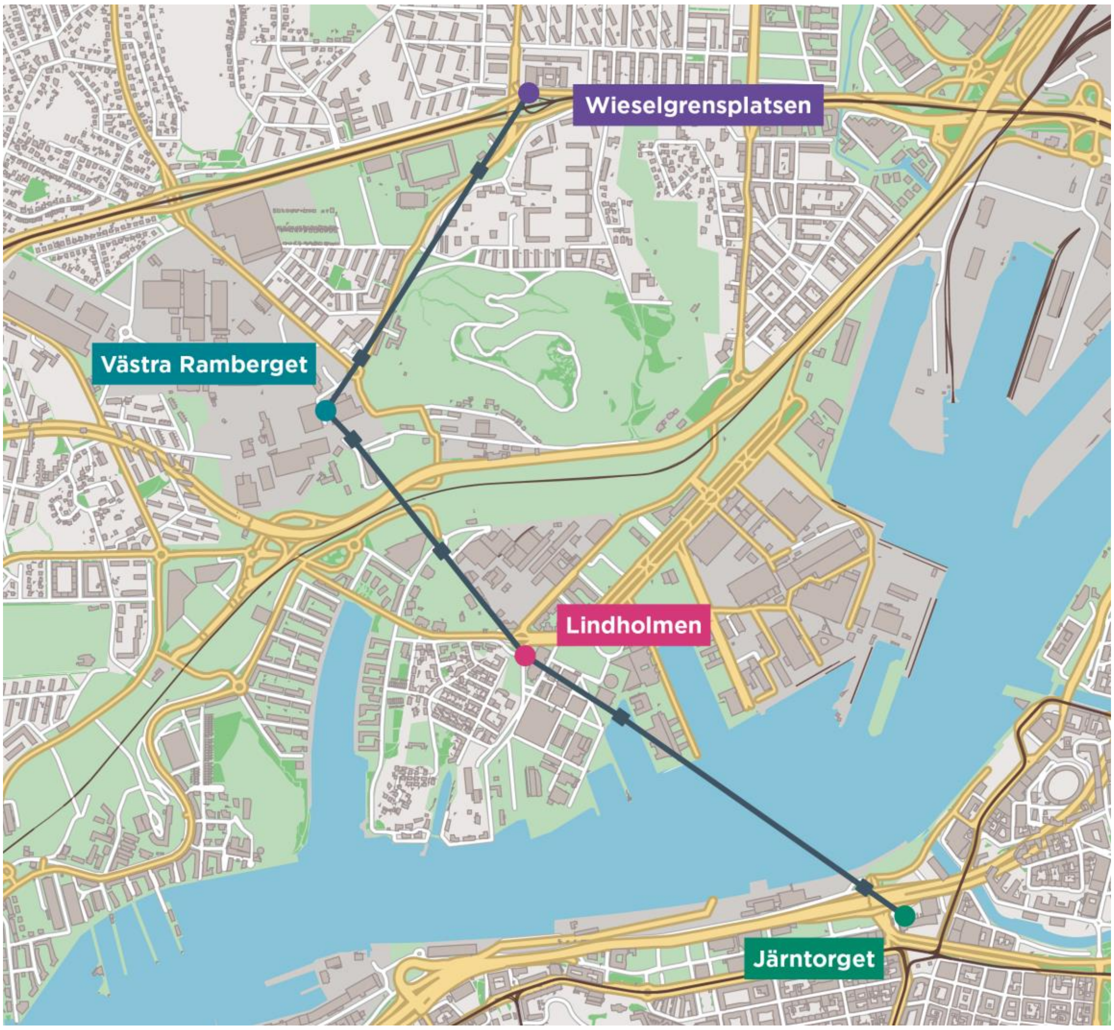


Figure 2.2 Planned locations of stations, towers and cable. The placements are common for both design alternatives. The towers are called A to F. Tower A is closest to Järntorget while tower F is closest to Wieselgrensplatsen. Source for Figure: Trafikkontoret Göteborgs Stad (2018).

2.3.3 Design Alternative 1

In the first design, the stations are larger than in design 2. The stations are intended to be similar to travelling centres. A description of this design alternative can, for instance, be found in a program document by Lindeberg et al. (2018). The stations include auxiliary functions not related to the cable car system itself, for example cafés, restaurants or shops. These are intended to provide services and help to attract visitors. Another motivation for these services is to give an increased feeling of security and safety in connection to the stations. The design vision included open and light spaces intended to give travellers a good overview of the station, and a high degree of visibility, enhancing the perceived safety of the passengers. Goals related to materials included robust and environmentally beneficial materials with long lifetimes and that would be easy to maintain. An example of how the station at Järntorget would look can be seen in Figure 2.3.

Figure 2.3 Visualisation of the station at Järntorget in design alternative 1, an example of one of the four stations. Source: Sweco (2017). Available under Creative Commons licence.

The large volumes of the roofs can be noted in Figure 2.3 (Lindeberg et al., 2018). Due to the large stations, much of the pillars for walls and beams for roofs are made of steel as opposed to concrete in alternative 2 (Jessica Ekberg (project manager, Tyréns), personal communication[2]). The roof contains several folded surfaces around the platform. It also consists of two layers, the outer being a PV clad roof decking while the inner is triangulated timber-clad ceiling (Jessica Ekberg, personal communication). The facades of the buildings include parts made of energy-saving glass. The depot at Västra Ramberget is located under the station, and other stations include basements contributing to structural support. Climate zones will vary between different areas in the stations. Service areas like cafés and toilets will have a normal room temperature while higher variations are allowed in waiting areas, platforms and staircases, including

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[2] Personal communication with Jessica Ekberg occurred in the time span January to May, 2020. This is the case for the whole report but will be omitted in the text below.

escalators and elevators (Lindeberg et al., 2018). The towers in this original design are so called UNS towers (named after the architecture company UNS), similar to the one shown in Figure 2.5.

2.3.4 Design Alternative 2

As stated above, the geographical placements of the four stations are the same as in the first design. However, during the redesign three different alternative design solutions were developed (see Table 2.2): A four-station alternative with the same amount of stations as in the original design; a three-station solution where the last station Wieselgrensplatsen is excluded but with the possibility to expand and build a station there in the future; and a three-station solution without the possibility to expand (Trafikkontoret Göteborgs Stad, 2019). No final decision was made as the cable car project was stopped before a final design was chosen. However, the solution with four stations was the one that fulfilled the ambition of connecting the city in the best way. The traffic office of the City of Gothenburg states that a three-station solution does not achieve the main purpose of the cable car project of serving as a cross link and connecting the city, only the solution with four station would do this (Trafikkontoret Göteborgs Stad, 2019). Based on this, and that the most fair comparison of the design alternatives before and after design revision would be to compare designs with the same amount of stations, the alternatives assessed and compared in this report will be design alternative 1 (before the design revision) and the variant of design alternative 2 with four stations (after the design revision).

Two different types of towers were discussed. A so called "simple steel tower" and the "UNS fyrkantsprofil" which was a simplified version of the original UNS towers from design 1. When the project was suspended, no final choice between the towers had been made. However, the simple steel tower was cheaper. In the four-station solution the cost of the whole project was estimated to be 2.10 billion SEK with the simple steel towers and 2.38 billion SEK with the UNS towers (Tyréns, 2019). In this study, it is assumed that the simple steel towers would be used. This is based on that this would be the most probable alternative based on the lower costs (Jessica Ekberg & Jakob Persson, personal communication).

Table 2.2 Overview of the six possible combinations of design alternative 2. The alternative with four stations and "simple steel towers" are assessed in this study. Other alternatives, marked with "-", are outside the scope of this study and not included in the comparison with design alternative 1.

Variants of design 2	"Simple steel towers"	UNS towers
3 stations without possibility to expand to Wieselgrensplatsen	-	-
3 stations with possibility to expand to Wieselgrensplatsen	-	-
4 stations	Investigated variant of design alternative 2	-

The goal of the second design was to find the simplest and most compact design that would still fulfill the main qualities and requirements specified for the cable car. All the stations consist of the same parts seen in Figure 2.4 and will thus mostly contain the same design solutions. The roofs are smaller than in the previous design and will be folded down. A volume of glass and wood will be placed on concrete platforms. The frame will be made of wooden beams to support the roof. Lighter elements of wood are built between the supporting elements in the roof construction (Tyréns, 2019).

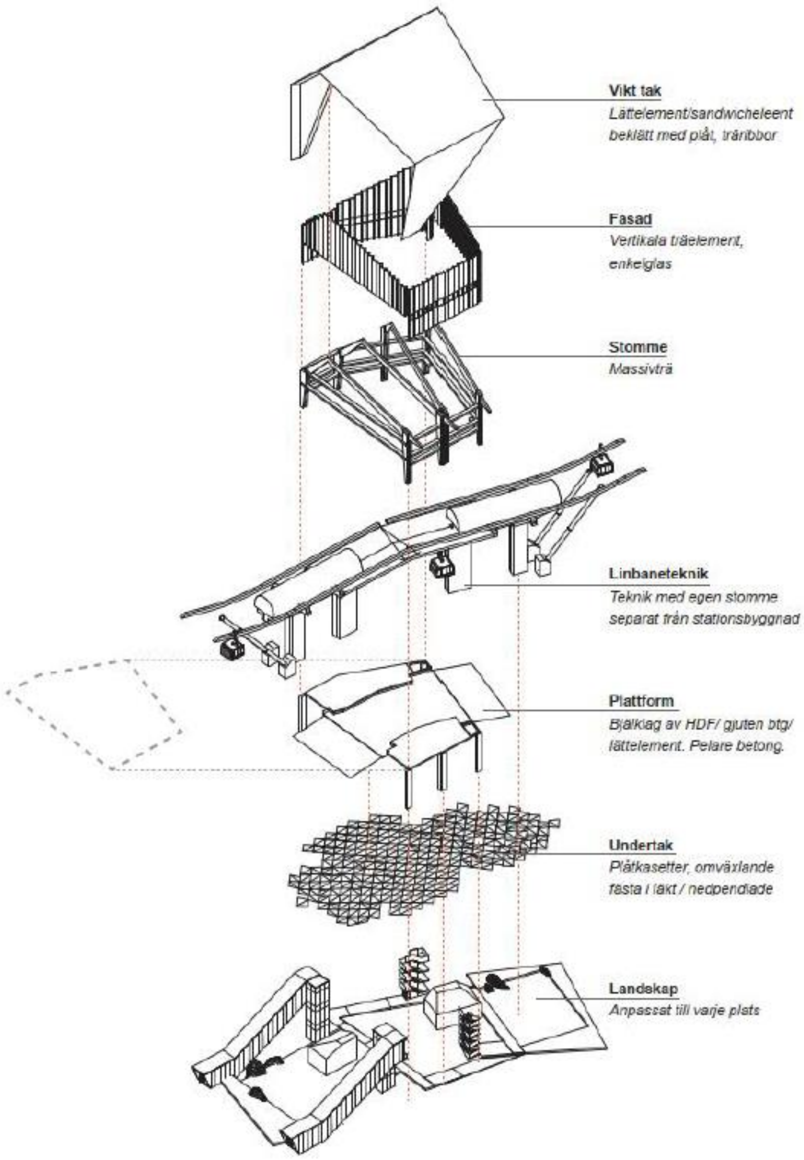


Figure 2.4 Typical design elements for the stations in design alternative 2. Source: Tyréns (2019).

In a report by Ejeborn (2019), consequences of the second design compared with the first are discussed. The change from travelling centers to smaller stops includes several consequences. No shops or cafés are included and public bathrooms are also removed. The removal of these facilities means that services for travelers and residents in the area will be removed as well as a potential function as a meeting place. Apart from service and comfort, the perceived safety may decrease due to less people at the stations. Ejeborn (2019) also discusses changes in the design itself. Facilities are no longer planned on the ground floor (see the pillars in Figure 2.4 and compare to Figure 2.3). The depot for gondolas at Västra Ramberget is no longer placed at the basement level but at the same level as the platform. (Ejeborn, 2019).

The method used for the foundation has been replaced with a more cost-efficient alternative with more piles compared to the first design (Ejeborn, 2019). The main reason that more piles are needed is because the geotechnical conditions of the sites were known in greater detail at this (later) stage compared to when design 1 was created (Jakob Persson and Jessica Ekberg, personal communication). The roof area of the stations is minimized so that it only covers the platform. Escalators and technical facilities will be protected in an alternative way, they are thus not incorporated into the actual building in the same way as in design 1. (Ejeborn, 2019). Glass facades are still present but the share of glass compared to the frame structure in the facade has changed.

2.3.5 Passenger Capacity

The passenger capacity was 2000 persons travelling in each direction per hour (p/dir,h) in the first alternative and 1000 p/dir,h in the second alternative (Ejeborn, 2019). However, the maximum capacity in alternative 2 may be raised further if more gondolas are added. Ejeborn (2019) states that the new capacity may be increased to 1500 p/dir,h and that this capacity would still be able to handle the projected travelling demand and thus not bring any large negative impact compared to alternative 1. Furthermore, it would perhaps be possible to add more gondolas later in alternative 2, making the passenger capacity between the two alternatives equal (Jakob Persson and Jessica Ekberg, personal communication). Thus, it is judged that a fair comparison between the alternatives may be performed regarding maximum capacity and the ability to fulfil the same function of transporting people. However, it should be noted that the cost may rise in alternative 2 compared to the projected cost, if more gondolas were to be added (Jakob Persson, personal communication). However, the gondolas are part of the cable car technology which is not within the scope of this study due to lack of specific data (see also the goal and scope definition in Section 3.2.2).

2.3.6 Main Differences Between the Alternatives

Some of the main differences between the alternative designs are shown in Table 2.3.

Table 2.3 Table summarising main differences between the assessed alternatives. Sources: Ejeborn (2018), Glans (2019), Tyréns (2019). Personal communication: Jakob Persson (JP) and Jessica Ekberg (JE).

	Design alternative 1	Design alternative 2
Estimated cost	4,1 billion SEK	2,1 billion SEK
Type of tower	UNS tower	"Simple steel tower"
Type of station	Travelling centers	Ordinary stops
Total station area	Ca 17000 m^2	Ca 5600 m^2
Roof design	Larger volumes	Flatter with less area
Passenger capacity (p/dir,h)	2000 (Ejeborn, 2019)	1000-1500 (Ejeborn), possibly 2000 (JP & JE, personal communication).
Opening hours	19 h/day	16 h/day

One main difference between the alternatives is the size of the stations, which is also connected to the change from travelling centres to stops including removal of commercial areas. The roof design is another main difference. As described in the above section, the passenger capacity is slightly lower in design 2 but could be raised if more gondolas were added. Several social aspects could differ between the alternatives. Passengers may feel less secure in the second alternative if less people are moving through the stations as services and the potential as a meeting place are removed (Ejeborn, 2019). Another example of a difference is that gondolas will stop completely in alternative 1, while they will slow down in alternative 2 when embarking and disembarking the gondola.

The tower design is another difference. In the first alternative, UNS towers would be used, while simple steel towers are assumed to be used in the second design, see Figure 2.5. The simple steel towers are cheaper and contain less material. The UNS tower would also be more difficult to construct due to angles, and unique fabricated steel parts (Jakob Persson, personal communication). Further comparison between the tower designs will be done below, where the amount of steel will be compared. However, it may be mentioned that the simple steel towers are not perceived as fulfilling the same aesthetical qualities according to some stakeholders because of the simplified design (Ejeborn, 2019).

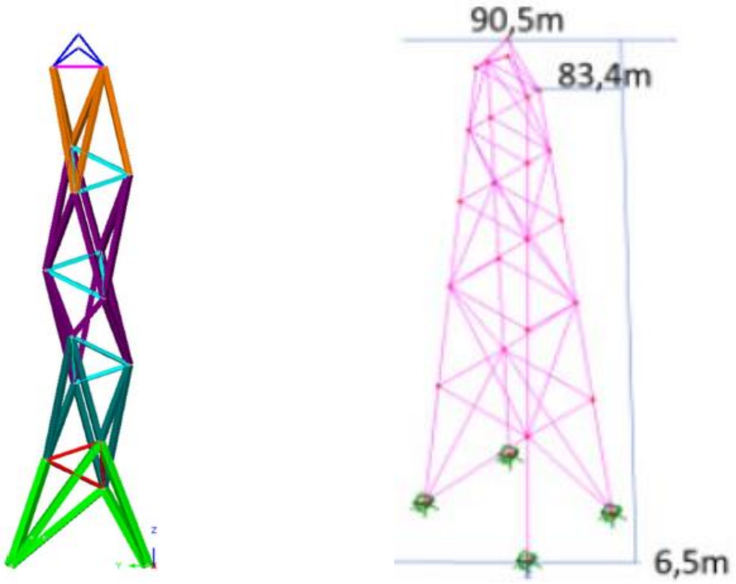


Figure 2.5 Comparison between the two tower designs showing the UNS tower to the left and the simple steel tower to the right. The UNS tower shown is the simplified UNS fyrkantsprofil which is a simplification of the original UNS design. The original tower used in design 1 contains even more steel. Each corresponding tower has the same height in the different designs, i.e. tower A is the same height in both alternatives. However, the height of the different towers A-F differ depending on location (The dimensions of the simple steel tower in the Figure refer to tower F). Sources: Figure with the UNS tower (Tyréns, 2019). The simple steel tower is from sources for steel weights (see also Figure A.2 in the appendix) supplied by NCC (used with permission).

2.3.7 Operation and Maintenance

Maintenance is an important issue for urban cable cars. These are frequently used and the maintenance policy should be based on an analysis of the system already at the design stage (Clément-Werny et al., 2011). There are calculations on cost estimates for operation and maintenance of the Gothenburg cable car. The exact maintenance activities were estimated by Leitner ropeways (Glans, 2019). For that reason, the exact maintenance activities are not known. There were also other factors making a comparison of maintenance difficult. For the first design, calculations had been done based on an average cable car, while the calculations for the second design were adapted to the Gothenburg cable car specifically (Glans, 2019).

The main drivers for operation and maintenance costs are identified as electricity bills, and wear-out and renovation of cable car components (Glans, 2019). The operation and maintenance costs show a significant decrease after the redesign compared to before (Trafikkontoret Göteborgs Stad, 2019). Changed opening hours from 19 to 16 hours as well as decreased station areas contributed to this (Glans, 2019). However, it is not known how significant the difference in climate impact will be and how this relates to the difference in cost. Maintenance is excluded from the scope of the study and is thus not included in the inventory analysis or impact assessment. This is motivated by the lack of data, and since much of the maintenance is connected to the cable car technology which is also excluded from the scope. It might be assumed that the climate impact from operation and maintenance of the stations is larger in the first alternative because of the larger areas but that the maintenance of the cable car technology itself is roughly the same, but this is not possible to quantify.

The electricity consumption is included in the analysis. It is known for the cable car itself and is roughly the same for both alternatives since the cable car technology remained unchanged. The electricity consumption of the stations will be estimated based on the station areas for the four stations, and templates in Klimatkalkyl. For the cable car technology, 100 % green energy was intended to be used. This was because the electricity was going to be procured under a contract of the Gothenburg Traffic Office where this was a requirement (Glans, 2019).

3 Methodology

In this section, an overview of the general work process is first described. Secondly, the method used in the specific steps of an LCA study is described in more detail.

3.1 Overview of the Work Process

The main method was that two separate climate calculations were made in Klimatkalkyl, one for each design alternative (before and after design revision respectively). A comparison was then made between the climate impact of the two alternatives and the factors contributing most to the climate impact were identified. The climate calculations were mostly based on the first and second lists of bid items and quantities in the project (bills of quantities). The first list was based on data on the original design. The second was based on the work that was carried out in 2019, where the entire design of the cable car, towers and stations, was redesigned. The lists of bid items and quantities have been produced and, shared as sources for this report, by NCC.

The first step in the work process was to get an overview of the background and context of the cable car project in order to formulate the preliminary goal and scope definition of the study together with Tyréns. Meetings were held with Tyréns and NCC where the bills of quantities as well as differences between the alternatives and delimitations were discussed. In the meeting with NCC, the bills of quantities were explained and subsequently compiled and supplied by NCC (via Jakob Persson). These served as the main source for the climate calculations and input in Klimatkalkyl. The bid item lists were analysed continuously during the work process to determine data gaps and delimitations and which assumptions needed to be made.

In the inventory analysis, the material data in the bill of quantities was sorted into input categories in Klimatkalkyl and aggregated (see Section A.1 in Appendix). As described in Section 2.2, Klimatkalkyl requires input in certain predefined units depending on the building part or type measure. These units did not always match the units in the bill of quantities. Recalculations were performed to convert the units of each item in the bill of quantities to the correct input unit for each category in Klimatkalkyl. The impact assessment was then performed in Klimatkalkyl. However, a cable car and all its components are not included in the tool. During the inventory analysis, those materials and operations not included in Klimatkalkyl needed to be approximated with other existing objects in Klimatkalkyl, or complementing data needed to be found.

One specific case where alternative data was needed was when categories in the bill of quantities were not specifying the type or amounts of specific materials. For instance, this was the case for different types of installations and parts of the stations such as walls, facades and roofs. These examples were expressed as areas but without a material quantity being given. In Klimatkalkyl, there are objects that are expressed as areas, like bitumen-bound layers, geotextiles, pavestones and others. But the tool does not contain area-based emission factors for general categories of installations, like heating, sanitation etc., nor does it include area-based approximations of materials in walls, roofs or other areas that could be used in this case. Thus, the methodology of using Klimatkalkyl was complemented with impact assessments based on other sources for these areas and was done outside of Klimatkalkyl.

The results were then compiled and compared between the two design alternatives to assess the difference in climate impact and the influence of different parameters. The most important parameters were identified. A sensitivity analysis on the climate impact of concrete was also performed.

3.2 Goal and Scope definition

As defined in Section 1.1, the goal of this study was to produce and compare two climate calculations for the design alternatives of the cable car before and after the design revision in 2019. In this section, the scope of the study will be described and defined by describing the functional unit of the study and setting system boundaries and delimitations.

3.2.1 Functional Unit

As stated above, the functional unit serves as a basis for comparison of the assessed alternatives in an LCA. In the case of the cable car, the main function is to transport passengers between the different stations and as explained in Section 2.4.5 the passenger capacity between the two alternatives may be regarded as approximately equal. Both assessed design options also include the same four stations, making the function of transportation equal also in the perspective of where and how far the cable car would allow passengers to travel within the city. The functional unit in this study is chosen to be “one cable car system”, consisting of the four stations (Järntorget, Lindholmen, Västra Ramberget and Wieselgrensplatsen) and six towers.

Although the chosen functional unit fulfils the purpose of serving as a basis for comparison between the two assessed design alternatives, it is acknowledged that it may not be suitable for comparing the cable car with other means of transportation, or other cable cars. For such a comparison to be made a more general functional unit, like person-km, could be of use. It may also be noted that the first design alternative with its larger stations may provide other additional functions, such as serving as a social meeting place or providing a wider range of services to passengers like shops or cafés. However, these services are not needed for the main function of transporting passengers and are thus not deemed suitable to serve as a functional unit in this study. The fact that such additional services are not needed for the actual cable car system was also shown as they were removed in design alternative 2 but that the cable car was still regarded as fulfilling its main function of transportation (Ejeborn, 2019).

3.2.2 Scope and Delimitations

Defining the scope of the study is done by making delimitations in several areas in order to decide what to investigate and what to exclude from the assessment. Starting with which environmental impacts to be assessed, global warming potential (GWP) is the only impact category to be investigated in the study. Klimatkalkyl also includes the primary energy consumption in the calculations but this is excluded from the scope. No other impact categories are included in the Klimatkalkyl and are thus not possible to assess with the chosen methodology.

The main scope in terms of life cycle stages for materials will be A1-A5 (see Table 2.1). But A4 is often omitted since it is not included in version 6.1 in Klimatkalkyl (although it was added in version 7.0 as described above. Some data for emission factors only includes A1-A3 if A5 is not specified. Some parts of the use phase (stage B, see Figure 2.1) is also included. The energy use of the cable car technology is known and included in the assessment. Energy use in the station buildings such as heating and electricity are assessed based on templates in Klimatkalkyl and is thus also included. Replacements of parts are included as part of the Klimatkalkyl tool as it assumes replacements based on the lifetimes of individual objects, but maintenance activities are not included due to lack of data. The end-of-life phase is not included in the Klimatkalkyl model and will not be included in this study.

The intended lifetime of the cable car was not known exactly. In the cable car project, it was assumed that the stations would have a lifetime of 50 years while the towers and constructions below ground would have a lifetime of 100 years (Jessica Ekberg, personal communication). This was the same for both designs. Since the lifetime of different objects in Klimatkalkyl are specified (see Section 2.2), it is possible to analyze the yearly climate impact based on the individual parts. The yearly climate impact in Klimatkalkyl is thus calculated in this way without using a lifetime for the whole cable car.

When it comes to the geographical scope, the location is Gothenburg. The data in Klimatkalkyl aims to represent average data and the geographical applicability for most of it is either Sweden or Europe, but there are also some emission factors that are global averages although this is not as common (Trafikverket, 2017). Since Klimatkalkyl is developed for Swedish users, most of the data is applicable for Swedish conditions.

As described above, three different design solutions for the cable car were developed after the design revision as part of design alternative 2: A four-station alternative with the same number of stations as in the original design; a three-station solution where the last station Wieselgrensplatsen is excluded but with the possibility to expand there in the future; and a three-station solution without the possibility to expand (Trafikkontoret Göteborgs Stad, 2019). This study will only look at the option with four stations and the simple steel towers and compare that to alternative 1, no other alternatives will be assessed. Neither will the cable car be compared to other possible modes of transportation in the area, such as bus, tram or ferry.

The cable car mechanism itself, such as engine, gondolas and cables, were only included in the bill of quantities in the form of the total cost of the technology. Exact data such as weights or material composition in the cable car technology is only known by the manufacturer Leitner ropeways. NCC, who compiled the bills of quantities, only knew the cost for the system. Since no specific types or amounts of materials are known for the cable car technology it is excluded from the scope of this study due to lack of data. These parts would be similar for both designs and will thus not influence the relative comparison between the alternatives. However, it should be noted that to know the full climate impact of the cable car, the cable car technology should ideally have been included if it had been possible. Energy use from operation of the cable car mechanism is however known and will be included within the scope. It is assumed to be approximately equal between the alternatives, based on the similarity in cable car technology.

Lack of data also made it necessary to exclude several parts of the stations from the study. This is in some cases because the project was suspended before all specific design choices (including specific materials for some parts) were made. In such cases, only templates were used in the bill of quantities to approximate costs, while no actual materials were known. No furniture or inventories will be included in the analysis because the detailed design of these were not entirely completed. In the first design, stations were more similar to travelling centers. The inventories of stores or other businesses in such store facilities will not be included. Issues like perceived safety of passengers and additional services provided within the stations will differ between the alternatives. No calculations will be performed on such additional functions as part of the climate calculations.

General Assumptions

As already described, it is assumed that the variant of design alternative 2 with four stations and simple steel towers would have been the most likely alternative to be chosen. This assumption was done out of the necessity to limit the scope by choosing and assessing one of the proposed variants of design alternative 2. In general, average material data has been used during calculations in the inventory analysis and the impact assessment. This was consistent with the Klimatkalkyl model where average data is often used. Regarding specific materials, the assumptions were dependent on the information in the bill of quantities and more specific assumptions are presented in the appendix. In cases for objects with specific dimensions, a search was done for objects with similar dimensions. If the dimensions of and material in, for instance a pipe, in a source was the same as in the bill of quantities, data for that pipe was assumed to be representative although the specific manufacturers were not always specified in the bill of quantities.

3.3 Inventory Analysis

This section begins with an overview of the main sources used. Then, the general principles of calculations are shown, followed by an overview of some of the most important materials in the inventory.

3.3.1 Data and Sources

The bill of quantities for each design alternative, compiled by NCC, constitute the main sources for the inventory analysis and results. They are discussed here together with other sources that were used.

3.3.1.1 Bills of Quantities

The main source material are lists of bid items (bill of quantities) created and supplied by NCC. The purpose of the bill of quantities is to calculate the cost of the project by giving an overview of different parameters, activities and objects. The bills of quantities are presented in the Appendix. The main bill of quantities are shown in Section A.1, the steel weights in towers in Section A,2 and the amount of piling and sheet piling in Section A.3. As can be seen, the lists are quite detailed in showing some parameters while some others are based on templates. However, it should be noted that the bills of quantities are made primarily for calculating the costs for different parameters and objects rather than showing the environmental impact. For this reason, the exact material is not always specified but only the costs. The costs for each category are removed from the appendix and not included in this report. The bill of quantities has been produced by NCC in the calculation software MAP. A compilation of the bid item lists was performed by Jakob Persson at NCC and delivered as three different documents per design alternative showing:

- The construction steel in the towers,
- The piles and sheet piling for foundations of towers and stations,
- The main bill of quantities.

The data was divided into the two design alternatives 1902 and 1910 (indicating the year and month when the respective list was produced), corresponding to the designs before and after the design revision. For design alternative 2, the data was specifically for the case with simple steel towers and four stations. Specific methods of all calculation procedures performed by the NCC when creating the bill of quantities are not included in this thesis but it may be noted that there were motivations behind all figures and calculation (Jakob Persson, personal communication). Some data is based on calculations on project specific data like design drawings and documents. Some data is also based on assumptions or templates based on knowledge of other previous projects within NCC (Jakob Persson, personal communication).

As a result of the bills of quantities being created primarily for showing the economic costs associated with different parameters rather than for calculating environmental impacts, there are some uncertainties arising when estimating the climate impact. These uncertainties may have an influence on the results and the comparison between the two alternatives. For example, the type of material that components consist of is not always known since this was not always needed when assessing the costs. One example is for parts of the stations like floors and walls. Here, a final decision had not always been made on what material to use. In the bill of quantities, cost estimates had been done based on possible choices. In some cases, this resulted in these parameters being given in square meters of roof or wall without the actual material being known. These objects expressed as “areas” fulfil the intended purpose of estimating costs but are not possible to assess through Klimatkalkyl because the types and quantities of materials were not given. Because of this, a complementary assessment of some parts of the stations was done outside of Klimatkalkyl. This was based on areas from the bill of quantities together with area-based emission factors from other sources.

It may also be noted that there is a risk for double-counting in some cases unless excluding some parameters. For instance, in some cases, the actual material is listed (for example concrete volumes) but within the same category there may also be transportation of the same concrete volumes given in the weight of the material transported (one referring to the cost of the material and the other to transport costs). Other examples are that some categories are costs for contractors, often expressed in areas. In many cases, these areas represent materials not included elsewhere in the model. But for concrete for instance, the concrete volumes shown in one place of the lists will be used by the contractors resulting in a risk for double-counting if including the material in both categories. In some cases, this led to uncertainties in interpreting the lists.

The newer list of bid items (for design 2) may be slightly more exact in some respects. For instance, the geotechnical conditions of the specific sites were known with a higher certainty at the time of the second design, leading to a higher (and more exact) number of piles for the second alternative (Jakob Persson, personal communication).

3.3.1.2 Other Sources

Other sources were needed to complement the bill of quantities. For information on the cable car, several documents that were created during the cable car project were used. For instance, showing the designs and explaining parts of the reasoning behind each alternative. For theory, scientific articles or reports were used. These were also used for finding emission factors outside of Klimatkalkyl. Environmental product declarations were also used in some cases. Some data from companies was used when recalculating the units of some objects from the bills of quantities to the units required for input in Klimatkalkyl. This was for instance data on dimensions, weights or densities for specific kinds of products, or products similar to those in the bill of quantities. In some cases, information was received through personal communication. Jakob Persson, engineer from NCC and Jessica Ekberg, project manager from Tyréns, have both been involved in the cable car project and contributed with help in interpreting the bills of quantities and in finding and discussing information related to the cable car. Naturally, the data within Klimatkalkyl has also been an important source material for the study as the impact assessment has been done in the tool.

3.3.2 General Calculation Procedure

Each item in the bill of quantities that was not excluded from the scope was assigned to the corresponding building part or type measure in Klimatkalkyl that was judged to represent the item in the best way. The amounts of each item were then recalculated to the correct input unit for their corresponding building part or type measure (if needed). The calculation procedure varied from object to object. The bill of quantities are shown in Section A.1 with brief explanations for calculations and delimitations for each category in Section A.5. In general, densities, volumes, weights or other dimensions were used. In some cases, no existing building parts or type measures in Klimatkalkyl were similar to an item. In these cases, new categories were added based on emission factors from other sources. However, several objects also needed to be excluded due to the difficulty in estimating their climate impact. Then, the different items in the same Klimatkalkyl category were summed up and aggregated. This aggregated amount was then used as input in Klimatkalkyl as a basis for the impact assessment. The aggregated inventory in Klimatkalkyl for each design can be seen in Tables 4.3 and 4.4. It should be noted that the climate impact could not be assessed for all objects.

3.3.3 Overview of Inventory Parameters and Materials

In this section, some of the main categories of inventory parameters are presented and discussed. All materials are not described in this section but a summary of included parameters in the impact assessment in Klimatkalkyl can be found in Tables 4.3 and 4.4.

Concrete

The properties of concrete vary depending on the specific type. Different variants may be manufactured in different ways with varying emissions of greenhouse gases as a consequence. In Klimatkalkyl there are two main kinds of concrete, one is simply called *concrete* (based on CEM I) while the other is called *concrete, class 2* (based on CEM II). Apart from this, there are a range of predefined objects made from concrete, such as piles, walls, pavestones and others. These predefined objects are made of ordinary *concrete* in Klimatkalkyl. Since only two types of concrete are included in the tool, these average values may not necessarily have the same emission factor as all different types of concrete used in the project. This may be an uncertainty. The standard emission factors in Klimatkalkyl is used for concrete in this study. However, a sensitivity analysis is also performed where the emission factor of concrete is decreased to assess how this would affect the results.

The density of a material usually has implications for its climate impact. For instance, in transportation a heavier load may cause more emissions. In this work, the density also influences the results because it affects the recalculation procedure in the inventory analysis where concrete sometimes is translated from weight (tonnes) in the bill of quantities, to volume (m^3) in Klimatkalkyl. For instance, no exact density is specified for the different kinds of concrete in the bill of quantities. Instead, the same density of concrete which is specified within Klimatkalkyl has been used, 2,4 ton/m^3. This value can be motivated within the scientific literature. Elfgren (accessed 2020, a) gives that same density. Guo (2014) states that ordinary concrete has a density in the range of 2.1 to 2.4 ton/m^3 (while the density of lightweight concrete could be significantly lower). According to these sources, the density used is thus within the range of ordinary concrete. Reinforced concrete is one of the most used building materials in Sweden and improves characteristics such as strength and flexibility of the concrete (Elfgren, accessed 2020, b). Like ordinary concrete, the density of reinforced concrete is approximately 2,4 ton/m^3, the weight percentage of steel in the concrete is usually in the range of 0,1-3 % (Elfgren, accessed 2020, b).

Towers

As shown above, different tower designs were used in the different design alternatives. The steel weights of the towers are based on data supplied by NCC. The towers need to have a certain height to keep the necessary distance between the cable car and areas and buildings below. As stated above, towers A-F have different heights depending on their placements. Each individual tower has the same height irrespective of design. Tower A thus has the same height in both designs and the same goes for each of the other towers. As shown in Table 3.1, the UNS towers consist of more steel than the corresponding simple steel towers due to their different structures. The towers also include 25 tonnes of steel called the *top structure*. This is cable car components from Leitner and the only part of the actual cable car technology where specific material and weight is known (Jakob Persson, personal communication). For the sake of consistency, these 25 tonnes per tower are left out from the climate calculations since they are part of the cable car technology which is excluded from the scope of this study. That weight is not part of the values presented in Table 3.1.

Table 3.1 Steel weights of towers A-F for the UNS towers (in design alternative 1) and the "simple steel towers" (in design alternative 2). The steel weights are based on data supplied by NCC (see Section A.2 in the Appendix).

Tower	Steel weight [tonnes]	
	UNS towers (design 1)	Simple steel towers (design 2)
A	1103	428
B	1872	1024
C	1379	681
D	616	194
E	1038	388
F	1385	694

Piles and Sheet Piling

Several different piles and sheet piling are used in the project. The inventory of these is divided into three different categories for both design alternatives.

- Piling used for the stations and towers
- Sheet piling used for construction of the stations and towers
- Piling for cranes and cables used during construction

The piles are left in the ground after construction. It is also assumed that the sheet piling is left in the ground. In theory, it is possible to recover and reuse the sheet piling in other construction projects. However, when NCC did their calculations in the bill of quantities they assumed that it would be left in the ground (Jakob Persson, personal communication). This is because it is not always possible to remove the sheet piling from the ground depending on the conditions, they may also be too damaged to reuse. Taking them up, cleaning them and making them ready for reuse would also cost approximately the same as leaving them in the ground and buying new ones. There are thus no economic incentives to reuse them (Jakob Persson, personal communication). With that said, it is possible that some would have been taken up after construction of the cable car as well.

Steel piles

In Klimatkalkyl version 6.1, there are general types of piles for different materials like "steel pipes" or "concrete piles" with certain assumed dimensions that are not always the same as those in the project. For this reason, the data has been adjusted based on project specific data. The steel piles in Klimatkalkyl v.6.1 are piles with a steel core. The piles in the bill of quantities are instead steel pipe piles. Table 3.2 shows the amount of different piles used in the project while Table 3.3 shows the weights that were used for each pile. Weak piles refer to thinner piles with smaller dimensions.

Table 3.2 *Amount of steel piles used in the project. Data is based on the bill of quantities (See Tables A.3 and A.6 in the Appendix). "-" refer to that no piles of that type were used design alternative 1.*

Design	**1**	**2**
Total number of piles	411	1362
Pile dimension	**Total length per pile type**	
323/12,5	*10 973 m*	*31 368 m*
170/12,5	*3840 m*	-
Weak piles		
Klen påle, 115/6,3	-	6488 m
Klen påle, 115/8	-	13 296 m
Stag 500 kN + påle 140	-	810 m
Stag 500 kN + 140/12,5	-	559 m
140/8	-	288 m
Tot. weak piles	-	*21 441 m*

Table 3.3 *Types of steel pipe piling used in the project and their corresponding weight per meter used in the calculations. In the third column, the dimensions of the pile used as a source is specified. The data for the thicker 323/12,5 piles are from Kynningsrud (2015). The data for the different types of weaker piles are from Ruukki (2014).*

Pile type	**Weight**	**Source for weight**
323/12,5	96.0 kg/m	Rörpåle 323,9/12,5 (Kynningsrud)
Weak piles		
Klen påle, 115/6,3	16,8 kg/m	RR115/6,3 (Ruukki)
Klen påle, 115/8	21,0 kg/m	RR115/8 (Ruukki)
Stag 500 kN + påle 140	26,0 kg/m	RR140/8 (Ruukki) No thickness given, assumed to be similar to other 140 piles in the project. 8 mm is assumed rather than 12,5 for a more conservative estimate.
Stag 500 kN + 140/12,5	32,0 kg/m	RR(s)140/10 (Ruukki)
140/8	26,0 kg/m	RR140/8 (Ruukki)
170/12,5	48,0 kg/m	RR170/12,5 (Ruukki)

Concrete piles

The piling for cranes and cables are of the types SP1 and SP2. SP stands for Standard Pile (*standardpåle* in Swedish) and is a standardized type of concrete pile. The width is 235 mm for SP1 and 270 mm for SP2 (IVA Commission on pile research, 1996). In Klimatkalkyl there is only one type of concrete pile without further specification in its name. When looking at the included materials in the model (concrete and rebars) it can be seen that they are based on an SP1 pile of 235 mm. In this study, the weight of the SP2 piles was changed by the scaling factor 270/235 ≈ 1,15. When using this method, it is assumed that the ratio of materials (concrete and steel) in an SP2 pile is the same as in an SP1 pile.

Table 3.4 The amount of concrete piles used in the project (same for both alternatives). Based on data in Tables A.5 and A.8 in the Appendix.

Pile type	**Design 1**	**Design 2**
SP1, 14 m	1820 m	1820 m
SP2	2144 m	2144 m

Sheet piling

There are three types of sheet piling used in both design alternatives: L603, L604 and AZ26. In Klimatkalkyl there is only one type of sheet piling, expressed in m^2. The dimensions and material composition may vary some but the material should be approximately the same (mainly steel). It is assumed that the general type of sheet piling in Klimatkalkyl will represent the total amount of these different types.

Earth, crushed rock, gravel, etc.

The bills of quantities include masses of both earth and crushed rock that needs to be moved and transported in connection to the construction of towers and stations. Furthermore, different types of earth for planting, sand, gravel and natural stones for paving or similar are included. Klimatkalkyl includes masses of earth and crushed rock as two different cases. Both types of masses can be classified as either case A or case B. In case A, the masses are reused within the same project. In case B, masses from excavation are excess and not reused in the same project, and masses for filling need to be taken from outside the project site (Thåström & Pellebergs, 2008). While the bill of quantities presents the masses by weight, the input in Klimatkalkyl must be given in volume. Thus, the mass of each material quantity is divided by the corresponding density of each material in order to obtain the volume.

Erlandsson (2010) gives densities for macadam with the same specific dimensions as in the bill of quantities, 1,3 ton/m^3 for macadam with the size 4-8 mm and 1,4 ton/m^3 for the size 8-16 mm. For the rest of the crushed rock, the dimensions (and type) in Erlandsson (2010) does not match those in the bid item lists. It is thus assumed that all other crushed rock has a density of 1,8 ton/m^3 which is the value that is listed in Klimatkalkyl. Although the exact density would vary depending on the properties and size distribution of the crushed rock. Gravel is only included in Klimatkalkyl as a resource that is either part of building parts or included in construction and maintenance activities. Since it is not included as a standalone material in the model, it is assumed to have a similar climate impact as crushed rock and is thus classified as such in the inventory. The density for (dry) gravel is set to be 1.5 ton/m^3 as recommended by Erlandsson (2010).

Construction Machinery and Vehicles

There are many categories of construction machinery used during the building process. In most cases, the specific vehicles are specified in the bill of quantities. These will contribute to GWP through their use of diesel. The diesel consumption for different machinery and vehicles is calculated based on values and use times for different construction machinery and vehicles from Erlandsson (2013).

Energy consumption per year for the cable car technology

Based on an operation and maintenance calculation for the cable car, the energy requirement for the cable car technology itself without the actual station facilities included, such as lightning, heating etc., would cost 451 000 euro per year. The electricity price used in the calculations was 0,093 euro/kWh. Consequently, the estimated electricity consumption was 4,8 million kWh/year, as can be found by dividing the cost per year by the electricity price. (Jessica Ekberg, personal communication).

All the electricity used by the cable car technology itself would be procured under a contract of the Gothenburg Traffic Office (Trafikkontoret) where a requirement is 100% green electricity (Glans, 2019). The electricity consumption of the stations is not known but by using templates for the type measure *station building* in Klimatkalkyl it is possible to estimate energy consumption per station area. This data is based on a railway station and only gives an estimate rather than project specific data. It is not specifically stated that the energy required for the stations needs to fulfill the requirement of 100 % green electricity.

Installations

Several categories of installations are included and expressed as areas (in m2). These installation categories include heating, sanitation, electricity, ventilation and sprinkler systems. The areas for installations in the bill of quantities are calculated by NCC based on previous projects and should give a good approximation at this stage in the design process although the exact amount of materials within the installation is not known (Jakob Persson, personal communication). Since Klimatkalkyl does not contain general categories of installations as building parts but only specific objects such as pipes, another source had to be used for the impact assessment. Average values for installations were found in KBOB et al. (2016) where the GWP for different categories of installations were given per square meter. This made it possible to use the areas of the different installations from the bills of quantities in the inventory analysis. These are summarized in Table 3.5. The impact assessment can be seen in Table A.13 in the appendix.

Table 3.5 Different types of installations for both design alternatives. Areas for each type of installation are aggregated from the bill of quantities.

Installations	Design alternative 1	Design alternative 2
Sanitation/heat	15 121 m2	2358,5 m2
Sprinkler	14 518 m2	1393 m2
Air	15 632 m2	4071,5 m2
Electricity	15 726 m2	4074,5 m2
Electricity Facade Lightning	10 553 m2	-

Facades, roofs, surfaces and complements to the structural frame

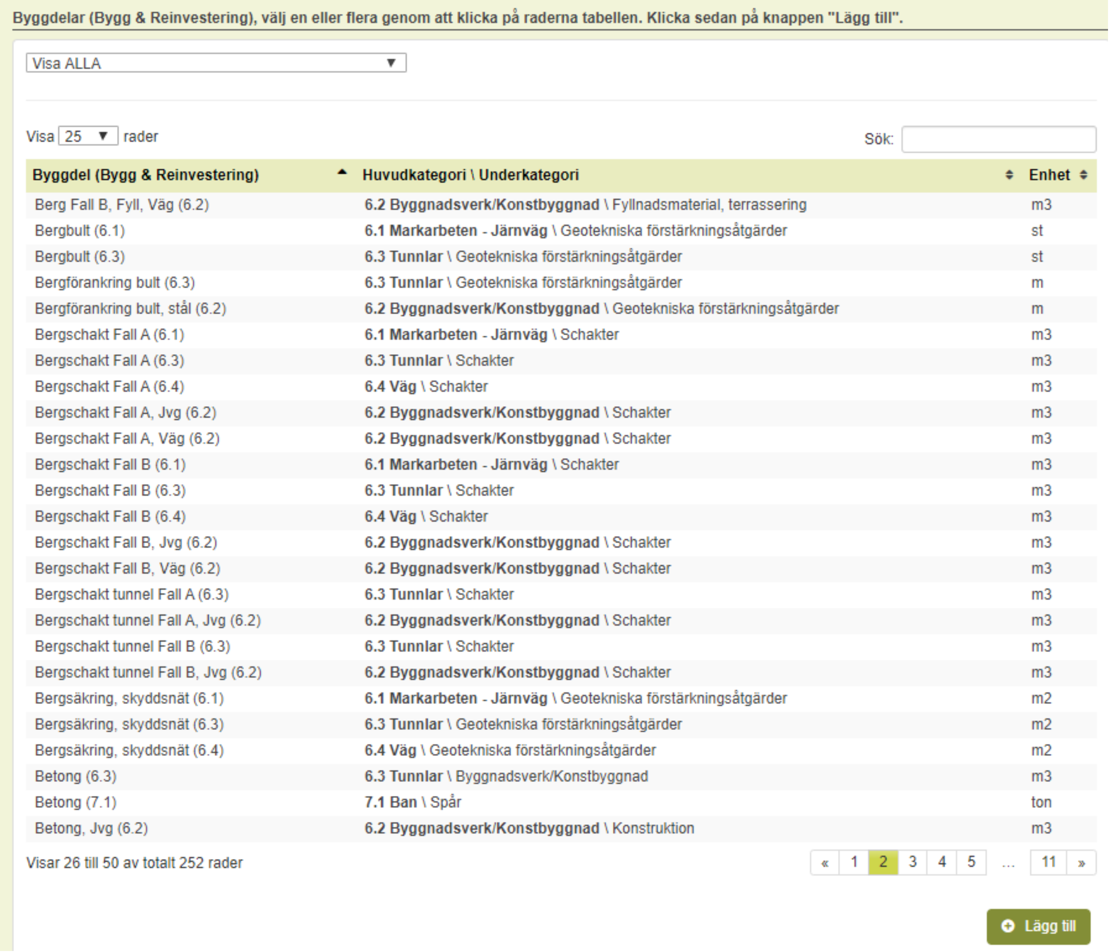
Similar to installations, some areas of the facades, roofs and other surfaces are expressed as areas without the specific material being given. During the cable car project, several materials were discussed but no final decision was made for all areas. However, even if the exact material is not always known, the areas for walls and roofs are known with high accuracy (Jakob Persson, personal communication). This is likely due to the actual building structure being known more precisely. The lack of exact material quantities meant that the areas in the inventory were compiled as a basis for impact assessment outside of Klimatkalkyl similar to installations (see Section 3.4.2).

3.4 Impact Assessment

The main part of the impact assessment was performed in Klimatkalkyl based on the bills of quantities. For installations and surfaces with unspecified material, the impact assessment was performed as a complement outside of the tool.

3.4.1 Modelling in Klimatkalkyl

When setting up Klimatkalkyl it is possible to choose between different versions of the model. In this study, version 6.1 is used as it was the latest available version because version 7.0 had not yet been released. Two different folders were set up, one for each design alternative. In the inventory analysis, the different parameters had previously been summed up and aggregated into input categories in Klimatkalkyl. An example of how the interface looks when searching for building parts can be seen in Figure 3.6. When choosing a category, the amount is inserted so that it matches the specific unit, see Figure 3.7.



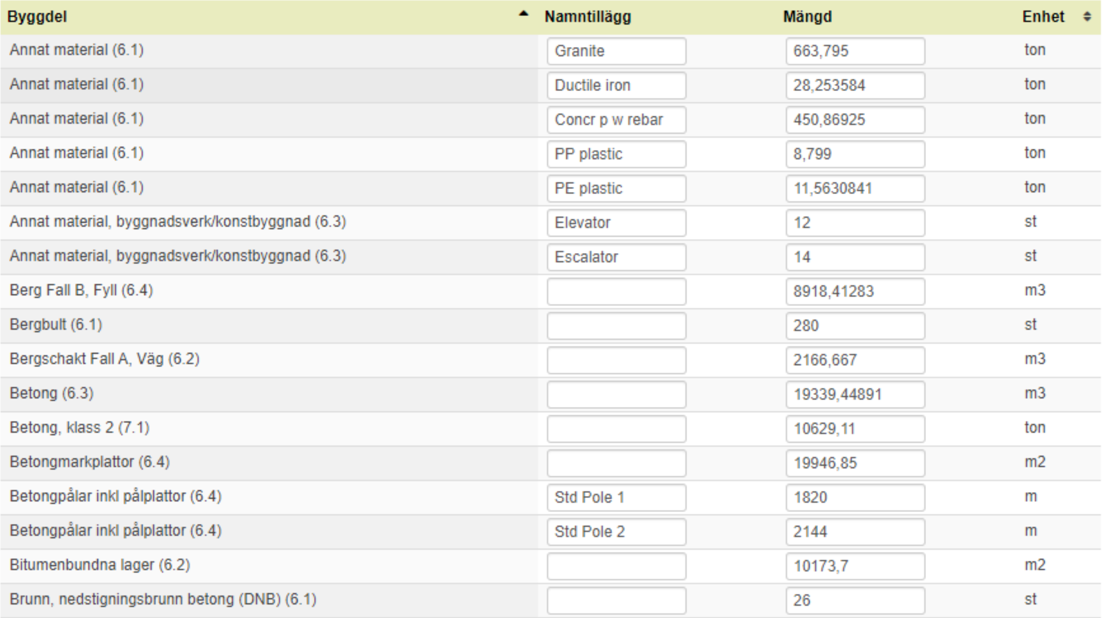
Byggdelar (Bygg & Reinvestering), välj en eller flera genom att klicka på raderna tabellen. Klicka sedan på knappen "Lägg till".

Byggdel (Bygg & Reinvestering)	Huvudkategori \ Underkategori	Enhet
Berg Fall B, Fyll, Väg (6.2)	**6.2 Byggnadsverk/Konstbyggnad** \ Fyllnadsmaterial, terrassering	m3
Bergbult (6.1)	**6.1 Markarbeten - Järnväg** \ Geotekniska förstärkningsåtgärder	st
Bergbult (6.3)	**6.3 Tunnlar** \ Geotekniska förstärkningsåtgärder	st
Bergförankring bult (6.3)	**6.3 Tunnlar** \ Geotekniska förstärkningsåtgärder	m
Bergförankring bult, stål (6.2)	**6.2 Byggnadsverk/Konstbyggnad** \ Geotekniska förstärkningsåtgärder	m
Bergschakt Fall A (6.1)	**6.1 Markarbeten - Järnväg** \ Schakter	m3
Bergschakt Fall A (6.3)	**6.3 Tunnlar** \ Schakter	m3
Bergschakt Fall A (6.4)	**6.4 Väg** \ Schakter	m3
Bergschakt Fall A, Jvg (6.2)	**6.2 Byggnadsverk/Konstbyggnad** \ Schakter	m3
Bergschakt Fall A, Väg (6.2)	**6.2 Byggnadsverk/Konstbyggnad** \ Schakter	m3
Bergschakt Fall B (6.1)	**6.1 Markarbeten - Järnväg** \ Schakter	m3
Bergschakt Fall B (6.3)	**6.3 Tunnlar** \ Schakter	m3
Bergschakt Fall B (6.4)	**6.4 Väg** \ Schakter	m3
Bergschakt Fall B, Jvg (6.2)	**6.2 Byggnadsverk/Konstbyggnad** \ Schakter	m3
Bergschakt Fall B, Väg (6.2)	**6.2 Byggnadsverk/Konstbyggnad** \ Schakter	m3
Bergschakt tunnel Fall A (6.3)	**6.3 Tunnlar** \ Schakter	m3
Bergschakt tunnel Fall A, Jvg (6.2)	**6.2 Byggnadsverk/Konstbyggnad** \ Schakter	m3
Bergschakt tunnel Fall B (6.3)	**6.3 Tunnlar** \ Schakter	m3
Bergschakt tunnel Fall B, Jvg (6.2)	**6.2 Byggnadsverk/Konstbyggnad** \ Schakter	m3
Bergsäkring, skyddsnät (6.1)	**6.1 Markarbeten - Järnväg** \ Geotekniska förstärkningsåtgärder	m2
Bergsäkring, skyddsnät (6.3)	**6.3 Tunnlar** \ Geotekniska förstärkningsåtgärder	m2
Bergsäkring, skyddsnät (6.4)	**6.4 Väg** \ Geotekniska förstärkningsåtgärder	m2
Betong (6.3)	**6.3 Tunnlar** \ Byggnadsverk/Konstbyggnad	m3
Betong (7.1)	**7.1 Ban** \ Spår	ton
Betong, Jvg (6.2)	**6.2 Byggnadsverk/Konstbyggnad** \ Konstruktion	m3

Visar 26 till 50 av totalt 252 rader

Figure 3.6. Example of the interface of Klimatkalkyl. Here showing an example of different building parts and their corresponding units. Source: Klimatkalkyl (retrieved May, 2020).

Materials not included in the tool can be added. When adding materials manually, the category “other material” is chosen. In Figure 3.7, the name of the added category has been added, e.g. granite or ductile iron. It is then possible to change material quantities and emission factors as seen in Figure 3.8. This can also be done for already existing building parts to adapt parameters to project specific data. For example, the amount of steel per meter of pile was changed. It is also possible to change emission factors for one material in the entire project and not only per individual building part or resource.



Byggdel	Namntillägg	Mängd	Enhet
Annat material (6.1)	Granite	663,795	ton
Annat material (6.1)	Ductile iron	28,253584	ton
Annat material (6.1)	Concr p w rebar	450,86925	ton
Annat material (6.1)	PP plastic	8,799	ton
Annat material (6.1)	PE plastic	11,5630841	ton
Annat material, byggnadsverk/konstbyggnad (6.3)	Elevator	12	st
Annat material, byggnadsverk/konstbyggnad (6.3)	Escalator	14	st
Berg Fall B, Fyll (6.4)		8918,41283	m3
Bergbult (6.1)		280	st
Bergschakt Fall A, Väg (6.2)		2166,667	m3
Betong (6.3)		19339,44891	m3
Betong, klass 2 (7.1)		10629,11	ton
Betongmarkplattor (6.4)		19946,85	m2
Betongpålar inkl pålplattor (6.4)	Std Pole 1	1820	m
Betongpålar inkl pålplattor (6.4)	Std Pole 2	2144	m
Bitumenbundna lager (6.2)		10173,7	m2
Brunn, nedstigningsbrunn betong (DNB) (6.1)		26	st

Figure 3.7. Example of the interface of Klimatkalkyl. Here different building parts can be seen.. The field “Namntillägg” is simply for writing comments in addition to the name. Note the preset units for the different input categories. Source: Klimatkalkyl (retrieved May, 2020).

Byggdelar

Annat material (6.1) *Granite* 664 ton 465

Kommentar byggdel

Resurser

Resurs	Standard	Egen mängd	Enhet	Transporter
Annat material	1,00		ton/ton	0

Emissionsfaktor resurs		Klimat (kg CO2e/ton)	Energi (MJ/ton)
Annat material	Standard	0	0
	Eget värde	700	

Kommentar resurs emissionsfaktor

Trafikverket (2017)

Figure 3.8. Example of the interface of Klimatkalkyl. Here showing an example on how the amount of material and the emission factor can be changed for a building part. Source: Klimatkalkyl (retrieved May, 2020).

The emission factors used in the impact assessment can be divided into those already part of Klimatkalkyl in Table 3.6 and those that are manually added in Table 3.7. The emission factors are used in several of the building parts in the results as several building parts may contains the same material. In Table 3.7, some objects, such as granite and geotextile, exist only as resources within other building parts. It is not possible to use only such standalone resources as input. In such cases, the emission factor for the resource in Klimatkalkyl has been used but added separately as “other material”. Concrete pipes are most easily calculated based on weight in the bill of quantities. In Klimatkalkyl, the pipes are given in meters. To be able to use the weight as a basis for calculation, a weight-based impact factor has been calculated based on the share between concrete and steel rebars in pipes in Klimatkalkyl which is also supported by data from St:Eriks (2012).

Table 3.6 Emission factors from Klimatkalkyl. The “Geographical scope” column refers to the geographical area for which the emission factor is valid and is based on Trafikverket (2017).

Name	GWP [kg CO_2 eq./”unit”]	“unit”	Geographical scope
Asphalt 6,5 % bitumen	0,044	kg	Sweden
Concrete	0,16	kg	Sweden
Cement (CEM II)	0,7	kg	Sweden
Diesel (MK 1)	2,88	litre	Sweden
Electricity	0,0973	kWh	Nordic
Geotextile, PP textile	1,98	kg	Europe
Gravel	0,00376	kg	Nordic
Truck	0,106	tkm	Sweden
Explosive (Tovex)	2,5	kg	Switzerland (production)
Steel, rebars	1,03	kg	Global
Steel, general value	1,5	kg	EU average
Wood	59,2	m^3	Sweden and Finland
Polyethylene, HDPE	2	kg	Europe

Table 3.7 Emission factors manually added to Klimatkalkyl for objects that were manually added to the tool. The values for emission factors from Trafikverket (2017) are already included in Klimatkalkyl as resources but are manually added since resources cannot be added without being part of a building part or type measure.

Object	GWP [kg CO2eq./ ”unit”]	“unit”	Source
Ductile iron	3,41	kg	Venkatesh et al. (2009)
Elevator	6254,9	elevator	Salmelin et al. (2002)
Escalator	44,4	escalator	KONE (2010)
Granite	0,70	kg	Trafikverket (2017)
Concrete pipe incl. steel rebar	0,17	kg	98,5 % concrete + 1,5 % steel for rebars (Klimatkalkyl and St:Eriks, 2012)
Polyethylene (PE) of different densities	2,0	kg	Trafikverket (2017)
Polypropylene (PP)	2,0	kg	Trafikverket (2017)

3.4.2 Complementary Impact Assessment Outside of Klimatkalkyl

As stated above, several categories in the bill of quantities are expressed as areas [m2]. Some of these categories are installations, such as heating, sanitation, electricity, ventilation and sprinkler systems. Other “areas” are roofs, facades, inner walls and complements to the main frame. Since the exact material composition is not known in these cases and Klimatkalkyl does not include templates for areas of installations or facades, complementary data was found.

Installations

For the material in installations, data from KBOB et al. (2016) was used for ventilation, electricity, heat and sanitation. Since installations for heat and sanitation are given as one category in the bill of quantities, an average value for these were used. Façade lightning was excluded from the scope since it was expressed in different ways between the alternative bill of quantities. In design 1, it was expressed as an area similar to other installations, but in design 2 it was expressed as the cost of having façade lightning for each station but without specified areas. Sprinkler installations were excluded due to lack of emission data in the source used. Calculations for installations are shown in Table A.13 in the appendix and the aggregated results are shown in Table 4.2.

Facades, roofs, surfaces and complements to the structural frame

Exact materials were not given for these parts of the stations. The materials are estimated based on categories in Kanafani et al. (2019) where emissions are given per square meter for different parts of a building based on the material used. The materials are chosen based on plausible options that could have been used in the cable car in order to give an estimation of the GWP of the surfaces. It is possible that more detailed assessments could have been done of the cable car program documents in order to find clearer differences between the materials likely to be used in each design. This could have better captured the difference between the two design alternatives. There is also a risk that this method will only capture the GWP from surfaces and not all parts of the building structure under them. This could mean that parts of the climate impact will be missed. For example, for the big roofs in design 1 the surfaces are bigger than in alternative 2 meaning that this difference in climate impact will be assessed. However, the larger roof construction under the surface might not be fully captured in the climate assessment in this way. Despite not being fully accurate, this method is intended to at least capture an estimate of the climate impact of the included surfaces. In the source, 100 years is specified as the lifetime for the buildings assessed in the study (Kanafani et al., 2019). The assessed "areas" was divided into four categories based on the bill of quantities. The calculations for the impact assessment are shown in Tables A.9-A.12 in the appendix. Aggregated results from the impact assessment are shown in Table 4.1.

4 Results

The main impact assessment has been conducted using Klimatkalkyl but other sources for impact assessment were needed for installations and parts of the station as described above. Due to the difference in method, the results assessed in Klimatkalkyl, based on the bill of quantities of stations, towers and foundations, are presented separately from areas and installations assessed outside the tool. This is intended to make a separation of the results possible because of different kinds of uncertainties and specificity of data. The assessed GWP resulting from areas is presented in Table 4.1. The GWP from the different categories of installations is presented in Table 4.2. The results from Klimatkalkyl are shown in Table 4.3 for the first design, and in Table 4.4 for the second design. In Table 4.5 the results are combined and the total climate impact of the assessed parameters is presented. After the total climate impact has been presented, important parameters are identified. The results are then given on an annual basis and compared with the yearly climate impact from the electricity required for operations.

Table 4.1 Summary of the climate impact of the different areas: facades, waterproofing/roofs, surface layers and complements to frame.

	GWP [tonnes CO2eq.]	
	Design 1	Design 2
Facades	858	855
Waterproofing/roofs	530	265
Surface layers	198	67
Complements to frame	327	68
Total	**1914**	**1254**

Table 4.2 Summary of the climate impact for different types of installations.

Installations	GWP [tonnes CO2eq.]	
	Design 1	Design 2
Sanitation/heating	29	5
Sprinkler	-	-
Air	192	50
Electricity	352	50
Total	**574**	**105**

*Table 4.3 Aggregated inventory list for design 1. * Manually added building part. "x" refers to "number of" an object.*

Alt. 1	Amount	Unit	Construction, total [tCO2eq.]	Construction and reinvestment [tCO2eq.]
Total			**34 608**	**329**
Granite *	664	ton	465	4
Ductile iron *	28	ton	96	1
Concrete pipes with rebars *	451	ton	77	1
PP plastic *	9	ton	18	0
PE plastic *	12	ton	23	0
Elevator *	12	x	75	1
Escalator *	14	x	1	0
Rock case B, Fill	58 709	m3	485	6
Rock bolt	280	x	3	0
Rock excavation case A	2 167	m3	10	0
Concrete	19 339	m3	7 426	62
Concrete, class 2	10 629	ton	1 364	23
Concrete ground plates	19 947	m2	447	11
Concrete piles SP1	1 820	m	52	1
Concrete piles SP2	2 144	m	75	1
Bitumen-bound layers (asphalt 180 mm)	10 174	m2	181	5
Well	26	x	8	0
Well (estimated)	28	x	8	0
Diesel, diggers	392	m3	1 128	14
Diesel, other machinery	246	m3	710	9
Electricity during construction	534 000	kWh	52	0
Earth case B, Fill	90 435	m3	202	3
Layer of geotextile	89 751	m2	47	0
Plastic pipe. dim. 200	1 155	m	8	0
Steel, rebars	2 532	ton	2 608	22
Steel, construction, tower A	1 103	ton	1 655	14
Steel, construction, tower B	1 872	ton	2 808	23
Steel, construction, tower C	1 379	ton	2 069	17
Steel, construction, tower D	616	ton	924	8
Steel, construction, tower E	1 036	ton	1 554	13
Steel, construction, tower F	1 365	ton	2 048	17
Steel piles (96 kg/m)	10 973	m	1 596	20
Steel piles (48 kg/m)	3 840	m	282	4
Wood	37	m3	2	0
Sheet piling	33 356	m2	6 104	51

*Table 4.4 Aggregated inventory list for design 2. * Manually added building part. "x" refers to "number of" an object.*

Alt. 2	Amount	Unit	Construction, total [tCO2eq.]	Construction and reinvestment [tCO2eq.]
Total			**29 345**	**284**
Granite *	79	ton	55	0
Ductile iron *	27	ton	90	1
Concrete pipes with rebars *	320	ton	54	0
PP plastic *	9	ton	18	0
PE plastic *	0	ton	0	0
Elevator *	5	x	31	0
Escalator *	8	x	0	0
Rock case B, Fill	53 999	m3	446	6
Rock bolt	140	x	2	0
Rock excavation case A	2 167	m3	10	0
Concrete	25 298	m3	9 714	81
Concrete, class 2	2 154	ton	276	5
Concrete ground plates	11 584	m2	260	6
Concrete piles SP1	1 820	m	52	1
Concrete piles SP2	2 463	m	86	1
Bitumen-bound layers (asphalt 180 mm)	9 502	m2	169	4
Well	26	x	8	0
Well (estimated)	28	x	8	0
Diesel, diggers	276	m3	794	10
Diesel, other machinery	131	m3	376	5
Earth case B, Fill	66 374	m3	148	2
Layer of geotextile	80 248	m2	42	0
Plastic pipe. dim. 200	1 331	m	10	0
Steel, rebars	2 833	ton	2 918	24
Steel, construction, tower A	428	ton	642	5
Steel, construction, tower B	1 024	ton	1 537	13
Steel, construction, tower C	681	ton	1 021	9
Steel, construction, tower D	194	ton	291	2
Steel, construction, tower E	388	ton	582	5
Steel, construction, tower F	699	ton	1 048	9
Steel piles	31 368	m	4 562	57
Steel piles	6 488	m	173	2
Steel piles	13 296	m	438	5
Steel piles	810	m	33	0
Steel piles	559	m	28	0
Steel piles	288	m	12	0
Wood	145	m3	9	0
Sheet piling	18 600	m2	3 404	28

4.1 Total Climate Impact of Materials and Construction

The total climate impact of materials and construction is the impact occurring during the life cycle stage A1-A5 (although as previously described, A4 is often not included in the data used). Electricity consumption is not included here but shown below when the climate impact per year is shown. As can be seen in Table 4.5, the majority of the GWP comes from the assessment in Klimatkalkyl, while the areas of roofs, walls etc. have a smaller contribution to GWP. The contribution from installations are quite small and it should be emphasised that this results from the material in the installations, not from the operation of them.

Table 4.5 Summary of the climate impact for Klimatkalkyl and the areas and installations that were assessed separately.

	GWP [tonnes CO_2 eq.] for each alternative	
	Design 1	Design 2
Klimatkalkyl	34 608	29 345
"Areas" (roofs, walls etc.)	1914	1254
Installations (material)	574	105
Total	**37 096**	**30 704**

The total climate impact can be divided into different categories by aggregating categories of objects in Tables 4.3 and 4.4 to show which materials or objects that contribute the most to the GWP as is shown in Figure 4.1. The category *Other* includes the various objects that do not fit into any of the other categories and consists of materials with a small contribution to the total climate impact. Roofs, walls, and other surfaces are not included in Figure 4.1 but the difference between the alternatives and the relative importance of these can be seen in Table 4.5.

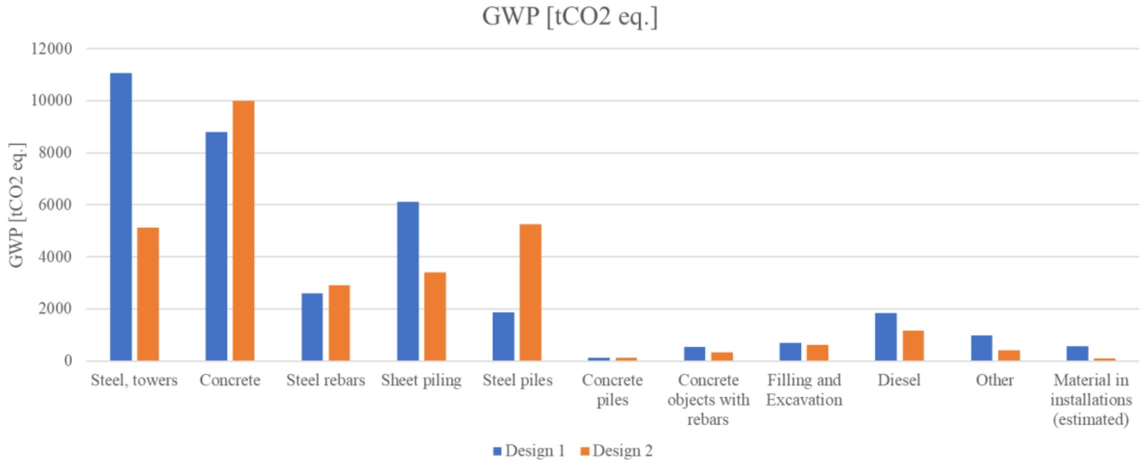


Figure 4.1 A comparison of the GWP resulting from different categories in the two different design alternatives.

4.1.1 Influential Parameters in Design 2

Part of the aim was to investigate the parameters contributing most to the climate impact in design 2. When dividing the GWP into categories, the parameters contributing the most to GWP can be identified. This division made for design 2 can be seen in Figure 4.2.

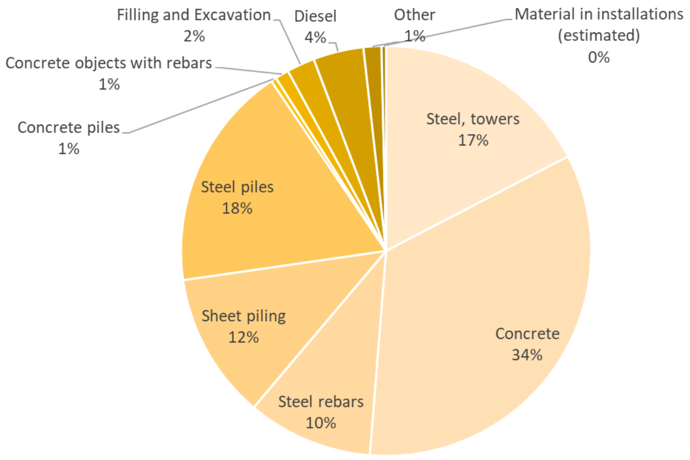


Figure 4.2 Chart showing the relative contribution to GWP in design alternative 2 (areas of roofs, walls etc. are not included).

4.1.2 Division into Towers and Stations

The climate impact can also be divided between towers and stations. A fully accurate division between these is not possible because the parameters in the main bill of quantities are not always divided into towers and station. For example, for construction machinery and diesel emissions no such distinctions are made. The same is true for rock and earth masses but also for several other parameters. However, by looking at the bill of quantities an approximate division can be made.

For design 2, it can be seen that all of the weak steel piles are used for the stations. Of the total length of the 323/12,5 steel piles, approximately 64,5 % are used for the stations and 35,5 % for the towers, this ratio is thus the same for the GWP. Concrete piles are used for anchoring cables and cranes that are used for building the towers. The GWP from the towers will thus be the sum of the GWP for the steel in the six towers, plus all the concrete piles and 35,5 % of the GWP from the 323/12,5 piles. In Figure 4.3, the rest of the total GWP that is not resulting from the towers or sheet piling is classified as resulting from the stations. Even though some of that GWP may come from diesel, masses etc. connected to the towers, the majority are connected to the stations. Some of the sheet piling can also be divided into either towers or stations but in Figure 4.3 the total amount of sheet piling is shown separately. As previously stated, the sheet piling could potentially be removed and reused and not necessarily be left in the ground.

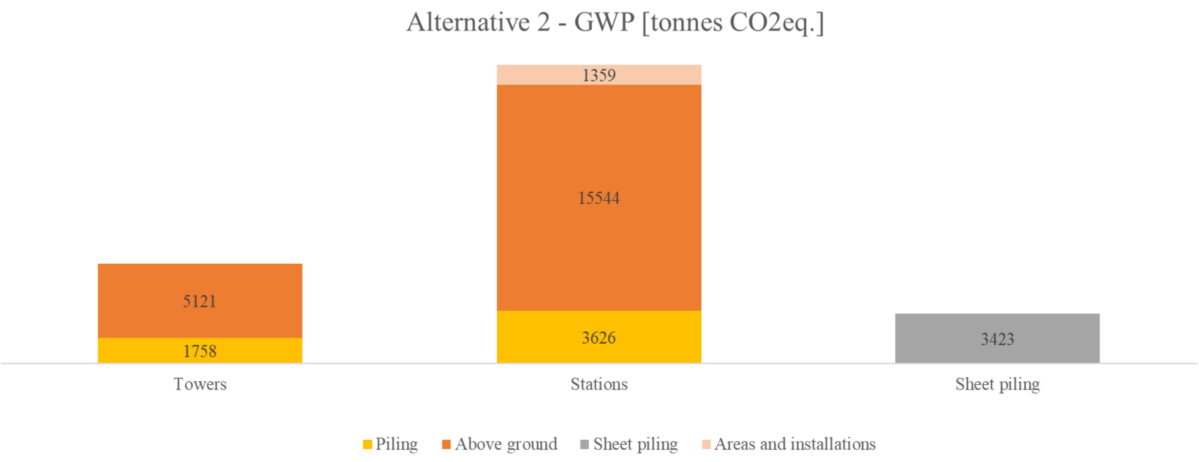


Figure 4.3 Showing the distribution of GWP between towers, stations and sheet piling in design alternative 2. For towers and station, the GWP is divided into piling and "above ground" (which include everything except the piling).

The same procedure is done for design alternative 1 and shown in Figure 4.4. It can be seen that the GWP resulting from the parts of the stations above ground is similar. As previously shown, the UNS towers and the larger amount of sheet piling in design 1 cause more GWP than the simple steel towers and sheet piling in design 2.

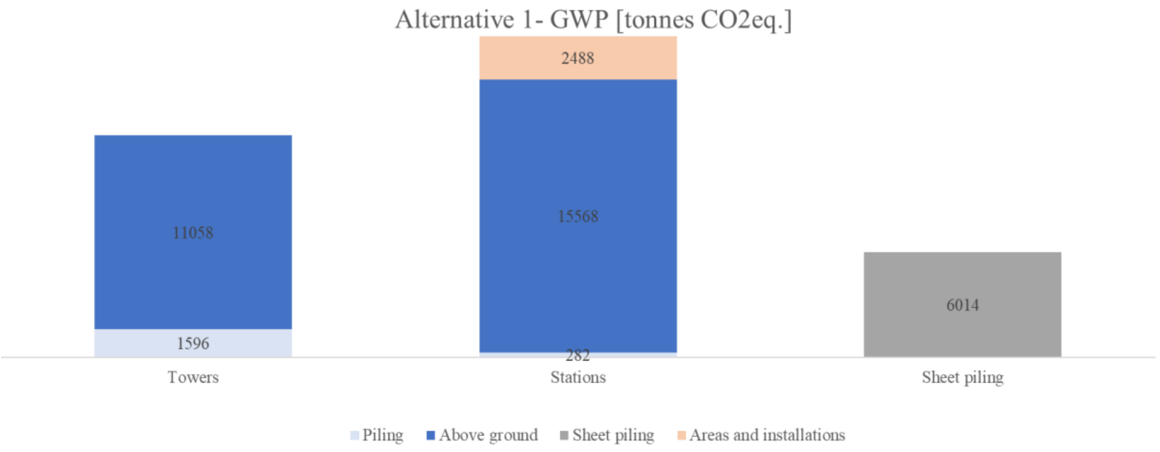


Figure 4.4 Showing the distribution of GWP between towers, station and sheet piling in design alternative 1. For towers and station, the GWP is divided into piling and "above ground" (which include everything except the piling).

4.2 Climate Impact per Year

Klimatkalkyl also presents the results as "construction and reinvestment" per year. As described in Section 2.2, the total environmental impact from construction is partitioned to a yearly basis based on the lifetime of each object included in the study. It is assumed that each object is replaced by a new one of the same type after its lifetime has ended (i.e. reinvestment). Since Klimatkalkyl bases this partitioning on the lifetime of the individual building parts, the lifetime of the cable car does not need to be known. The model assumes that it operates continuously and building parts are replaced when their lifetime has ended. It should thus be noted that the GWP for construction and reinvestment should not be added to the total climate impact as this would be double-counting. These are two different ways of presenting the same results. Materials with a longer lifetime will have a smaller relative share of climate impact per year. This is because the climate impact caused by the life cycle stages A1-A5 is partitioned over more years, making the impact per year smaller. Figures 4.5 and 4.6 are generated by Klimatkalkyl and show the distribution between different emission factors for the yearly climate impact of design alternatives 1 and 2 respectively.

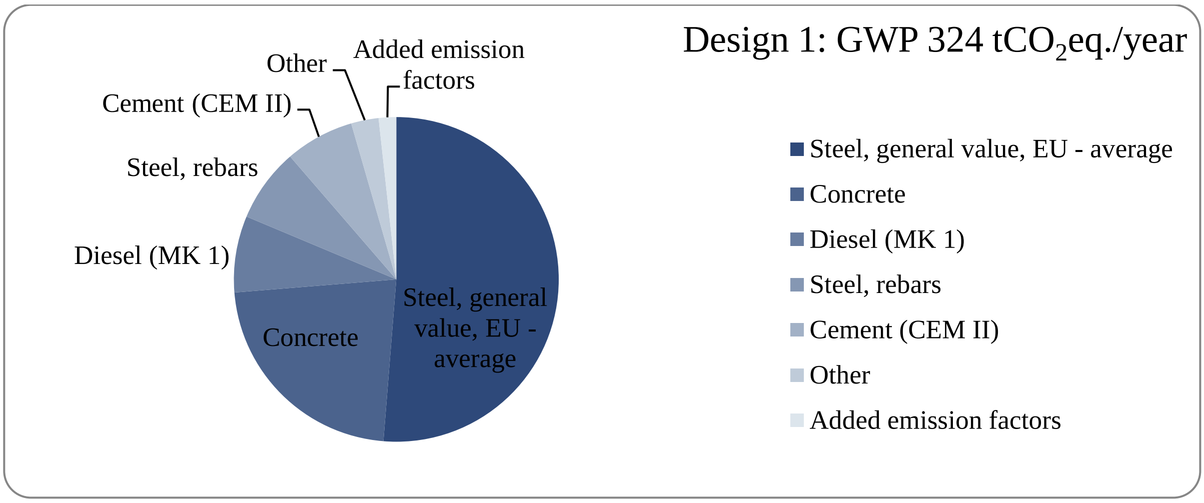


Figure 4.5 Design 1, GWP per year. "Added emission factors" refer to the manually added emission factors from materials not included in Klimatkalkyl by default.

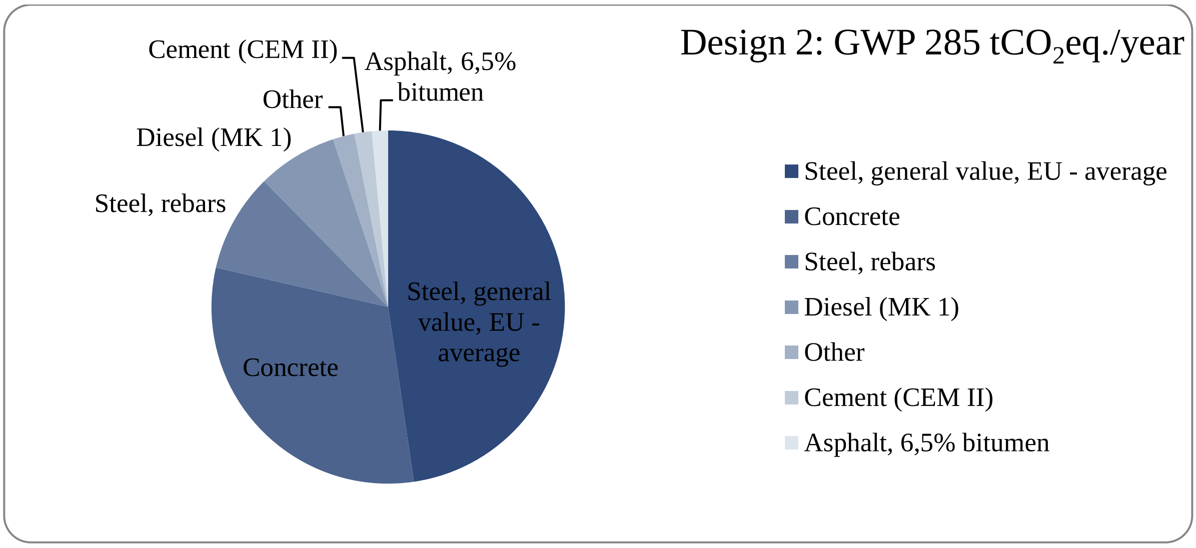


Figure 4.6 Design 2, GWP per year.

Table 4.6 shows the yearly climate impact based on both the construction and reinvestment, and electricity consumption of the cable car technology and the stations. The materials for installations were assessed outside of Klimatkalkyl and no lifetime was specified. Given the small share of GWP resulting from the material in installations, this yearly contribution to GWP should be negligible. It should be repeated that the GWP of installations only originates from the materials and production and not the use phase. For the roofs, facades, surfaces and complements to the frame, a lifetime of 100 years is assumed since this was the assumed lifetime for the assessed building in the source (Kanafani et al., 2019).

The electricity consumption of the cable car technology is known on a yearly basis as stated above in the inventory analysis. The electricity used for the cable car technology should be 100 % green. Being based on renewable energy, it would thus cause a negligible climate impact in comparison to the Nordic electricity mix as shown in Table 4.6. The emissions from the corresponding energy use with the Nordic electricity mix is included to show the environmental gain per year from using renewable energy. The production of renewable electricity causes little or no GWP during operation but production of the infrastructure for electricity production could cause emissions. This not taken into account here.

The electricity consumption of the stations is based on templates from Klimatkalkyl for a station building and is an estimation based on the station area in Table 2.3. In the second design, it is likely that the electricity consumption from heating is very low in comparison to the electricity required to operate the cable car due to the small stations (Jessica Ekberg, personal communication).

Table 4.6 Summary of the climate impact on a yearly basis. The impact from raw materials, production and construction in life cycle stage A has been distributed on a yearly basis based on lifetimes of objects in Klimatkalkyl. The GWP from installations is assumed to be negligible.

Life cycle stage	**Parameter**	**Design 1** [tCO$_2$eq./year]	**Design 2** [tCO$_2$eq./year]
A	Construction and Reinvestment, Klimatkalkyl	329	284
	Construction and Reinvestment, Façades, roofs etc.	19	13
	Materials in Installations	-	-
B	Electricity, cable car, **IF** Nordic electricity mix had been used (**theoretical comparison**)	467	467
	Electricity, cable car, 100% green electricity (**real case**)	~0	~0
	Electricity, stations (Nordic electricity mix, approximated based on railway station areas in Klimatkalkyl)	104	34

4.3 Sensitivity Analysis

Concrete was found to be one of the materials with the highest climate impact. When changing the emission factor of concrete, it can be seen how sensitive the overall results are to the GWP of concrete. This is especially interesting considering the average values that are used in Klimatkalkyl. If the emission factor changes without big changes in the overall results, it may indicate that the system is not so sensitive towards changes in emission factors for concrete and average values may thus be used. If the order of the results changes, it is a sign that accurate data for concrete is important.

According to the organisation *Svensk Betong* (*Swedish Concrete*), concrete of the types XF4, XS3, XD3 (concrete used outdoors with exposure to salt and frost) have a climate improvement potential in the range of 10-21 % per m^3 of concrete (Lindgren et al., 2020). The majority (although not all) of the concrete used in both designs are of this type. This improvement potential will be used as the basis for a sensitivity analysis. However, these values should be interpreted with some caution since it is not always known if more environmentally beneficial concrete than what is required is already used in some cases (Lindgren et al., 2020). If concrete with lower GWP is already used, the improvement potential will be smaller.

In the sensitivity analysis, the emission factor is changed in Klimatkalkyl. The installations, facades, roofs and other areas not assessed in Klimatkalkyl are not affected by the change. The results of the change in emission factor on the total GWP can be seen in Table 4.7. The emission factor was changed for all "ordinary" *concrete* in Klimatkalkyl but not for *concrete, class 2*.

The emission factor was decreased by 10 % and 21 % respectively. For design 1, the GWP 34 608 tCO_2 in Klimatkalkyl decreased to 33 817 and 32 926 tCO_2 respectively. For design 2, the GWP decreased from 29 345 tCO_2 to 28 339 and 27 208 tCO_2 respectively. When adding the GWP from objects assessed outside Klimatkalkyl the results are as shown in Table 4.7.

Table 4.7 Sensitivity analysis where potential environmental improvements of concrete are compared with the standard value in Klimatkalkyl.

Climate Impact	Emission factor concrete, GWP [$kgCO_2eq.$/kg]	Design 1 Tot. GWP [$tonCO_2eq.$]	Design 2 Tot. GWP [$tonCO_2eq.$]
Klimatkalkyl	0,16	37 096	30 704
Reduced by 10 %	0,144	36 305	29 698
Reduced by 21 %	0,126	35 414	28 567

It can thus be seen that even if the climate impact of concrete was decreased by 21 % for the first design alternative, its total GWP would still be higher than alternative 2 even if the emission factor for concrete in alternative 2 remained unchanged.

5 Analysis of Results

In this section, the results presented in the previous section are analysed. First, a comparison between the alternatives is discussed. This is followed by a summary of important parameters, a comparison of the GWP of the cable car to other buildings, and a presentation of an alternative functional unit.

5.1 Comparison between the Design Alternatives

When comparing the total climate impact of both design alternatives, it can be seen that the second design has a smaller impact in total but that there are some differences within the overall results.

5.1.1 Towers

The biggest difference between the two designs when looking at the separate categories in Figure 4.1 is the climate impact from the steel in the towers. It is clear that the simple steel towers are the best choice from a climate perspective and the choice of tower design is thus an important parameter in determining overall climate impact of the cable car. The GWP of the individual towers are dependent on the amount of steel in each tower and in turn on the height of the tower. As can be seen in Table 5.1, the GWP differs between the towers in the same design (because of different heights). Certain heights are needed to keep the necessary distance to the ground below but it can be seen the simple steel towers would give to significantly lower emissions. As can be calculated from the total GWP from the towers, a change from the original UNS towers to the simple steel towers would save approximately 46 % of the GWP resulting from the steel in the towers. The steel piles in the foundation will also contribute to the GWP of the towers as seen in Figure 4.3 but not as much as the steel in the actual tower constructions.

Table 5.1 Showing the GWP per tower and the total GWP for the six towers in each design alternative.

Towers	Alternative 1 (UNS)		Alternative 2 (simple steel)	
	GWP [tCO_2 eq.]	%	GWP [tCO_2 eq.]	%
Total	**11 058**	**100**	**5121**	**100**
A	1655	15,0	642	12,5
B	2808	25,4	1537	30,0
C	2069	18,7	1021	19,9
D	924	8,4	291	5,7
E	1554	14,1	582	11,4
F	2048	18,5	1048	20,5

5.1.2 Foundations

The foundations have a big impact. The amount of sheet piling is larger in alternative 1 because the larger stations means that more sheet piling is needed during construction (Jessica Ekberg, personal communication). It should be remembered that parts of the sheet piling can be removed and reused. Some more emissions are likely to occur from the machinery used to remove the sheet piling and possibly also from cleaning and maintenance of sheet piling before reuse. But given the large share of climate impact from the material in the sheet piling, even compared to all the diesel used during the entire construction process, there will still be a large net saving of emissions by removing and reusing the sheet piling.

Concrete piles were used for cranes and cables, and since the same number of cranes were used for both alternatives, the amount of concrete piles is also the same. However, this amount is far less than the amount of steel piles used for the stations and towers which is partly why the concrete piles have such a small climate impact in the project.

There is a higher amount of steel pipes, and resulting GWP, in alternative 2 despite the smaller stations. This is however, because more information was known about the geotechnical conditions at the time of the second design (Jakob Persson, personal communication). Because of this, the increased amount of piles has more to do with increased information about the amounts of piles required than with an active design choice. In reality, the larger stations in design 1 could possibly have needed the same amount of piles, or more, if the geotechnical conditions had been known to the same extent. This is a result of the lack of exact project specific data earlier in the design process. The location of stations and towers will have an influence, for example no piles at all are used for the station at Västra Ramberget because it is placed directly at the rock and thus needs no steel piles to anchor it.

5.1.3 Stations

Based solely on the bills of quantities it was not possible to allocate the use of concrete to different parts of the cable car. Most of the concrete is however used in connection to the stations and the use of concrete is slightly higher in alternative 2 despite the smaller stations. The steel rebars is used together with the concrete and thus correlates with the amount of concrete and is also slightly larger in alternative 2.

The difference in size of the stations can be seen in many other parameters. The sheet piling was mentioned before, but in general less of other materials are used as well when stations are smaller. For the category named “other”, design alternative 1 contributes more to GWP. This is in some cases due to the larger size of the stations. Diesel used during construction was higher in alternative 1 because more construction machinery was used during construction. This is likely because of the larger stations.

Green electricity was found to be beneficial even compared to the relatively clean Nordic electricity mix. This shows the high influence of the electricity mix on the climate impact in the use phase of the cable car. The difference between electricity based on renewables and an ordinary electricity mix would potentially be larger for cable car projects in other geographical areas than Sweden if the electricity mix was more carbon-intensive than the Nordic electricity mix.

5.2 Important Parameters for Climate Impact

Based on the comparison between the alternatives and the relative contribution to GWP from different parts of the stations, towers and foundations, several important parameters can be seen, some of which are shown in Table 5.2.

Table 5.2 Summary of important parameters that have a large influence on the climate impact.

Examples of important parameters
Amount of concrete
Type of concrete
Tower design and amount of steel
Size of stations
Sheet piling removal/reuse
Piling/Geotechnical conditions
Electricity consumption, electricity mix and green electricity
Diesel for construction machinery

5.3 Comparison with Station in Klimatkalkyl

A cable car is a unique building but it might still be interesting to compare the GWP per area to that of other buildings. One comparison that can be made is with the type meaasure *station building* in Klimatkalkyl. This station is applicable for railway stations in Sweden and the estimated energy consumption for station buildings in Table 4.6 is based on the same station. The emission factor in Klimatkalkyl is approximately 240 kg CO_2eq./m^2. It is described as a "station building above ground of the type travelling centre or similar" and the data is based on a multi-storey building consisting of concrete, steel, wood and glass.

In order to make an area-based comparison, the GWP of the cable car first needs to be recalculated to a per-area basis. For a fairer comparison with the station building in Klimatkalkyl, the towers are excluded. Sheet piling is also excluded since it is not known if this was included in the Klimatkalkyl station. Figure 4.3 gives the total GWP from stations in design 2 (excluding sheet piling and towers) to be 20 529 tonnes CO_2eq. The area of the stations in design 2 is 5600 m^2. This gives a corresponding value for design alternative 2 at 20 529 tCO_2eq./5600 m^2 = 3,7 tCO_2/m^2 which is significantly higher than the station in Klimatkalkyl.

For a full comparison of how the cable car relates to other buildings, more data and more types of building should be assessed. It is also worth considering that the cable car stations might need another design to carry the cable car compared to a railway station. However, this way of showing emissions per area might tell something about how efficiently spaces have been used when it comes to climate emissions.

But when doing the same calculation for design 1 the value per m^2 would be much lower since the climate impact would be divided by the larger station area of 17 000 m^2. However, this would be the case even if the total GWP would be higher in alternative 1 because of the larger area. Since the large area is not needed for the main function of transportation, it could be argued that the measurement of eco-efficiency per area might be misleading in that it hides a large total impact that might be unnecessary for the main function of the station.

5.4 An Alternative Functional Unit

As discussed in the goal and scope definition, another possible functional unit than the main one used in the study is person-km. This can serve as a basis for comparison with other studies for example. Numbers needed for recalculation of the climate impact into person-km are given in Table 5.3. The length of the cable car will be roughly 3 km (Trafikkontoret Göteborgs Stad, 2019). Data on passenger capacity was presented in Sections 2.3.5 and 2.3.6. The climate impact per year is the total climate impact shown in Table 4.6 (assuming Nordic electricity mix for station and renewables for the cable car technology).

Table 5.3 Basis for calculations of an alternative functional unit.

Alternative	Capacity [p/h,dir]	Climate Impact [$tCO_2eq.$/year]	h/year	Length/dir	GWP [gCO2eq./p,km]
Design 1	2000	452	8760	3 km	8,6
Design 2	1000	331			12,6
	1500				8,4
	2000				6,3

Dividing the climate impact per year with the number of hours per year gives the total climate impact (expressed in GWP) per hour. Dividing this with the capacity of people transported per hour and the length per direction of the cable car will give the GWP per person-km. This calculation is shown in Equation (5.1).

$$\frac{GWP}{p,km} = \frac{Climate\ impact}{8760\ h/yr} * \frac{1}{Capacity} * \frac{1}{L} \tag{5.1}$$

By using Equation (5.1) and inserting the data for design 1 as an example, the GWP per person-km for design 1 would be calculated according to Equation (5.2).

$$\frac{GWP}{p,km} = \frac{452\ tCO2eq./yr}{8760\ h/yr} * \frac{1}{2000\frac{p}{h},} * \frac{1}{3\ km} = 8{,}6\,\frac{gCO2eq}{p,km} \tag{5.2}$$

However, it should be noted that the different values for the passenger capacity is based on the maximum capacity of the cable car. If only say 1500 people travels in design 1, the actual climate impact per passenger-km would still be higher in comparison to alternative 2. Furthermore, a modification of the equation could be to take opening hours into account. As shown in Table 2.3, the opening hours of the two designs would vary. This could influence the total passenger capacity over an entire day. However, since the travelling prognosis may vary during the day, it is uncertain exactly what impact this would have. For example, if less people travelled at night. The impact of the cable car being closed during that time might be less than if it was closed during a period with a higher travelling demand. This potential difference is not considered here.

6 Discussion

In this section, the findings of the study are discussed. Discussions include implications of the results, a discussion on Klimatkalkyl, uncertainties and limitations and future research.

6.1 Implications of Results

The results show that the second design alternative has a smaller climate impact than the first and that it is thus both more cost-effective and climate-effective at the same time, showing that synergies between economic and environmental benefits can be achieved. It was shown that the large amounts of steel and concrete had the most influence of the different parameters contributing to GWP. Focus on these materials, for example through dematerialisation, could be an important way to reduce climate impact. At the same time, these materials are important in the structure of the buildings and towers. It is clear that there is room for improvement in several areas and that an increase life cycle perspective already in the design phase might help to highlight and address this.

For the towers, this is especially visible since two different designs can be directly compared to each other. It has been argued in the cable car project that UNS towers were more aesthetically appealing and thus were preferable over the simple steel towers. But the simple steel towers had advantages when it came to a cheaper cost and a simpler structure which made construction and maintenance easier. The major difference in GWP shows that the simple steel towers are clearly preferable from a climate perspective and adds an argument for considering life cycle perspectives as a factor when choosing between different alternatives. The difference in GWP came from the difference in the steel weight in each tower, resulting from the aesthetic design, also showing that early LCAs could give insight into decreasing the amount of materials. Based on sources from the cable car project other differences were also found, such as UNS towers requiring more maintenance and being more costly and difficult to construct due to irregular shapes. This was not included in the impact assessment but could still point to a benefit of standardized dimensions and designs although the actual steel weight would have the most influence. Even though the towers need to have a certain height so that the towers will need to contain a certain amount of steel, there is still a large opportunity for emission reductions when moving to the simple steel design. Cable cars need some infrastructure to function and to carry the actual cable car technology, not just for passenger comfort and attractivity. But it has been shown that the climate impact can be decreased while still fulfilling the same purpose of transporting passengers.

Based on, for instance, Table 5.2, several possibilities to decrease the climate impact may be identified through the help of LCA:

- Decrease use of concrete if possible. Choosing concrete with less GWP per unit might also contribute some to lowering overall GWP, especially if large amounts are used.

- Lightweight design, especially of the towers, connecting to the benefits of the simple steel tower compared to UNS towers.

- The size of stations. Smaller stations lead to lower emissions from, for example, diesel and sheet piling because of smaller areas and less construction needed.

- Reusing sheet piling is a good measure from a climate standpoint. This is especially relevant since this is a clear active choice that might be considered. One argument against it was that no economic benefits were gained since the cost of taking up the sheet piling and washing them would cost as much as new ones. But including the beneficial climate aspect might contribute to making this beneficial overall. From a life cycle perspective, it becomes clear that it is valuable to remove, and if possible, repair, reuse or recycle the sheet piling. As stated above this would not matter much from a simply economic perspective. But from a climate standpoint, it would be beneficial to reuse them.

- Location and geotechnical conditions. This might have been too late to change in the case of the redesign of the cable car but heights of the towers could have been somewhat reduced based on their location and less piling might have been needed depending on the geotechnical conditions at the construction sites for towers and stations. There are however many other aspects to consider when deciding locations for towers and stations so this might not be prioritized.

- The method of piling might influence the climate impact. There was a clear difference between the first design alternative with fewer piles and the second with more. However, this was also connected to the geotechnical conditions in this case.

- Reduce the use of fossil-based fuels, like diesel. If possible, electricity or biofuels might serve as replacements if construction machinery that might use these are available.

- Take the electricity mix into account. This was done for the cable car technology where 100 % green electricity was intended to be used. During the use phase this will have a large relative impact in decreasing the climate impact, even compared to the Nordic electricity mix which is relatively clean.

This last point also means that cable cars will be more environmentally beneficial in regions where a cleaner electricity mix is used. This will also be important to consider if cable cars are planned in other areas than the Nordic region, where the electricity mix might cause even more emissions per unit of electricity. In summary, some choices in the design and construction phase will influence the sustainability of cable cars and likely other types of infrastructure, which points at the benefits of LCAs or other climate assessments as a complement to simply looking at costs. In some places, the study confirmed the problem of lack of data in the design phase. As more life cycle studies are done on different kinds of buildings, the assumptions for different buildings will possibly be more robust. At the same time, infrastructure and buildings may have differences in design that average data cannot distinguish between if project specific data is not available. It is harder to make assumptions based on available data when the projects are unusual. For cable cars specifically, the fact that the stations and towers may look so different, point to that it is important to take the specific design into account when assessing the sustainability of cable cars, and other transportation infrastructure. An increased focus on LCA and climate calculations could contribute to this.

6.1.1 Benefits of an Increased Life Cycle Perspective

Sustainability can be divided into the three dimensions environmental, economic and social sustainability. Assessing the social and economic dimensions are outside the scope of this thesis but it is worth noting that different benefits have been discussed for each design alternative. For example, the first design with its service facilities and shops was put forward as a meeting place to a higher degree and was intended to increase the perceived safety of passengers through a higher amount of people moving through the stations. On the other hand, the second design is cheaper and has a lower investment cost as well as lower operation and maintenance costs, which is beneficial from an economic standpoint. At the same time both alternatives where aimed to connect the city through bridging barriers like roads and river.

By using increased life cycle thinking in the form of LCA through Klimatkalkyl or other tools, there is a possibility to assess and quantify the climate impact and add this as a basis on which to base a choice of establishing, designing, or choosing between building or infrastructure projects. Although there have been discussions relating to some environmental issues in the cable car project, such as materials and the use of green electricity, these issues have not been quantified and compared in the same way as economic costs.

To include environmental impacts in the design phase can contribute to a holistic view of the project. It also shows which areas to focus on for improving the climate impact over the life cycle. Potential synergies that may be achieved are also shown, such as decreasing cost and environmental impact at the same time. In the same way as environmental impacts over the life cycle can be influenced during the design phase of an infrastructure project, the conditions of achieving economic and social sustainability can be influenced in the design phase as well. Thus, an increased focus on a life cycle perspective may lead to a more holistic view overall.

6.2 Discussion on Klimatkalkyl

The main tool used in the method was Klimatkalkyl. Overall, Klimatkalkyl could be used to assess the materials responsible for most of the climate impact in the study but not all. That some materials were not possible to assess were because of a combination of the way that data were given in the bill of quantities (without material quantities being specified for instance), and some categories lacking in Klimatkalkyl. At the same time, the possibility to add own data and emission factors, and to modify existing ones means that how well Klimatkalkyl can be used also depends on how the bills of quantities are structured and how easy it is to find complementary information.

There was not always enough building parts or type measures to match the different types of objects in the bill of quantities in detail, such as the specific type of sheet piling, or the specific dimensions of different steel pipe piles. At the same time, Klimatkalkyl is based on average data and the idea is that new objects can be added if it is needed. From that perspective, it is up to the user to choose the level of project specific detail in a study. One way is to find a similar object that already exists in Klimatkalkyl. In this study this was done for different types of wells for example. Several different types of concrete wells were approximated as the type of concrete well that existed in Klimatkalkyl. In other cases, the building parts were edited, such as for piling. In yet other cases, data for completely new materials were found outside of the model, like ductile iron. Often several options are possible for the user depending on what fits best. There is a learning curve in using the tool and interpreting the information within. A more experienced user may find it easier to make methodological choices in adapting project specific data to the correct input in Klimatkalkyl in the best way. However, this flexibility allows for several ways of modelling which is an advantage.

The default is that average data is used. This has the advantage of being relatively simple to use. But the average values in the model did not always suit the project specific data. There might be a risk (if not changing emission factors) that Klimatkalkyl cannot distinguish between several different kinds of the same material with different environmental impacts. For example, this could have been an issue for concrete where the large amount could mean that even a small change in emission factors could influence the results. If one type of concrete had a higher GWP per unit than another but was approximated as having the same average emission factor, some possibilities to see the difference could be lost if not modifying emission factors. For the cable car, the results in the sensitivity analysis showed that changing the emission factors of concrete did not change the overall ranking between the alternatives but there was some influence of the climate impact of each alternative. Introducing several kinds of concrete might also increase the complexity of the model which might not always be beneficial.

There can be both benefits and drawbacks with average data versus more specific data in the inventory. If more specific type measures and building parts were included, less adaptations and additions of new data might have been needed and it would have been easier to find the right fit compared to the bill of quantities. This could have allowed for inclusion of more objects from the bill of quantities. On the other hand, more specific objects might make the tool more complex and less easy to get an overview of and use. Both these ways can sometimes be used in Klimatkalkyl since some materials only exist as one type while some others have several variants, like different dimensions. In general, some parts of the station buildings were hard to assess because of the structure of the data. This was mostly the case for installations and parts of roofs, walls and other surfaces expressed as areas, but also for some other objects where the exact material composition was unknown.

Some material, like plastic, should perhaps be possible to add as masses (not just as specific objects, like pipes). Similar to how concrete and steel can be now. One solution could perhaps be to make it possible to add resources (like plastic) separately (since they are already in the model) without being part of a building part. However, this could possibly cause confusion for the user as to whether to use standalone resources, or a type measure or building part.

Examples of specific objects that were missing in Klimatkalkyl were different kinds of pipes and wells, escalators and elevators. The model is continuously refined and it seems increased precision is added by the addition of more specific objects. One example relevant for this work is for different kinds of piles where more types of both steel and concrete piles was added in version 7.0 of Klimatkalkyl. Some of the manual changes to building parts that needed to be done was implemented, for example steel pipe piles were added and the concrete piles were split in SP1, SP2 and SP3 pipes rather than just being of one type in version 6.1.

In summary, Klimatkalkyl could be used to compare design alternatives and to assess the main parameters of the cable car. But depending on the difference in material, project specific data may be needed for a fair comparison. In these cases, Klimatkalkyl will likely need to be complemented with other data. The extent to which other data is needed may also depend on the structure of the bill of quantities and how specific the amounts of materials there are. However, even the existing database in Klimatkalkyl could account for the vast majority of climate impact from the project because it contained steel, concrete, diesel and different earth and stone masses etc. It also contained specific objects like sheet piling and piling (event though the piling was modified in this case). This indicates that Klimatkalkyl can be a valuable tool in identifying climate hotpots when assessing infrastructure objects. Even possibly for more unusual ones like cable cars even if exactly all materials might be hard to assess depending on the specific infrastructure object in question. There could potentially be other LCA tools that could also be used. Possibly combined with Klimatkalkyl. If another LCA tool could be used for components that are lacking in Klimatkalkyl while Klimatkalkyl could be used for those building parts that it specialises in. More research would be needed and this cannot be addressed through this study.

6.3 Uncertainties and Limitations of the Study

Some of the uncertainties were unavoidable in this study, since not all materials in the stations had yet been decided. Other factors contributing to both limitations and uncertainty are lack of data and average values. The data can be said to be divided into three different categories:

- Data that is included in the study (based on parameters that are known).
- Data that is excluded from the study but similar between the alternatives.
- Data that is excluded from the study and different between the alternatives.

The ideal situation would be that all environmentally relevant flows are included in the study, and that all data would fit in the first category. This was not practically possible in this case however due to lack of data. This means that the full climate impact of the entire cable car system was not possible to assess. The aim was then to capture the relative difference in climate impact between the alternatives. Data that is similar between the designs but excluded will not influence the relative comparison in the same way. One notable example of this is the cable car technology that remained unchanged during the design revision. It proved hard to make this distinction between the data. For example, some of the excluded maintenance activities might be largely similar since they depend on the cable car technology. But other parts of the maintenance may depend on the size of the stations which would differ. It may also be hard to assess the distribution between how much of the actual GWP from the system that is known through the data included in the study, and how much that is excluded and not known. This is one of the major limitations of the study.

The cable car technology was a main category that was excluded in the chosen methodology. The only known material was 25 tonnes of steel in each tower. Some other parts of this technology (like cables or gondolas) could have possibly been roughly estimated. But there were also many components that were not known enough to be approximated. It was thus judged that the delimitations of this study would be more clearly defined if the whole cable car technology was excluded. Especially since the data would need to be largely based on assumptions and approximations if it was included.

All objects in the bill of quantities were not possible to assess. Several of the uncertainties and limitations are shown in Table 5.2. Several are connected to each other in that they have to do with missing data. The specific materials and design of the stations were not yet fully decided when the bills of quantities were made. This was one reason why approximations of some areas needed to be made. In other cases, there were some challenges in interpreting the bills of quantities and to know which data that was included or not. For example, some parts of the structural frames of the stations were possibly missing. There should have been steel beams in the stations as well but this was not found in the bills of quantities meaning that it had to be excluded. Finally, some differences in knowledge about the project between the time that the two design alternatives, and their corresponding bills of quantities, were created could influence the results. The lifetime was taken into account through Klimatkalkyl. Another way could have been to assume 50 or 100 years or somewhere in between. But since no lifetime was decided, this was also considered an uncertainty.

Table 5.2 Summary of uncertainties and limitations in the study.

Uncertainties and limitations
Cable car technology excluded
Maintenance excluded
Energy use of stations approximated based on templates
Amount of piles in alternative 1 (less knowledge than when alternative 2 was created)
Not possible to assess "areas" (roofs, walls, facades etc.) in the bill of quantities, approximations and assumptions were made which influenced the results
Specific materials not always decided due to still being in the design phase
Sometimes hard to interpret what was included in the bills of quantities, or find data needed for estimating the climate impact
Average values for emission factors sometimes used rather than project specific data
Some structures and objects from the buildings not included in the study
Lifetime of cable car and material
Conversion from bill of quantities to Klimatkalkyl

The total climate impact of both alternatives will likely be higher in reality because of the exclusion of the parameters mentioned above. The difference between the alternatives might also be larger. For example, if the corresponding parts of each station are excluded, more climate impact will likely be "missed" from design 1 because of the larger areas. One example is the roofs. Due to the larger stations and thereby larger areas, as well as the voluminous roofs that might not have been fully captured by this study, it can be estimated that the difference between the GWP of the two alternatives would increase with all project specific data available. But this is not entirely certain as it would also depend on the material used in the respective design alternative. Finally, it is possible that more data could have been requested or approximated from other stakeholders in the project. This could possibly have eliminated some of these uncertainties and limitations but a deeper assessment of this was not possible within the scope of this thesis.

6.4 Future Research

There were a range of uncertainties within the study and some parameters had to be excluded. To get a more exact estimation of the climate impact of the whole cable car system, the missing data would need to be determined more closely. At present the Gothenburg cable car project has been abandoned and it currently seems like continued investigations of current or alternative designs will not be occurring. For this reason, it might not be possible to get accurate data on the full system in the future, such as the final choice of materials inside the stations. If more inventory data on cable cars and cable car technology was made publicly available in the future, the possibility to estimate factors such as the cable car technology might give a more holistic picture of future assessments of cable cars.

As more life cycle assessments of buildings and infrastructure are performed, the inventory of parameters related to these will grow. This might make estimations easier to make if project specific data is missing since a larger number of new studies may also cover more unusual buildings like the cable car. However, the climate impact of other cable cars will depend on project specific designs. As was shown in this study the design may have a large impact. It could be interesting with more types of design alternatives being studied in the future to see how the climate impact could be decreased further.

Apart from examining the possibility of redesigning the cable car (which led to design alternative 2), an investigation was tasked with assessing alternative transport solutions in the area when the first design proved too expensive (Göteborgs Stad Trafikkontoret, 2019). Alternative transport solutions include ferry, bus and tram. It would be interesting to assess and compare these alternatives and their climate impact to the cable car. However, it is emphasised that these alternatives are not yet at the same detailed level as the cable car (Göteborgs Stad Trafikkontoret, 2019), making a comparison difficult at this stage in time.

A comparison between Klimatkalkyl and other, more detailed, LCA tools and databases for different infrastructure projects would be interesting in order to investigate how much the results in Klimatkalkyl would differ from other databases. This could add new knowledge on how well the average values in Klimatkalkyl represent different types of infrastructure and building projects. As the tool is continuously updated, more research on how to develop it in the best way could also be the aim of future studies.

7 Conclusion

The main aim of this thesis has been to make a comparison of the climate impact of two design options of the Gothenburg cable car before and after the design revision in 2019. In the original concept design, the four stations were larger and designed as travelling centers while the six UNS steel towers had a more complex structure requiring more steel. In the new design, the stations were smaller. As a part of the second design several possible variants had been proposed. The option chosen to represent design alternative 2 in this study had four stations and so called "simple steel towers".

As part of the overall aim, the first objective was to assess if the redesign had positive effects in reducing the climate impact of the design. It was found that the overall climate impact was reduced in alternative 2 compared to the first concept design. However, it was also found that there was a lack of data for some parameters and parts of the system which made exclusions of those parts necessary, for example the cable car technology, maintenance and some parts of the stations, like parts of the structure.

The second objective was to identify the main parameters that contributed to the climate impact, especially for the current design alternative 2. It was found that steel and concrete were the materials that contributed to the greatest climate impact. The large amounts of these materials in stations, towers, piling and sheet piling were one important factor for this large influence. Even though the stations were smaller in design 2, more concrete was used. This is likely due to more concrete being used in the pillars and beams within the structure of the stations in the second design. The UNS towers in design 1 had a significantly higher climate impact than the "simple steel towers" in design 2. Steel piles and sheet piling used in the foundations also had a large impact. Finally, the size of the stations influenced several parameters apart from steel and concrete. For example, more diesel was required for the larger stations. Another important factor over the whole life cycle is the electricity mix used and there is a significant benefit in using green electricity for the cable car technology (as was planned in both design alternatives).

The third objective of the study was to assess how well Klimatkalkyl could be used to assess the climate impact of the cable car. Klimatkalkyl was the main tool to be used but due to the structure of the bill of quantities and the inventory data, some additional sources were also used for the impact assessment. It was found that Klimatkalkyl could be used for assessing the climate impact of the materials and identify parameters with a large impact if the amount and type of material was specified in the source material. Difficulties arose because of the structure of the bill of quantities where the materials was not always specified, for example certain parts of the stations expressed as areas could not be assessed. By default, Klimatkalkyl relies on average data for emission factors, if only using the existing inventory data in the model, some project specific data may be lost or not possible to assess. However, the possibility of adding own materials and changing emission factors and material add flexibility to the tool which make it possible to adapt to more unusual projects like the cable car if the amounts of materials are possible to assess.

As a case study of a cable car, this study also shows the difficulty in finding accurate inventory data for cable cars since the impact of the overall facility is highly dependent on the types of towers, their design and the number of stations. The foundations also play a part, highlighting that the site for the stations will influence the climate impact. The geographical placement also has an influence on emissions through the electricity mix. Green electricity will play a large part over the entire life cycle. Finally, it should be emphasised that this study cannot claim to show the full climate impact of the cable car since, for instance, the cable car technology, the maintenance and parts of the stations were not included in the study due to lack of data. However, it was found that the stations and towers contribute to a significant climate impact. It was also shown that design choices will influence the climate impact of the cable car. This in turn confirms the benefits of implementing life cycle thinking when planning and constructing infrastructure. The uncertainties and average data proved a difficulty in assessing the exact climate impact of the cable car, which is in line with scientific theory of projects in the design stage. However, even with some uncertainties and average values, estimations of environmental impacts serve as a valuable addition to a holistic perspective in the design phase. The Gothenburg cable car project is put on hold, but hopefully this study has served as a case study on major factors of climate impact in an infrastructure project and shown the possible benefits of including LCA-based tools in the decision-making process as a complement to economic costs and other factors, and when deciding between different design solutions.

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Personal Communication

Jessica Ekberg, project manager, Tyréns. Personal communication occurred at times during the period from January to May, 2020.

Jakob Persson, engineer (*entreprenadingenjör*), NCC. Personal communication occurred at times during the period from February to April, 2020.

Klimatkalkyl

The Klimatkalkyl model is openly accessible online at Trafikverket via http://webapp.trafikverket.se/Klimatkalkyl/

A Appendix

In the appendix, the bills of quantities and calculation are presented. In Section A.1, the main bills of quantities are shown, in Section A.2 the steel in the towers, in Section A.3 the piling and sheet piling. The impact assessment of surface layers, complements to main frame, roofs, facades and installations are shown in Section A.4. Brief explanations to calculations and delimitations made in the main bills of quantities are given in Section A.5.

A.1 Main Bill of Quantities

In the following section, the bills of quantities for design alternative 1 (made 1902) and design alternative 2 (made 1910) are presented.

Table A.1. Bill of quantities for design 1

Design alternative 1

🟨 Assessed outside of Klimatkalkyl
🟩 Included in inventory Klimatkalkyl

		Amount			Name in Klimatkalkyl	Recalculation	Unit	Comments
41111	Fyllnadsjord							
	Fyllnadsjord (ton) inkl. trp	142900	ton	🟩	Jord Fall B, Fyll	89312,5	m3	D=1,6 ton/m3 for earth masses (Klimatkalkyl based on Erlandsson (2010)). Divide mass by density of earth masses/gravel to get the volume.
41112	Växtjord							
	Planteringsjord Hasselfors E-jord inkl.trp. (ton)	600,1528	ton	🟩	Jord Fall B, Fyll	375,0955	m3	D=1,6 ton/m3. Assumed that the density is the same for these soils as for earth masses in Klimatkalkyl.
	Växtbädd-ytlager inkl.trp. (ton) pris?	647,9928	ton	🟩	Jord Fall B, Fyll	404,9955	m3	D=1,6 ton/m3. Klimatkalkyl/(Erlandsson, 2010).
	Hasselfors Trädgårdsjord E (ton)	383,24	ton	🟩	Jord Fall B, Fyll	239,525	m3	D=1,6 ton/m3. Klimatkalkyl/(Erlandsson, 2010).
	Skelettjord komplett (bedömt)	0	m3		-	-		
41120	Grusmaterial							
	Sorterat grus 0-8 mm (ton) inkl. trp	1595,748	ton	🟩	Berg Fall B, Fyll	1063,832	m3	D=1,5 ton/m3 (Klimatkalkyl via Erlandsson (2010)). Assumed that gravel can be approximated as being in the same category as crushed rock.
	Kabelsand inkl trp (ton) inkl. trp	144,375	ton	🟩	Jord Fall B, Fyll (sand)	103,125	m3	Assumed that the impact of sand can be classified as earth, depending mainly on transport. D = 1,4 ton/m3 (Snabbgrus, accessed 2020, a)
	Väggrus 0-18 mm inkl trp (ton)	967,0365	ton	🟩	Berg Fall B, Fyll	644,691	m3	D=1,5 ton/m3 (Klimatkalkyl via Erlandsson (2010)). Assumed that gravel can be approximated as being in the same category as crushed rock.
41122	Sorterat grus (ej std)							
	Rörgravsgrus 0-8 mm inkl. trp	10814,83475	ton	🟩	Berg Fall B, Fyll	7209,889833	m3	D=1,5 ton/m3 (Klimatkalkyl via Erlandsson (2010)) and Snabbgrus (accessed 2020, c).
41131	Råbergmaterial							
	Sprängsten (ton)	3900	ton	🟩	Bergschakt Fall A	2166,666667	m3	D=1,8 ton/m3. Density of crushed rock (Klimatkalkyl, based on Erlandsson (2010)),
	Kreditering i kross	399,623308	ton		-	-		Excluded, unknown exatctly what this refers to.
41133	Krossat bergmaterial							
	Makadam 4-8 mm (ton) inkl. trp	322	ton	🟩	Berg Fall B, Fyll	247,6923077	m3	D=1.3 Erlandsson (2010)
	Samkross 0-18 mm (ton) inkl. trp	15,4752	ton	🟩	Berg Fall B, Fyll	8,597333333	m3	D = 1,8 ton/m3 (Klimatkalkyl, based on Erlandsson (2010))
	Samkross 0-32 mm (ton) inkl. trp	1200	ton	🟩	Berg Fall B, Fyll	666,6666667	m3	D=1,8 ton/m3
	Samkross 0-32 mm (ton) inkl. trp	2236,725	ton	🟩	Berg Fall B, Fyll	1242,625	m3	D=1,8 ton/m3
	Samkross 0-32 mm (ton) inkl. trp	6796,5	ton	🟩	Berg Fall B, Fyll	3775,833333	m3	D=1,8 ton/m3
	Samkross 0-32 mm (ton) inkl. trp	17,333333	ton	🟩	Berg Fall B, Fyll	9,629629444	m3	D=1,8 ton/m3
	Samkross 0-32 mm (ton) inkl. trp	2658,8	ton	🟩	Berg Fall B, Fyll	1477,111111	m3	D=1,8 ton/m3
	Samkross 0-32 mm (ton) inkl. trp	1302,375	ton	🟩	Berg Fall B, Fyll	723,5416667	m3	D=1,8 ton/m3
	Samkross 0-32 mm (ton) inkl. trp	1642,2	ton	🟩	Berg Fall B, Fyll	912,3333333	m3	D=1,8 ton/m3
	Samkross 0-32 mm (ton) inkl. trp	284,625	ton	🟩	Berg Fall B, Fyll	158,125	m3	D=1,8 ton/m3
	Samkross 0-32 mm (ton) inkl. trp	5278,5	ton	🟩	Berg Fall B, Fyll	2932,5	m3	D=1,8 ton/m3
	Samkross 0-32 mm (ton) inkl. trp	300	ton	🟩	Berg Fall B, Fyll	166,6666667	m3	D=1,8 ton/m3
	Samkross 0-32 mm (ton) inkl. trp	1030,5	ton	🟩	Berg Fall B, Fyll	572,5	m3	D=1,8 ton/m3
	Samkross 0-40 mm (ton) inkl. trp	13365,378	ton	🟩	Berg Fall B, Fyll	7425,21	m3	D=1,8 ton/m3
	Samkross 0-63 mm inkl.trp. (ton)	1855,656	ton	🟩	Berg Fall B, Fyll	1030,92	m3	D=1,8 ton/m3
	Samkross 0-90 mm (ton) inkl. trp	50284,24596	ton	🟩	Berg Fall B, Fyll	27935,6922	m3	D=1,8 ton/m3
	Samkross 0-150 mm (ton) inkl. trp	55	ton	🟩	Berg Fall B, Fyll	30,55555556	m3	D=1,8 ton/m3
	Makadam 8-16 mm (ton) inkl. trp.	664,7	ton	🟩	Berg Fall B, Fyll	474,7857143	m3	D=1.4 Erlandsson (2010)/IVL
41210	Fabriksbetong							
	Betong C20/25 S2 trög 32	2,001	m3	🟩	Betong	2,001	m3	Average concrete as in Klimatkalkyl is assumed.
	Betong C20/25 XC 1 16 S4 Cem II	4428,795	m3	🟩	Betong, klass 2	4428,795	m3	Cem II = Concrete , class 2 in Klimatkalkyl
	Betong C30/37 S3 lätt 32	30,072	m3	🟩	Betong	30,072	m3	
	C35/45 vct 0,40 S3 - XD3, XS3, XF4	19188,75	m3	🟩	Betong	19188,75	m3	
								Difference compared to 1910: Note that no plastic-moulded objects are included here
41222	Plattor och marksten av betong							
	Marksten hög kvalité	11051,25	m2	🟩	Betongmarkplattor	11051,25	m2	No thickness is given. Assume default thickness as in Klimatkalkyl (done in 1910 as well).
	Marksten hög kvalité	7455	m2	🟩	Betongmarkplattor	7455	m2	
	Marksten hög kvalité	43,05	m2	🟩	Betongmarkplattor	43,05	m2	
	Marksten hög kvalité	1397,55	m2	🟩	Betongmarkplattor	1397,55	m2	
41224	Kantstöd av betong							
	Hållplatskantstöd 400x1000x320 mm	42	m	🟩	Betong	5,376	m3	Assuming that each support lies next to each other on the length. The total dimensions will then be 0,40m*42m*0,32m
	Hållplatskantstöd 400x1000x320 mm	18,9	m	🟩	Betong	2,4192	m3	Assuming that each support lies next to each other on the length. The total dimensions will then be 0,40m*18,9m*0,32m. Steel rebars are not considered. Judged reasonable since steel constitute less that 0.5% of the total weight (Benders, 2015).
	Kantstöd Benders frakt	8	ton		-	-	-	Excluded to avoid doublecounting
	Kantstöd Benders frakt	3,6	ton		-	-	-	Excluded to avoid doublecounting
41230	VA- material av betong							
	Avser nedstigningsbrunn dim 1000 mm, komplett	26	st	🟩	Brunn, nedstigningsbrunn betong	26	st	Assumed same dim. as in Klimatkalkyl

	Rensbrunn dim 400 mm komplett	4	st	🟩	Brunn, nedstigningsbrunn betong (estimated)		4	st	Estimated with other concrete well in Klimatkalkyl
	Elementbrunn för S1400BTG // Pris?	1	st	🟩	Brunn, nedstigningsbrunn betong (estimated)		1	st	Estimated with other concrete well in Klimatkalkyl
	Brunn för D500BTG // Pris?	1	st	🟩	Brunn, nedstigningsbrunn betong (estimated)		1	st	Estimated with other concrete well in Klimatkalkyl
	Fraktkostnad VA material av betong inkl pallar o dyl 0-900 kr/ton	531,75675	ton	-	-	-	-		Excluded since this concerns the transport cost. Packaging and other material may also be included in the tranpsort. Excluded to avoid doublecounting.
	225 Oarm rakt rör l=1700 112kg/m	52,5	m	🟩	Betong		2,45	m3	
	225 Oarm rakt rör l=1700 112kg/m	63	m	🟩	Betong		2,94	m3	
	300 Oarm rakt rör l=2000 140 kg/m	105	m	🟩	Betong		6,125	m3	
	300 Oarm rakt rör l=2000 140 kg/m	210	m	🟩	Betong		12,25	m3	
	400 Oarm rakt rör l=2200 330 kg/m	78,75	m	🟩	Betong		10,828125	m3	
	400 Oarm rakt rör l=2200 330 kg/m	78,75	m	🟩	Betong		10,828125	m3	
	225 Oarm kortrör l=500 61 kg/st	0	st	-	-	-			-
	225 Oarm kortrör l=500 61 kg/st	0	st	-	-	-			-
	300 Oarm kortrör l=500 88 kg/st	5	st	🟩	Betong		0,183333333	m3	
	400 Oarm kortrör l=500 138 kg/st	5,625	st	🟩	Betong		0,3234375	m3	
	400 Oarm kortrör l=500 138 kg/st	5,625	st	🟩	Betong		0,3234375	m3	
	225x225 Oarm grenrör 45° 116 kg/st	0	st	-	-	-	-		
	225x225 Oarm grenrör 45° 116 kg/st	0	st	-	-	-	-		
	300x225 Oarm grenrör 45° 152 kg/st	0	st	-	-	-	-		
	400x225 Oarm grenrör 45° 218 kg/st	0	st	-	-	-	-		
	400x225 Oarm grenrör 45° 218 kg/st	0	st	-	-	-	-		
	225 Oarm krokrör 7°-45° 27-49 kg/st	0	st	-	-	-	-		
	225 Oarm krokrör 7°-45° 27-49 kg/st	0	st	-	-	-	-		
	300 Oarm krokrör 7°-45 38-99 kg/st	0	st	-	-	-	-		
	400 Oarm krokrör 7°-22.5° 63-95 kg/st	7,5	st	🟩	Betong		0,246875	m3	Assume average weight between 63 and 95 kg/st
	400 Oarm krokrör 7°-22.5° 63-95 kg/st	7,5	st	🟩	Betong		0,246875	m3	Assume average weight between 63 and 95 kg/st
	VA- material för infällning av AS1400-ledning	2	x	-	-	-	-		Excluded due to lack of data.
	600 Arm hk 110 raktrör l=2200 466 kg/m	168	m	🟩	Betongrör m. arm.		78,288	ton	Added as new emission factor, see main report
	800 Arm hk 110 raktrör l=2200 855 kg/m	78,75	m	🟩	Betongrör m. arm.		67,33125	ton	
	1400 Arm hk 135 raktrör l=2200 1864 kg/m	126	m	🟩	Betongrör m. arm.		234,864	ton	
	500 Arm hk 200 raktrör l=2200 400 kg/m	84	m	🟩	Betongrör m. arm.		33,6	ton	
	500 Arm hk 200 raktrör l=2200 400 kg/m	63	m	🟩	Betongrör m. arm.		25,2	ton	
	500 Arm hk 200 kortrör l=1000 340 kg/st	0	st	-	-	-	-		
	500 Arm hk 200 kortrör l=1000 340 kg/st	2,4	st	🟩	Betongrör m. arm.		0,816	ton	
	600 Arm hk 165 kortrör l=1000 450 kg/st	9,6	st	🟩	Betongrör m. arm.		4,32	ton	
	800 Arm hk 165 kortrör l=1000 860 kg/st	7,5	st	🟩	Betongrör m. arm.		6,45	ton	
	Dagvattenbrunn dim 400 mm, komplett, inkl. 3 m rör dim 160 mm	7	st	🟩	Brunn, nedstigningsbrunn betong (estimated)		7	st	Estimated with other concrete well in Klimatkalkyl
	Spillvattenbrunn dim 400 mm, komplett, inkl. 3 m rör dim 160 mm	7	st	🟩	Brunn, nedstigningsbrunn betong (estimated)		7	st	Estimated with other concrete well in Klimatkalkyl
	Rännstensbrunn dim 400 mm, komplett, inkl. 3 m rör dim 160 mm	8	st	🟩	Brunn, nedstigningsbrunn betong (estimated)		8	st	Estimated with other concrete well in Klimatkalkyl
41262	Markprodukter av natursten								
	Råkantsten - RV 4. Import Rak sten. (81 kg/m)	220	m	🟩	Granit		17,82	ton	Weight calculated
	Råkantsten - RV 4. Import Rak sten. (81 kg/m)	880	m	🟩	Granit		71,28	ton	
	Råkantsten - RV 4. Import Rak sten. (81 kg/m)	2420	m	🟩	Granit		196,02	ton	
	Råkantsten - RV 4. Import Rak sten. (81 kg/m)	1430	m	🟩	Granit		115,83	ton	
	Råkantsten - RV 4. Import Rak sten. (81 kg/m)	330	m	🟩	Granit		26,73	ton	
	Råkantsten - RV 4. Import Rak sten. (81 kg/m)	110	m	🟩	Granit		8,91	ton	
	Råkantsten - RV 4. Import Rak sten. (81 kg/m)	495	m	🟩	Granit		40,095	ton	
	Råkantsten - RV 4. Import Rak sten. (81 kg/m)	2310	m	🟩	Granit		187,11	ton	
41311	Trävirke								
	Virke 50x200 sågat gran G4-2	2750	m	🟩	Trä		27,5	m3	Assumed that the dimensions are in mm and rectangular planks
	K-virke 45x95 gran C14	299,2	m	🟩	Trä		1,27908	m3	
	Trekantsläkt 21x21 snedsågad	2561,477184	m	🟩	Trä		0,564805719	m3	
	Formbräda 22x95 G4-4	826,98	m	🟩	Trä		1,7283882	m3	
	Formregel 45x95 G4-4	784,02	m	🟩	Trä		3,3516855	m3	
	Kompositstag < 1,2m inkl kapkostnad	1112,458782	m						
	Periform grundkostnad	344,914034	m2						
	Periform hyra	1747,083333	m2						Difficult to estimate due to unknown dim. and materials of form work
	Skivform med brädor	922,617492	m2						
41323	Plywoodskivor								
	OSB plywood t=11 b=900 NCC Supply	231,6	m2	🟩	Trä		2,5476	m3	V=t*A. t=11mm
41420	Armering								
	Armering B500B d=10	13000	kg	🟩	Stål, armering		13	ton	
	Armering B500B d=10	13000	kg	🟩	Stål, armering		13	ton	
	Armering B500B d=10	18500	kg	🟩	Stål, armering		18,5	ton	
	Armering B500B d=10	21500	kg	🟩	Stål, armering		21,5	ton	
	Armering B500B d=10	18700	kg	🟩	Stål, armering		18,7	ton	
	Armering B500B d=10	14000	kg	🟩	Stål, armering		14	ton	
	Armering B500B d=10	33000	kg	🟩	Stål, armering		33	ton	
	Armering B500B d=10	13000	kg	🟩	Stål, armering		13	ton	
	Armering B500B d=10	40000	kg	🟩	Stål, armering		40	ton	
	Armering B500B d=10	24000	kg	🟩	Stål, armering		24	ton	
	Armering B500B ILF (klippt o bockat) ca	2322506,986	kg	🟩	Stål, armering		2322,506986	ton	
	Armeringsnät NPS500 8100	551,25	kg	🟩	Stål, armering		0,55125	ton	
41530	VA- material av plast och metall								
	Rördelar 25%	5570	x						Excluded because type and amount of material is not known exactly. Also, the material should only be a small part of the total amount of piping in the project (Jakob Persson).
	Rördelar diverse.	2100	x						
	Infiltrationskassetter	340	m3		Excluded				
	Infiltrationskassetter oförutsätt	340	m3						
	63 PE elsvetsmuff PN 10	17,5	st	🟩	PE		4,025	kg	m=0,23 kg (Markvaruhuset, 2020)
41531	Självfallsledningar (ej std)								
	200 PP-markrör l=6m	110	m	🟩	Ledning av plaströr, dränrör dim 200		110	m	
	200 PP-markrör l=6m	330	m	🟩	Ledning av plaströr, dränrör dim 200		330	m	

	200 PP-markrör l=6m	440	m	🟩	Ledning av plaströr, dränrör dim 200	440	m	
	200 PP-markrör l=6m	110	m	🟩	Ledning av plaströr, dränrör dim 200	110	m	
	200 PP-markrör l=6m	110	m	🟩	Ledning av plaströr, dränrör dim 200	110	m	
	200x174 PP-markrör Pragma PP l=6m	393,75	m	🟩	PP	2706,436911	kg	The weight of the pipe is calculated based on the density of the PP and the pipe wall thickness.
	315x276 PP-markrör Pragma PP l=6m	367,5	m	🟩	PP	5987,44893	kg	
	200x110 PP-markgrenrör	5	st	🟩	PP	10	kg	Weight for markgrensrör with the same dimensions as in the BoQ is 2,0 kg (Uponor, 2017)
	200x110 PP-markgrenrör	15	st	🟩	PP	30	kg	Weight for markgrensrör with the same dimensions as in the BoQ is 2,0 kg (Uponor, 2017)
	200x110 PP-markgrenrör	20	st	🟩	PP	40	kg	Weight for markgrensrör with the same dimensions as in the BoQ is 2,0 kg (Uponor, 2017)
	200x110 PP-markgrenrör	5	st	🟩	PP	10	kg	Weight for markgrensrör with the same dimensions as in the BoQ is 2,0 kg (Uponor, 2017)
	200x110 PP-markgrenrör	5	st	🟩	PP	10	kg	Weight for markgrensrör with the same dimensions as in the BoQ is 2,0 kg (Uponor, 2017)
	200x110 PP-markgrenrör	2,5	st	🟩	PP	5	kg	Weight for markgrensrör with the same dimensions as in the BoQ is 2,0 kg (Uponor, 2017)
	200/226 Forshedamanschett	1	st		SBR (styrene-butadiene rubber)	0,76	kg	Forshedamanchett 0,76 kg (Rsk-databasen, 2013). Negligible impact, excluded.
	200 PP-markrör l=6m	55	m	🟩	Ledning av plaströr, dränrör dim 200	55	m	
41532	Tryckledningar (ej std)							
	150 VRS Pro rakt rör	246,75	m	🟩	Segjärn	6826,75	kg	Assuming that VRS Pro has rougly the same weight as other VRS pipes of the same size: 150: 166 kg/6m (Gustavberg rörsystem, 2012). Coating on pipes not considered in this category.
	200 VRS rakt rör	210	m	🟩	Segjärn	8015	kg	pipe weight 200 229 kg per 6 m (Gustavberg rörsystem, 2012)
	200 VRS rakt rör	105	m	🟩	Segjärn	4007,5	kg	pipe weight 200 229 kg per 6 m (Gustavberg rörsystem, 2012)
	250 VRS rakt rör	105	m	🟩	Segjärn	5320	kg	pipe weight 250: 304 kg per 6 m (Gustavberg rörsystem, 2012)
	300 VRS rakt rör	63	m	🟩	Segjärn	4053	kg	pipe weight 300: 386 kg per 6 m (Gustavberg rörsystem, 2012).
	150 VRS skjutmuff	0	st	-	-	-	-	
	150 låselement VRS	39,16745	st	🟩	Segjärn	31,33396	kg	0,8 kg (Gustavberg rörsystem, 2012). This element is assumed to be made of ductile iron like the pipes.
	200 låselement VRS	0	st	-	-	-	-	
	200 låselement VRS	0	st	-	-	-	-	
	300 låselement VRS	0	st	-	-	-	-	
	150 klämring VRS	0	st	-	-	-	-	
	200 klämring VRS	0	st	-	-	-	-	
	200 klämring VRS	0	st	-	-	-	-	
	250 klämring VRS	0	st	-	-	-	-	
	300 klämring VRS	0	st	-	-	-	-	
	63 PEM-rör PN10, L=100m	367,5	m	🟩	PEM (polyeten med medeldensitet).	9,059095869	kg	Thickness 5,8 mm. Ahlsell (n.d.)
	Rördelar tryck 20 %	0	x	-	-	-	-	
41533	Dränledningar (ej std)							
	110/95 DV-dräneringsrör L=4m	966	m		PE			
41534	Kabelskydd (ej std)							
	Kabelmarkeringsband bredd 125 mm	3300	m					
	50/42 PEH GULA kabelrör SRN	402,5	m		PEH			
	110/98 PEH GULA kabelrör SRN Tät	6540	m		PEH			
41536	Brunnar och betäckningar (ej std)							
	Färdig RB av plast inkl betäckning	26,666667	st					
	Färdig spolbrunn brunn av plast inkl betäckning & stuprörs anslutning	46	st					
41537	Ventiler / Armaturer (ej std)							
	1,2-2 Hawle teleskopgarn. DN 50-200	7	st		Excluded			
	63 Hawle Slussventil M Muffar (Ahlsell)	7	st					
	Belos slussventilbetäckning med rund ram flytande	7	st					
41650	Geotextil							
	Geotextil N2	6812,5	m2	🟩	Lager av geotextil	6812,5	m2	
	Geotextil kl 3	7826,5	m2	🟩	Lager av geotextil	7826,5	m2	
	Geotextil N3	4243,75	m2	🟩	Lager av geotextil	4243,75	m2	
	Geotextil kl N4 (ahlsell)	70867,9	m2	🟩	Lager av geotextil	70867,9	m2	
41860	Kemikalier							
	Formolja Formlen fat 220L	34,368	lit					Excluded
41890	Övrigt kemiskt- tekniskt material							
	Övrigt kemiskt tekniskt material	100	x					Excluded because specfic amounts cannot be seen from this template.
	Desinfektionsmtrl f metallrör(1kr/d=100)	100	x					
	Gödsel NPK	196,72	kg					The manure should not have a relevant environmental impact.
41910	Fästmaterial							
	Dubbelhuvad spik, räfflad, 75-3,4	0,4117	frp					
	Trådspik blank lös i låda 75x2,8 3000 st/frp	0,4117	frp			0,002281546	m3	Assumed to have a neglible climate impact
41916	Armerings och formsättningstillbehör							
	Formstag 8 mm 100-500 ändknopp std	150,36	st					
	Armeringstillbehör rakstål	929002,7944	x					Excluded. Difficult to estimate from this template. (The rebars themselves are assessed under another category).
42161	Stödmurar och terrängtrappor							
	L-stödmur 20 kN/m2 2000/2000/1350	40,3	st	🟩	Betong	21,5605	m3	Weight data for 20kN, h=1300mm, l=2000mm--> 1284 kg (Tranås cementvarufabrik, 2020) (Not exactly the same (1000 width of the third dim.) Approximation.
	Släntsteg av btg, tillägg håltagning för räcke	280	st	🟩	Betong	18,9	m3	Assumed same dimensions as "blocksteg" below in the category
	Halkskyddsbehandling blocktrappa (bedömt)	70	st		-	-	-	
	Konstrastmarkering blocktrappa (bedömt)	20	st					Markings: No data and likely negligble impact.
	Blocksteg av btg, natur, bredd=1500 (150x300)	0	st		-	-	-	
	Blocksteg av btg, natur, bredd=1500 (150x300)	350	st	🟩	Betong	23,625	m3	
42163	Fundament i mark							
	Belysningsfundament	10	st					Dimensions not possible to assess from this data
42165	Stängsel, staket och räcken							

	Trappräcke TRA avsl.del vfz	24	st					Unkown exactly how these would look and what dimensions they would have. (Vfz=varmförzinkat)
	Trappräcke TRB mellandel vfz	30	st					
	Trappräcke TRC startdel vfz	24	st					
42166	Parkmöbler, lek och idrottsutrustning							
	Parkmöbler, lek och idrottsutrustning inkl. montering för stn Järntorget // schablon	1	x		Based on templates. Uncertainties in how these would look and which materials and amounts that would be included. "Pollare" was aslo excluded since no other objects in this category was included even though a specific number was given.			
	Parkmöbler, lek och idrottsutrustning inkl. montering för stn Lindholmen // schablon	1	x					
	Parkmöbler, lek och idrottsutrustning inkl. montering för stn Västra Ramberget // schablon	1	x					
	Parkmöbler, lek och idrottsutrustning inkl. montering för stn Wieselgrensplatsen // schablon	1	x					
	Parkmöbler, lek och idrottsutrustning inkl. montering för Torn A // schablon	1	x					
	Parkmöbler, lek och idrottsutrustning inkl. montering för Torn C // schablon	1	x					
	Parkmöbler, lek och idrottsutrustning inkl. montering för Torn B // schablon	1	x					
	Parkmöbler, lek och idrottsutrustning inkl. montering för Torn D // schablon	1	x					
	Parkmöbler, lek och idrottsutrustning inkl. montering för Torn E // schablon	1	x					
	Parkmöbler, lek och idrottsutrustning inkl. montering för Torn F // schablon	1	x					
	Pollare. Vestre	530	st					
42169	Övrig markutrustning							
	Buffertcontainer	1	st		Excluded. These would likely be reused.			
	Mätcontainer	1	st					
	pH-justerare	0,666667	st					
	Partickelavskiljare lamell/container	1	st					
	Kemikaliecontainer	1	st					
	Slamhantering	1	st					
	Styrpumpar	2	st					
	Vintersäkring	1	st					
	El + kablage	0,333333	st					
42210	Grundläggnings och förstärkningsvaror							
	Schaktsläde 1.7x2.8x8.0 (BHL)	2,5	x					Assumed reuse (also small impact and same between the alternatives)
	Schaktsläde 1.7x2.8x8.0 (BHL)	1	x					
	Schaktsläde 1.7x2.8x8.0 (BHL)	1	x					
	Schaktsläde 1.7x2.8x8.0 (BHL)	1	x					
42230	Speciella anläggningsvaror							
	Div. utrustning kylning/Värme betong	20870	x					Not possible to assess from this document.
43100	Markanläggningsentreprenader							
	Återställning diverse anläggningar, ytor för stn Järntorget //	100	m2		Not possible to assess the climate impact (quite similar between the alternatives).			
	Återställning diverse anläggningar, ytor för Torn A // schablon	100	m2					
	Återställning diverse anläggningar, ytor för Torn B // schablon // Ökat pga osäker omfattning	1000	m2					
	Återställning diverse anläggningar, ytor för Torn C // schablon	100	m2					
	Återställning diverse anläggningar, ytor för stn Lindholmen // schablon	200	m2					
	Återställning diverse anläggningar, ytor för Torn D // schablon	100	m2					
	Återställning diverse anläggningar, ytor för stn Västra Ramberget // schablon	100	m2					
	Återställning diverse anläggningar, ytor för Torn E // schablon	100	m2					
	Återställning diverse anläggningar, ytor för Torn F // schablon	100	m2					
	Återställning diverse anläggningar, ytor för stn Wieselgrensplatsen // schablon	200	m2					
43111	Rivning, flyttningsentreprenader							
	Rivning bef P-Hus, Lindholmen	1	x					Excluded. Hard to asses since demolition in Klimatkalkyl only concerns road, not buildings
43135	Fjärrvärme / fjärrkylentreprenader							
	Omläggning FV, FK & Gas enl. Swecos kostnadsförslag dat. 2018-08-23 för Torn C	1	x		Not possible to assess amounts of material from this data. Excluded.			
	Fjärrvärmentreprenad dim ?? mm	100	m					
	Fjärrvärmentreprenad servis Lindholmen	100	m					
	Fjärrvärmentreprenad servis Wieselgrensplatsen	100	m					
	Fjärrvärmentreprenad stn Järntorget, budget Sweco	100	m					
	Omläggning Gasledning Lindholmen	1	x					
	Omläggning Fjärrvärmeledning Torn D	1	x					
	Omläggning Fjärrvärmeledning stn Västra Ramberget	1	x					
	Omläggning Gasledning Torn E	1	x					
	Fjärrkylentreprenad dim ?? mm	0	m					
43137	Vägbelysningsentreprenader							
	Vägbelysningsarmatur	10	st					Excluded
	Stolpe eftergivlig L=12 m (vägbelysning)	10	st					Excluded
43141	Bergsprängning / losshållningsentreprenader							
	Losshåll berg Hus volym (Ducimus)	50467,2	m3		Not possible to estimate emissions, some possible overlap with rock masses in Klimatkalkyl.			
	Losshåll berg Hus Yta (Ducimus)	6248	m2					
	Losshåll berg tillägg med elekrtoniska tändare (?)	6248	m2					
	Losshållning VA Hm>0,7	1488,170213	m2					
	Losshåll berg ledningsgrav Hm>0,7m	2348,170213	m3					
	Tätsöm berg c/c 600 (Ducimus)	0	m2					
	Vajersågning bergslänt (bedömt)	3500	m2					
	Bergskrotning vägg klass 1A	3520	m2					
	Bergskrotning vägg klass 2A	0	m2					
	Borrning för betongbalk spontfot m bakåtförankring	179	st					
43142	Bergförstärkningsentreprenader							
	Bergbult 25 mm l=6 m	280	st	🟩	Bergbult	280	st	Klimatkalkyl, made of steel, 12 kg/st
43152	Asfaltbeläggningsentreprenader							
	40 mm ABS 8 B70/100 (NCC Roads)	1790,1	m2	🟩	Bitumenbundna lager (180 mm)	397,8	m2	Recalculate asphalt areas to a volume by taking area*thickness, then divide by 0,18 m to get the corresponding area for the thickness in Klimatkalkyl (180mm).

	70 mm AG 22 B70/100 (NCC Roads)	1790,1	m2	🟩	Bitumenbundna lager (180 mm)	696,15	m2	
	32 mm ABT 11 (NCC Roads)	15476	m2	🟩	Bitumenbundna lager (180 mm)	2751,288889	m2	
	32 mm ABT 16 (NCC Roads) 70 mm AG 16 (NCC Roads)	22273	m2	🟩	Bitumenbundna lager (180 mm)	6310,683333	m2	Thickness distribution unknown. Mean thickness assumed (32+70)mm/2.
	Tillfällig asfaltbeläggning vid Hjultvätt	100	m2	🟩	Bitumenbundna lager (180 mm)	17,77777778	m2	Unkown thickness. If 32 mm i assumed based on it being temporary and thus probably not needing to be as robust.
43156	Väg och ytmarkeringsentreprenader							
	Ytmarkeringar för trafik (schablon) // stn Järntorget	1	omg		Markings. Probably negligible impact. Based on cost templates. The length/area to mark is not visible through this document.			
	Ytmarkeringar för trafik (schablon) // Torn A	1	omg					
	Ytmarkeringar för trafik (schablon) // stn Lindholmen	1	omg					
	Ytmarkeringar för trafik (schablon) // Torn E	1	omg					
	Ytmarkeringar för trafik (schablon) // Torn F	1	omg					
	Ytmarkeringar för trafik (schablon) // stn Wieselgrensplatsen	1	omg					
	Ytmarkeringar för trafik (schablon) // Torn C	1	omg					
	Ytmarkeringar för trafik (schablon) // Torn D	1	omg					
	Ytmarkeringar för trafik (schablon) // stn Västra Ramberget	1	omg					
43164	Platt- och markbeläggningsentreprenader							
	UE stensättning råkantsten RV4	8195	m					The same material as shown in other categories above. Excluded here to avoid double-counting.
43165	Stängsel, staket och räckesentreprenader							
	Stängsel, räcken, grindar komplett arb. för stn Lindholmen // schablon	1	x		Unknown amount and type. Possibly the material in a category above is used here.			
	Stängsel, räcken, grindar komplett arb. för stn Västra Ramberget // schablon	1	x					
	Stängsel, räcken, grindar komplett arb. för stn Wieselgrensplatsen // schablon	1	x					
	Stängsel, räcken, grindar komplett arb. för stn Järntorget // schablon	1	x					
43180	Trädgårdsentreprenader							
	Lövfällande träd, standardtyp	67	st		Vegetation is outside of scope and likely has a negligible climate impact.'			
	Plantering buskar	100	m2					
	Vegetationsytor, plantering, träd mm för stn Järntorget // schablon	1	x					
	Vegetationsytor, plantering, träd mm för Torn A // schablon	1	x					
	Vegetationsytor, plantering, träd mm för Torn B // schablon	1	x					
	Vegetationsytor, plantering, träd mm för stn Lindholmen // schablon	1	x					
	Vegetationsytor, plantering, träd mm för stn Västra Ramberget // schablon (460 m2)	1	x					
	Vegetationsytor, plantering, träd mm för stn Wieselgrensplatsen // schablon	1	x					
	Vegetationsytor, plantering, träd mm för Torn C // schablon	1	x					
	Vegetationsytor, plantering, träd mm för Torn D // schablon	1	x					
	Vegetationsytor, plantering, träd mm för Torn E // schablon	1	x					
	Vegetationsytor, plantering, träd mm för Torn F // schablon	1	x					
	Grässådd	4818	m2					
43214	Jordförstärkningsentreprenader							
	Jetpelare, komplett inkl. omh. av slurry (bedömt)	1019	st		Too little data is known for these different contractors, excluded in both designs			
43224	Broisoleringsentreprenader							
	Tätskikt bottenplattor	622	m					
43225	Skyddsimpregneringsentreprenader							
	Klotterskydd	600	m2					
43235	Spåranläggningsentreprenader							
	Ny spåranläggning Lindholmen inkl. grundläggning (komplett)	700	m					
	Återställning spåranläggning // 1 spår, vändzon inkl. grundläggning (komplett)	110	m					
43239	Övriga speciella anläggningsentreprenader							
	Leitner	1	x		THE CABLE CAR TECHNOLOGY (outside of scope due to lack of data)			
	Leitner	1	x					
	Leitner	1	x					
	Leitner	1	x					
	Leitner	1	x					
43320	Betongentreprenader							
	Stomme - prefab	9717	m2		The actual concrete material used here is shown under Fabriksbetong. Excluded here to avoid double-counting.			
	Stomme - prefab	1	m2					
	Stomme - platta på mark	5390	m2					
	Timtid diverse arbeten	0	tim					
43421	Tätskiktsentreprenader							
	Tätskikt typ epoxy	15107	m2	🟨	Shown as inventory tables. Emissions assessed outside of Klimatkalkyl.			
	Yttertak - Med vinklar och "nedvik"	8173,6	m2	🟨				
	Yttertak - Inv ytskikt/Undertak av marmorocskivor	9616	m2	🟨				
	Yttertak - Standard	648,55	m2	🟨				
43470	Glasfasadentreprenader							
	Fasader - Glas	6296	m2	🟨	Shown as inventory tables. Emissions assessed outside of Klimatkalkyl.			
	Fasader - täta delar	4277	m2	🟨				
	Glasttak	1442,4	m2	🟨				
43500	Stomkompletteringsentreprenader							
	Installationsgolv	457		🟨				
	Installationsgolv	16		🟨				
	Installationsgolv	480		🟨				
	Installationsgolv	3147		🟨				
	Installationsgolv	3147		🟨				
	Installationsgolv	87		🟨				
	Installationsgolv	20		🟨				
	Installationsgolv	188		🟨				
	Installationsgolv	28		🟨				
	Stomkomplettering Cafe	228		🟨				
	Stomkomplettering Teknik	7570		🟨				
	Stomkomplettering Plattformsyta	3605	m2	🟨				
	Stomkomplettering Cirkulation	522	m2	🟨				
	Stomkomplettering Cirkulation	1431	m2	🟨				
	Stomkomplettering Cirkulation	328	m2	🟨				
	Stomkomplettering Yta ej med i redovisningtext på ritning	4304	m2	🟨				
	Stomkomplettering, Kiosk	213	m2	🟨				
	Stomkomplettering, Butik	78	m2	🟨				

	Stomkomplettering, Tvättrum	69	m2	
	Stomkomplettering Publik WC	133		
	Personalrum (wc-dusch)	351	m2	
	Entré/kommunikation	385		Shown as inventory tables. Emissions assessed outside of Klimatkalkyl.
	Stomkomplettering, Säkerhetsrum	31	m2	
437	Ytskiktsentreprenader			
	Invändiga ytskikt Entré/kommunikation	385		
	Invändiga ytskikt Teknik/miljö	1276		
	Inv ytskikt, inredning, Kontrollrum	88	m2	
	Inv ytskikt, inredning, Cirkulation	1431	m2	
	Inv ytskikt, inredning, Cirkulation	328	m2	
	Inv ytskikt, inredning, Cirkulation	522	m2	
	Inv ytskikt, inredning, Säkerhetsrum	31	m2	
	Inv ytskikt, inredning,Cafe/Kiosk/Handel	519	m2	
	Invändiga ytskikt WC	45		
	Invändiga ytskikt Tvättrum	69		
	Invändiga ytskikt Plattformsyta	3605		
	Invändiga ytskikt Yta ej med i redovisningtext på ritning	3360		Shown as inventory tables. Emissions assessed outside of Klimatkalkyl.
	Inv ytskikt, inredning, Personalrum	351	m2	
44100	VS- installationsentreprenader			
	Installationer - Sanitet/Värme	3883	m2	
	Installationer - Sanitet/Värme	550	m2	
	Installationer - Sanitet/Värme	11	m2	
	Installationer - Sanitet/Värme	118	m2	
	Installationer - Sanitet/Värme	15	m2	
	Installationer - Sanitet/Värme	522	m2	
	Installationer - Sanitet/Värme	37	m2	
	Installationer - Sanitet/Värme	16	m2	
	Installationer - Sanitet/Värme	58	m2	
	Installationer - Sanitet/Värme	36	m2	
	Installationer - Sanitet/Värme	61	m2	
	Installationer - Sanitet/Värme	10	m2	
	Installationer - Sanitet/Värme	2392	m2	
	Installationer - Sanitet/Värme	57	m2	
	Installationer - Sanitet/Värme	508	m2	
	Installationer - Sanitet/Värme	62	m2	
	Installationer - Sanitet/Värme	359	m2	
	Installationer - Sanitet/Värme	41	m2	
	Installationer - Sanitet/Värme	349	m2	
	Installationer - Sanitet/Värme	41	m2	
	Installationer - Sanitet/Värme	44	m2	
	Installationer - Sanitet/Värme	34	m2	
	Installationer - Sanitet/Värme	50	m2	
	Installationer - Sanitet/Värme	18	m2	
	Installationer - Sanitet/Värme	39	m2	
	Installationer - Sanitet/Värme	11	m2	
	Installationer - Sanitet/Värme	18	m2	
	Installationer - Sanitet/Värme	20	m2	
	Installationer - Sanitet/Värme	1431	m2	
	Installationer - Sanitet/Värme	22	m2	
	Installationer - Sanitet/Värme	25	m2	
	Installationer - Sanitet/Värme	13	m2	
	Installationer - Sanitet/Värme	21	m2	
	Installationer - Sanitet/Värme	82	m2	
	Installationer - Sanitet/Värme	20	m2	
	Installationer - Sanitet/Värme	21	m2	
	Installationer - Sanitet/Värme	43	m2	
	Installationer - Sanitet/Värme	28	m2	
	Installationer - Sanitet/Värme	328	m2	
	Installationer - Sanitet/Värme	87	m2	
	Installationer - Sanitet/Värme	20	m2	
	Installationer - Sanitet/Värme	18	m2	
	Installationer - Sanitet/Värme	30	m2	
	Installationer - Sanitet/Värme	30	m2	
	Installationer - Sanitet/Värme	31	m2	
	Installationer - Sanitet/Värme	385	m2	
	Installationer - Sanitet/Värme	29	m2	
	Installationer - Sanitet/Värme	20	m2	
	Installationer - Sanitet/Värme	64	m2	
	Installationer - Sanitet/Värme	11	m2	
	Installationer - Sanitet/Värme	2974	m2	
	Installationer - Sanitet/Värme	19	m2	Emissions from installations are assessed outside Klimatkalkyl.
	Installationer - Sanitet/Värme	9	m2	
44120	Sprinklerinstallationsentreprenader (ej std)			
	Installationer - Sprinkler	14518	m2	Shown as inventory in report, but no emission factor was found.
44200	Luftbehandlingsentreprenader			
	Installationer - Luft	550	m2	
	Installationer - Luft	4394	m2	
	Installationer - Luft	11	m2	
	Installationer - Luft	118	m2	
	Installationer - Luft	15	m2	
	Installationer - Luft	522	m2	
	Installationer - Luft	37	m2	
	Installationer - Luft	16	m2	
	Installationer - Luft	58	m2	
	Installationer - Luft	36	m2	
	Installationer - Luft	61	m2	
	Installationer - Luft	10	m2	
	Installationer - Luft	2392	m2	
	Installationer - Luft	57	m2	
	Installationer - Luft	508	m2	
	Installationer - Luft	62	m2	
	Installationer - Luft	359	m2	
	Installationer - Luft	41	m2	
	Installationer - Luft	349	m2	
	Installationer - Luft	41	m2	
	Installationer - Luft	44	m2	
	Installationer - Luft	34	m2	
	Installationer - Luft	50	m2	

	Installationer - Luft	18	m2	
	Installationer - Luft	39	m2	
	Installationer - Luft	11	m2	
	Installationer - Luft	18	m2	
	Installationer - Luft	20	m2	
	Installationer - Luft	1431	m2	
	Installationer - Luft	22	m2	
	Installationer - Luft	25	m2	
	Installationer - Luft	13	m2	
	Installationer - Luft	21	m2	
	Installationer - Luft	82	m2	
	Installationer - Luft	20	m2	
	Installationer - Luft	21	m2	
	Installationer - Luft	43	m2	
	Installationer - Luft	28	m2	
	Installationer - Luft	328	m2	
	Installationer - Luft	87	m2	
	Installationer - Luft	20	m2	
	Installationer - Luft	18	m2	
	Installationer - Luft	30	m2	
	Installationer - Luft	30	m2	
	Installationer - Luft	31	m2	
	Installationer - Luft	385	m2	
	Installationer - Luft	29	m2	
	Installationer - Luft	20	m2	
	Installationer - Luft	64	m2	
	Installationer - Luft	11	m2	
	Installationer - Luft	2974	m2	
	Installationer - Luft	19	m2	Shown as an inventory (in m2) and assessed from another source than Klimatkalkyl
	Installationer - Luft	9	m2	
44300	Kraft-, tele- och belysningsentreprenader			
	Kraft-, tele- och belysningsentreprenader	1	x	
	Kraft-, tele- och belysningsentreprenader	1	x	
	Kraft-, tele- och belysningsentreprenader	1	x	
	Kraft-, tele- och belysningsentreprenader	1	x	
	Kraft-, tele- och belysningsentreprenader	1	x	
	Kraft-, tele- och belysningsentreprenader	1	x	
	Installationskostnad	1	st	
	Installationskostnad Mätcontainer	1	st	
	Installationskostnad pH-justerare	0,666667	st	
	Rörlig kostnad / år pH-justerare	1,333333	st	
	Installationskostnad Partickelavskiljare lamell/container	1	st	
	Installationskostnad Kemikaliecontainer	1	st	
	rörlig kostnad /år Kemikaliecontainer	1	st	
	Installationskostnad Slamhantering	1	st	
	rörlig kostnad /år Slamhantering	1	st	
	Installationskostnad Styrpumpar	2	st	
	rörlig kostnad /år el + kablage	1	st	
	Kraft, tele och belysningsentr.// Hsp kabel Pris?	300	m	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för stn Järntorget	1	x	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för Torn A	1	x	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för stn Lindholmen	1	x	
	Flytt av betalstation, komplett (bedömt)	1	x	
	El- och telekabel o_d från station till torn, dim? skarvar?	720	m	
	El- och telekabel o_d från station till torn, dim? skarvar?	840	m	
	El- och telekabel o_d från station till torn, dim? skarvar?	1200	m	
	El- och telekabel o_d från station till torn, dim? skarvar?	240	m	
	El- och telekabel o_d från station till torn, dim? skarvar?	300	m	
	El- och telekabel o_d från station till torn, dim? skarvar?	750	m	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för Torn B (behövs ej)	1	x	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för stn Lindholmen // gällande trafo, under utredning	1	x	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för stn Västra Ramberget // gällande trafo, under utredning	1	x	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för Torn C	1	x	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för Torn D	1	x	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för stn Västra Ramberget (behövs ej)	1	x	
	Ledningar HSP, LSP, styr, tele komplett arb.	400	m	
	Skarvar LSP, styr, tele komplett arb.	10	st	
	Extra enl. Linus	1	x	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för Torn E	1	x	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för Torn F	1	x	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för stn Wieselgrensplatsen	1	x	
	Ny telebrunn (bedömt)	1	x	
	Ny telebrunn (bedömt)	1	x	
	Ny telebrunn (bedömt)	1	x	
	Ny vägbelysning, markbelysning för stn Järntorget // schablon	1	x	
	Ny vägbelysning, markbelysning för Torn A // schablon	1	x	
	Ny vägbelysning, markbelysning för stn Lindholmen // schablon	1	x	
	Ny vägbelysning, markbelysning för stn Västra Ramberget // schablon	1	x	
	Ny vägbelysning, markbelysning för Torn B // schablon	1	x	
	Ny vägbelysning, markbelysning för Torn C // schablon	1	x	
	Ny vägbelysning, markbelysning för Torn D // schablon	1	x	
	Ny vägbelysning, markbelysning för Torn F // schablon	1	x	
	Ny vägbelysning, markbelysning för Torn E // schablon	1	x	

	Ny vägbelysning, markelysning för stn Wieselgrensplatsen // schablon	1	x		This category is approximated using the areas of electricity installations from another source. Cables etc. are excluded to avoid overlap and double-counting. Lighting are excluded based on that it is expressed with the unit "x", making it difficult to asses. (Facade lightnning is expressed in 1x per station in 1910, making a comparison difficult even though it is expressed in m2 in 1902).			
	Kraft, tele och belysningsentr.// Hsp kabel Pris?	0	m					
	Installationer - El	550	m2	🟨				
	Installationer - El	11	m2	🟨				
	Installationer - El	4488	m2	🟨				
	Installationer - El Fasadbelysning	1748	m2	🟨				
	Installationer - El Fasadbelysning	1924	m2	🟨				
	Installationer - El Fasadbelysning	3948	m2	🟨				
	Installationer - El	118	m2	🟨				
	Installationer - El Fasadbelysning	2933	m2	🟨				
	Installationer - El	15	m2	🟨				
	Installationer - El	522	m2	🟨				
	Installationer - El	37	m2	🟨				
	Installationer - El	16	m2	🟨				
	Installationer - El	58	m2	🟨				
	Installationer - El	36	m2	🟨				
	Installationer - El	61	m2	🟨				
	Installationer - El	10	m2	🟨				
	Installationer - El	2392	m2	🟨				
	Installationer - El	57	m2	🟨				
	Installationer - El	508	m2	🟨				
	Installationer - El	62	m2	🟨				
	Installationer - El	359	m2	🟨				
	Installationer - El	41	m2	🟨				
	Installationer - El	349	m2	🟨				
	Installationer - El	41	m2	🟨				
	Installationer - El	44	m2	🟨				
	Installationer - El	34	m2	🟨				
	Installationer - El	50	m2	🟨				
	Installationer - El	18	m2	🟨				
	Installationer - El	39	m2	🟨				
	Installationer - El	11	m2	🟨				
	Installationer - El	18	m2	🟨				
	Installationer - El	20	m2	🟨				
	Installationer - El	1431	m2	🟨				
	Installationer - El	22	m2	🟨				
	Installationer - El	25	m2	🟨				
	Installationer - El	13	m2	🟨				
	Installationer - El	21	m2	🟨				
	Installationer - El	82	m2	🟨				
	Installationer - El	20	m2	🟨				
	Installationer - El	21	m2	🟨				
	Installationer - El	43	m2	🟨				
	Installationer - El	28	m2	🟨				
	Installationer - El	328	m2	🟨				
	Installationer - El	87	m2	🟨				
	Installationer - El	20	m2	🟨				
	Installationer - El	18	m2	🟨				
	Installationer - El	30	m2	🟨				
	Installationer - El	30	m2	🟨				
	Installationer - El	31	m2	🟨				
	Installationer - El	385	m2	🟨				
	Installationer - El	29	m2	🟨				
	Installationer - El	20	m2	🟨				
	Installationer - El	64	m2	🟨				
	Installationer - El	11	m2	🟨				
	Installationer - El	2974	m2	🟨				
	Installationer - El	19	m2	🟨				
	Installationer - El	9	m2	🟨				
44400	Styr- och övervakningsentreprenader							
	Styr- och övervakningsentreprenader	210	m		Excluded from the scope. Unknown exactly what activties this refers to and not possible to assess climate impact.			
	Styr- och övervakningsentreprenader	273	m					
	Styr- och övervakningsentreprenader	238	m					
	Styr- och övervakningsentreprenader	160	m					
	Styr- och övervakningsentreprenader	202	m					
	Styr- och övervakningsentreprenader	237	m					
	Installationer - Styr	14518	m2					
44500	Transportutrustningsentreprenader							
	Installationer - Hissar	10	st	🟩	Hiss	10	st	
	Installationer - Hissar	2	st	🟩	Hiss	2	st	
	Installationer - Höj- och sänkbara plattformar	3	st					No data found
	Installationer - Rulltrappor	10	st	🟩	Rulltrappa	10	st	
	Installationer - Rulltrappor	4	st	🟩	Rulltrappa	4	st	
45140	Markkomprimeringsmaskiner							
	Envalsvält självg vibr ramstyrd 5-7 ton (Dynapac CA152D)	398,960067	bd					Vibrovält: 0,02 l/m2. Not possible to assess based on this data
	Envalsvält självg vibr ramstyrd 10-13 ton (Dynapac CA302D)	19,466635	bd					Vibrovält: 0,02 l/m2
	Envalsvält självgående vibr ramstyrd 20 ton (Dynapac CA6000D)	83,333333	bd					Vibrovält: 0,02 l/m2
	Vibratorplatta 465 kg (Swepac FB465)	13,1625	bd	🟩	Diesel MK1	70,551	liter	IVL Miljödata för arbetsfordon (Erlandsson, 2013): Vibroplatta 510 kg (diesel): Bränsleåtgång = 1,34 L/h. Utnyttjandegrad = 0,5 h/h. Assume 8h/bd (8h/day assumed in IVL)
	Vibratorplatta 450-700 kg (Swepac FB700)	762,856185	bd	🟩	Diesel MK1	4088,909152	liter	IVL Miljödata för arbetsfordon: Vibroplatta 510 kg (diesel): Bränsleåtgång = 1,34 L/h. Utnyttjandegrad = 0,5 h/h. Assume 8h/bd (8h/day assumed in IVL)
45150	El- och värmeutrustning							
	Gummikabel REVE 5x16 63 A	134946	bd		Likely negligible. Excluded in both			
	Generator bensin <3-7 kVA	1,555556	bd					
	Undercentral 125 A skåp	9,21875	st					
	Kompressor på hjul diesel 4 m3/min (KaeserM38	0	bd					
45172	Bygghissar							
	Bygghiss kugg 2200 kg	105	bd		Unknown data. Excluded.			
	Bygghiss kugg 2200 kg	168	bd					
	Bygghiss kugg 2200 kg	126	bd					
	Bygghiss kugg 2200 kg	84	bd					
	Bygghiss kugg 2200 kg	105	bd					
	Bygghiss kugg 2200 kg	126	bd					
45173	Liftar							

	Saxlift eldriven arbetsh=5.8 m (Genie 1930)	1239	bd					No data on electricity consumption for the elevator. Smaller climate impact compared to diesel
	Saxlift dieseldriven arbetsh=9.7 m (Genie GS3268RT)	1239	bd	🟩	Diesel MK1	19824	liter	IVL Miljödata: Personlyft: 4L/h, Load factor 0,5. If 8 h/day is assumed
	Bomlift eldriven arbetsh=8.8 m (Genie Z30/20N)	1239	bd					No data on electricity consumption for the elevator. Smaller climate impact compared to diesel
45180	Byggmaskiner							
	Alu- sloda med handtag b=1.0 m	5544	tim		Excluded from the scope due to difficulty in approximating emissions for all kinds of machinery. Done in both design alternatives. Also, several of these objects does not consume any fuel and the material in the tool itself is outside the scope.			
	Gipsbock (starke Arvid)	1606,5	bd					
	Avtappningsslang 6"	25200	bd					
	Skottkärra	1606,5	bd					
	Störttrumma Geda l=6 m	1606,5	bd					
	Gipsvagn (Starke Arvid)	1606,5	bd					
	Fodervagn (Starke Arvid)	1606,5	bd					
	Verktygskista 500 kg (Starke Arvid)	1606,5	bd					
	Släpkärra personbil < 1000 kg (Sävsjösläpet)	1606,5	bd					
	Transportvagn handdragen (Runelandhs)	1606,5	bd					
	Bruksblandare El handhållen	3213	bd					
	Valvstav 45-70 mm	5544	bd					
	Stavvibrator (alla typer) inbyggd motor och frekvensomformare	8316	bd					
	Frekvensomformare 2 uttag (Dynapac EU50)	4158	bd					
	Vibratorbalk dubbel 6.25 m (Dynapac BR64)	2772	bd					
	Glättningsmaskin el 1200 mm	2772	bd					
	Kompressor på ram för provtryckning 150 l/min	0	bd					
	Kompressor på hjul diesel 6 m3/min (Atlas XAS186DD)	9,301088	bd					
	Centrifugalpump el 550 l/min (Grindex Minex)	0	bd					
	Centrifugalpump el <1900 l/min (Grindex Minor)	252	bd					
	Centrifugalpump el <2400 l/min (Grindex Major H)	2016	bd					
	Centrifugalpump el <5900 l/min (Grindex Master N)	252	bd					
	Betongbask 750 l	2992,5	bd					
	Materialbask < 1000 kg	1606,5	bd					
	Skruvdragare batteri (Hilti SF4000)	3213	bd					
	Skruvdragare batteri automat (Hilti SD5000)	3213	bd					
	Bultpistol (Hilti DX460)	3213	bd					
	Mejselhammare luft < 6 kg	0	bd					
	Mejselhammare el 5 kg (Hilti TE500)	3213	bd					
	Bilningshammare el 30 kg (Hilti TE3000)	3213	bd					
	Sticksåg el	3213	bd					
	Tigersåg el "stor"	3213	bd					
	Handcirkelsåg el	3213	bd					
	Kap/klyvsåg d=125 (Gjerde Maxicut)	3213	bd					
	Kap/geringssåg d <100 (DW707)	3213	bd					
	Asfaltkap	20,447736	bd					
	Kärnborrningsutrustning	0,125	bd					
	Svetsmaskin för rör d < 400 mm	0,972222	bd					
	Svetsmaskin för elektrosvets. Dim 110-110 mm. (Bedömd hyra 2.500:-/vecka)	0,583333	bd					
	Kap/vinkelslip el	3213	bd					
	Handborrmaskin el	3213	bd					
	Borrhammare (Hilti TE30)	3213	bd					
	Klipptång handhållen (DC16,20)	5502	bd					
	Klippmaskin (Weelu 60/25)	1375,5	bd					
	Bockningsmaskin (Bendof Micro)	4126,5	bd					
	Bockningsmaskin (DBD25)	1375,5	bd					
	Radiebockningsutrustning (Weelu 320/400)	1375,5	bd					
	Najningsapparat batteri (RB650)	0	bd					
	Provtryckningspump handpump	0	bd					
45210	Lastbilar, dumprar, truckar							
	Vattenbil med tank	0,063898	tim					
	Tippbil 4-axl 17t	1,744083	tim					
	Tippbil 4-axl 17t	7,093333	tim					Potential overlap with earth and rock in Klimatkalkyl, but also relatively low environmental impact that are quite similar between the alternatives.
	Tippbil 4-axl 17t	0,405333	tim					
	Tippbil 4-axl 17t	0,810667	tim					
	Kranbil 3-axl 7t/15tm	18	tim	🟩	Diesel MK1	86,4	liter	IVL Miljödata: Mobile crane, lower effect assumed for both designs. 75-130 kw: 12L/h, load factor 0,4
	Kranbil 3-axl 9t/22tm	40	tim	🟩	Diesel MK1	192	liter	
	Kranbil 3-axl 9t/22tm	30	tim	🟩	Diesel MK1	144	liter	
	Kranbil 3-axl 9t/22tm	30	tim	🟩	Diesel MK1	144	liter	
	Kranbil 3-axl 9t/22tm	80	tim	🟩	Diesel MK1	384	liter	
	Kranbil 3-axl 9t/22tm	30	tim	🟩	Diesel MK1	144	liter	
	Kranbil 3-axl 9t/22tm	30	tim	🟩	Diesel MK1	144	liter	
	Kranbil 3-axl 9t/22tm	80	tim	🟩	Diesel MK1	384	liter	
	Kranbil 3-axl 9t/22tm	30	tim	🟩	Diesel MK1	144	liter	
	Kranbil 3-axl 9t/22tm	30	tim	🟩	Diesel MK1	144	liter	
	Kranbil 3-axl 9t/22tm	40	tim	🟩	Diesel MK1	192	liter	
	Kranbil 4-axl 39tm	915,6	tim	🟩	Diesel MK1	4394,88	liter	
45220	Grävmaskiner							
	Grävmaskin bandb 1,0 -1,2 m3 Lång sticka	2309,166667	tim	🟩	Diesel MK1	1385,5	liter	IVL: Assume minigrävare: load factor 0,25, 2,4 L/h
	Grävmaskin bandb (21.1325) 21-24 ton	60,5	tim	🟩	Diesel MK1	592,9	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1325: Bränsleåtgång = 14 L/h. Utnyttjandegrad = 0,7
	Grävmaskin bandb (21.1325) 21-24 ton	63,166667	tim	🟩	Diesel MK1	619,0333366	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1325: Bränsleåtgång = 14 L/h. Utnyttjandegrad = 0,7
	Grävmaskin bandb (21.1325) 21-24 ton	112,666667	tim	🟩	Diesel MK1	1104,133337	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1325: Bränsleåtgång = 14 L/h. Utnyttjandegrad = 0,7
	Grävmaskin bandb (21.1325) 21-24 ton	85,316667	tim	🟩	Diesel MK1	836,1033366	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1325: Bränsleåtgång = 14 L/h. Utnyttjandegrad = 0,7
	Grävmaskin bandb (21.1325) 21-24 ton	42,833333	tim	🟩	Diesel MK1	419,7666634	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1325: Bränsleåtgång = 14 L/h. Utnyttjandegrad = 0,7
	Grävmaskin bandb (21.1325) 21-24 ton	45,333333	tim	🟩	Diesel MK1	444,2666634	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1325: Bränsleåtgång = 14 L/h. Utnyttjandegrad = 0,7
	Grävmaskin bandb (21.1325) 21-24 ton	23	tim	🟩	Diesel MK1	225,4	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1325: Bränsleåtgång = 14 L/h. Utnyttjandegrad = 0,7
	Grävmaskin bandb (21.1325) 21-24 ton	16,666667	tim	🟩	Diesel MK1	163,3333366	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1325: Bränsleåtgång = 14 L/h. Utnyttjandegrad = 0,7
	Grävmaskin bandb (21.1328) 33-40 ton	4873,433333	tim	🟩	Diesel MK1	105266,16	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1328: Bränsleåtgång = 27 L/h. Utnyttjandegrad = 0,8
	Grävmaskin bandb (21.1322) 14-16 ton	1236,666667	tim	🟩	Diesel MK1	12119,33334	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1322 not found, instead 14-28 ton category is used: Bränsleåtgång = 14 L/h. Utnyttjandegrad = 0,7

	Grävmaskin bandb (21.1326) 24-28 ton	2	tim	🟩	Diesel MK1	19,6	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1326, instead 14-28 ton category is used: Bränsleåtgång = 14 L/h. Utnyttjandegrad = 0,7
	Grävmaskin bandb (21.1326) 24-28 ton	2	tim	🟩	Diesel MK1	19,6	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1326, instead 14-28 ton category is used: Bränsleåtgång = 14 L/h. Utnyttjandegrad = 0,8
	Grävmaskin bandb (21.1326) 24-28 ton	24	tim	🟩	Diesel MK1	235,2	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1326, instead 14-28 ton category is used: Bränsleåtgång = 14 L/h. Utnyttjandegrad = 0,9
	Grävmaskin bandb (21.1326) 24-28 ton	2	tim	🟩	Diesel MK1	19,6	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1326, instead 14-28 ton category is used: Bränsleåtgång = 14 L/h. Utnyttjandegrad = 0,10
	Grävmaskin bandb (21.1326) 24-28 ton	9,375	tim	🟩	Diesel MK1	91,875	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1326, instead 14-28 ton category is used: Bränsleåtgång = 14 L/h. Utnyttjandegrad = 0,11
	Grävmaskin bandb (21.1326) 24-28 ton	4	tim	🟩	Diesel MK1	39,2	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1326, instead 14-28 ton category is used: Bränsleåtgång = 14 L/h. Utnyttjandegrad = 0,12
	Grävmaskin bandb (21.1327) 28-31 ton	1005,069089	tim	🟩	Diesel MK1	16081,10542	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1327: Bränsleåtgång = 20 L/h. Utnyttjandegrad = 0,8
	Grävmaskin bandb (21.1327) 28-31 ton	627,8706	tim	🟩	Diesel MK1	10045,9296	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1327: Bränsleåtgång = 20 L/h. Utnyttjandegrad = 0,9
	Grävmaskin bandb (21.1327) 28-31 ton	0	tim	🟩	Diesel MK1	0	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1327: Bränsleåtgång = 20 L/h. Utnyttjandegrad = 0,10
	Grävmaskin bandb (21.1327) 28-31 ton	2270,915556	tim	🟩	Diesel MK1	36334,6489	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1327: Bränsleåtgång = 20 L/h. Utnyttjandegrad = 0,11
	Grävmaskin bandb (21.1327) 28-31 ton	780,656467	tim	🟩	Diesel MK1	12490,50347	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1327: Bränsleåtgång = 20 L/h. Utnyttjandegrad = 0,12
	Grävmaskin bandb (21.1327) 28-31 ton	581,373635	tim	🟩	Diesel MK1	9301,97816	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1327: Bränsleåtgång = 20 L/h. Utnyttjandegrad = 0,13
	Grävmaskin bandb (21.1327) 28-31 ton	5968,635687	tim	🟩	Diesel MK1	95498,17099	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1327: Bränsleåtgång = 20 L/h. Utnyttjandegrad = 0,14
	Grävmaskin bandb (21.1327) 28-31 ton	475,378341	tim	🟩	Diesel MK1	7606,053456	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1327: Bränsleåtgång = 20 L/h. Utnyttjandegrad = 0,15
	Grävmaskin bandb (21.1327) 28-31 ton	1157,19008	tim	🟩	Diesel MK1	18515,04128	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1327: Bränsleåtgång = 20 L/h. Utnyttjandegrad = 0,16
	Grävmaskin bandb (21.1327) 28-31 ton	1451,265689	tim	🟩	Diesel MK1	23220,25102	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1327: Bränsleåtgång = 20 L/h. Utnyttjandegrad = 0,17
	Grävmaskin bandb 40t m teleskopsticka	1236,666667	tim	🟩	Diesel MK1	26712,00001	liter	IVL Mijlödata för arbetsfordon: Two possibilities: 33-40t or 40-66t. Exact type unknown. Do a conservative assumption and assume the smallest since that would fulfill the 40t demand with a smaller fuel consumption? Bränsleåtgång = 27 L/h. Utnyttjandegrad = 0,8
	Grävmaskin hjulb (21.2418) 0.9-1.0 m3 m vagn	2796,010476	tim	🟩	Diesel MK1	87,7000002	liter	IVL: Assume minigrävare: load factor 0,25, 2,4 L/h
	Hydraul btghammare -30tons maskin	146,166667	tim		No emission factor in source			Excluded from both alternatives because data is given per ton of crushed rock, not applicable here.
	Grävmaskin bandb (21.1327) 28-31 ton - bro	843,58	tim	🟩	Diesel MK1	13497,28	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1327: Bränsleåtgång = 20 L/h. Utnyttjandegrad = 0,8
45230	Hjul och bandlastare, bandschaktare							
	Hjullastare (22.1517) 18-24 ton	5126,479783	tim	🟩	Diesel MK1	102529,5957	liter	IVL Miljödata för arbetsfordon: hjullastare capacity 17-24 ton: 25 L/h, load factor = 0,8
45240	Väghyvlar							
	Väghyvel	0,666667	tim	🟩	Diesel MK1	8,4000042	liter	IVL Miljödata för arbetsfordon: Assume lowest capacity: 18 L/h, load factor = 0,7
45250	Betongpumpar							
	Betongpump FB M46 pumpad m3	21242,01	m3					Not included due to double-counting of concrete
	Betongpump FB M42 grundavgift inkl 25 m3 pumpn	5	st	-	-	-		The material in the actual machinery is not assessed, only the fuel consumption during use
	Betongpump FB M46 grundavgift inkl 25 m3 pumpn	100	st	-	-	-		
	Betongpump FB M46 per timme	4098,267551	tim	🟩	Diesel MK1	32786,14041	liter	IVL Miljödata för arbetsfordon: Betongpump 130-560kW: Bränsleåtgång = 40 L/h. Utnyttjandegrad = 0,2
45270	Mobilkranar							
	Byggkran IGO 50	2100	bd	🟩	Diesel MK1	80640	liter	IVL Miljödata includes to mobil cranes. The type is unkown so the smaller is assumed: 12 L/h, load factor: 0,4 h/h. Assumed 8h/building day
46230	Trafikomläggningsentreprenader							
	Tillfälliga trafikomläggningar, % på MK för stn Järntorget	0	x		Temporary changes in traffic. Excluded due to lack of data.			
	Tillfälliga trafikomläggningar, % på MK för Torn B	0	x					
	Temorär flytt av flytbrygga // PRIS?	1	x					
	Nytt permanent läge flytbrygga // PRIS?	1	x					
	Tillfälliga trafikomläggningar, % på MK för Torn A	0	x					
	Tillfällig bro för GC-väg över schakten	1	x					
	Tillfälliga trafikomläggningar, % på MK för stn Wieselgrensplatsen	0	x					
	Tillfällig hållplats för spårvagn för stn Wieselgrensplatsen	1	x					
	Tillfälliga trafikomläggningar, % på MK för Torn F	0	x					
	Tillfälliga trafikomläggningar, % på MK för stn Lindholmen	0	x					
	Tillfälliga trafikomläggningar, % på MK för Torn C	0	x					
	Tillfälliga trafikomläggningar, % på MK för Torn D	0	x					
	Tillfälliga trafikomläggningar, % på MK för stn Västra Ramberget	0	x					
	Tillfälliga trafikomläggningar, % på MK för Torn E	0	x					
46250	Ställningsentreprenader							
	Ställning	6296	m2					Temporary construction should not be considered if reused. Assumed to be reused enough for the climate impact here to be negligible.
	Ställning	4277	m2		-			
46270	Kran och hissentreprenader							
	Avetablering liten byggkran	14	st					
	Etablering kuggstångshiss	6	st					
	Avetablering kuggstångshiss	6	st					
	Service byggkran	7	bmån					
	Service byggkran	14	bmån					
	Service byggkran	17	bmån					
	Service byggkran	7	bmån					
	Service byggkran	14	bmån					
	Service byggkran	22,4	bmån					
	Service byggkran	16,8	bmån					
	Service byggkran	13,066667	bmån					
	Service byggkran	15,866667	bmån					
	Service byggkran	20,533333	bmån					

	Service bygghiss	34	bmån		Excluded. Difficult to assess the climate impact of establishing and moving a crane, as well as service of the crane.			
	Etablering liten byggkran	14	st					
	Flyttar innom området	28	st					
46310	Renhållningsavgifter inkl hyra sopcontainer							
	Tippavgift brännbart inkl. trp. (ton)	120	ton		Excluded. End-of-life is outside of the scope and possible doublecounting with material from other categories that are waste in this step.			
	Tippavgift plaströr inkl. trp. (ton)	96	ton					
	Tippavgift osorterat inkl. trp. (ton)	20	ton					
	Tippavgift el, tele kablar inkl. trp. (ton)	0	ton					
	Tippavgift div. obrännbart (ton)	52	ton					
	Tippavgift div. obrännbart (ton)	30	ton					
	Tippavgift div. obrännbart (ton)	30	ton					
	Tippavgift div. obrännbart (ton)	20	ton					
	Tippavgift div. obrännbart (ton)	50	ton					
	Tippavgift div. obrännbart (ton)	15	ton					
	Tippavgift div. obrännbart (ton)	33	ton					
	Tippavgift div. obrännbart (ton)	30	ton					
	Tippavgift el, tele kablar inkl. trp. (ton)	14	ton					
	Tippavgift el, tele kablar inkl. trp. (ton)	1	ton					
	Tippavgift el, tele kablar inkl. trp. (ton)	5	ton					
	Tippavgift el, tele kablar inkl. trp. (ton)	4,27	ton					
	Tippavgift el, tele kablar inkl. trp. (ton)	0,5	ton					
	Tippavgift el, tele kablar inkl. trp. (ton)	0	ton					
46313	Deponiavgifter (ej std)							
	Tippavgift betong < 500 mm inkl trp (ton)	1420,1	ton		This category only refers to the cost of landfill (deponi). Excluded to avoid double-counting with other categories such as earth masses or residuesfrom concrete etc.			
	Tippavgift SGN-rör inkl trp (ton)	87,5	ton					
	Tippavgift FJV ledning inkl trp (ton)	294	ton					
	Tippavgift bänkar, papperskorgar, pollare, staket inkl trp (ton)	70	ton					
	Tippavgift ytskikt asfalt, betongplattor, kantstöd inkl trp (ton) PRIS?	10316,8	ton					
	Tippavgift asfalt inkl trp (ton)	741,312	ton					
	Tippavgift jordschakt inkl trp (ton)	4764	ton					
	Tippavgift jordschakt KM<MKM 80 kr/ton inkl trp, schaktbil 17t 70 kr/ton	220329,167	ton					
	Tippavgift berg 0 kr/t + trp 55 kr/t	145715,9427	ton					
46410	Handverktyg, redskap							
	Diamantklinga	11,684421	st					No data to assess climate impact (same and excluded from both designs) alternatives)
	Handverktyg, redskap (kostnad/Mk tim)	98320	mktim		-			
46630	Formutrustning							
	Arbetsställning	37007,3	m3		Excluded due to possible reuse and lack of exact data.			
	Formmaterial för avstängning	1368	m2					
	Formkostnad Cuplock	13776,0274	m3					
	Peri form bottenplatta H 1500	1694	m2					
	Peri form bottenplatta H 2500	500	m2					
	Peri form bottenplatta H 3000	420	m2					
	Form Bottendel	14900	m2					
46640	El, vatten, värme och ventilationsutrustningar							
	Elkabel REVE 5x16 63 A	323,958333	m					Not assessed here. Installations are instead approximated based on areas in an above category.
46650	Ställningar, skyddsräcken, arbetsbockar och stegar							
	Hantverkarställning 1.75x0.73	1239	st/bd		Assumed that these are reused in other projects. Excluded based on difficulty to allocate. This might also be what is referred to in "ställningsentreprenader". (No corresponding category in 1910).			
	Trappstege h=1.5 m	1239	bd					
	Arbetsbock 3 steg	1239	bd					
	Byggtrappa	1239	bd					
	Trapptorn av Haki h=6.5 m	1155	st/bd					
	Rullställning Haki h=2.7 m	1239	st/bd					
	Rullställning Haki h=4.7 m	1239	st/bd					
	Rullställning lättmetall 1.4x3.0 8 steg	1239	st/bd					
	Rullställning Zip up Snappy	1239	st/bd					
46680	Väderskyddsutrustning							
	Presenning JP503 köp 4.0x6.0	500	st	🟩	HDPE/LDPE (PE)	3000	kg	W=250 g/m2 (Jensen Protect AB, n.d.)
	Presenning JP503 köp 6.0x8.0	500	st	🟩	HDPE/LDPE (PE)	6000	kg	W=250 g/m2
	Presenning PE80 lättvikt köp 6.0x10.0	500	st	🟩	HDPE/LDPE (PE)	2550	kg	W=ca 85 g/m2
46690	Övrigt hyresmaterial							
	Gallervält b=1000	4,276522	bd					Excluded: Rented material, will be reused, low use time
47300	Besiktningar							
	Maskinbesiktning kran	14	st		Excluded. Difficult to estimate climate impact. Could be assumed to be maintenance (excluded)			
	Maskinbesiktning hiss	6	st					
47400	Kontroller och provningar							
	TV-inspekt av rörledn	700	m		Control and testing is excluded from the scope due to dificulty in approximating data.			
	Slamsugning brunn	14	st					
	Spolning självfallsledning	700	m					
	Täthetsprovning av självfallsledningar	700	m					
	Täthetsprovning nedstigningsbrunn dim 1000	0	st					
	Täthetsprovning nedstigningsbrunn dim 600	0	st					
	Täthetsprovning nedstigningsbrunn dim 400	14	st					
	Täthetsprovning nedstigningsbrunn dim 200	0	st					
	Täthetsprovning, spolning/rensning samt kloering av tryckledningar dim PE25-160 (bedömt)	1045	m					
	Filmning av rörledning	480	m					
	Filmning av rörledning	120	m					
	Filmning av rörledning	260	m					
	Filmning av rörledning	110	m					
	Filmning av rörledning	100	m					
	Filmning av rörledning	150	m					
	Filmning av rörledning	150	m					
53120	El- förbrukningsavgifter							
	EL-förbrukningsavgift	34000	kWh	🟩	tot	534000	kWh	
	EL-förbrukningsavgift	35000	kWh	🟩	Likely only a small part of the electricity used during construction (Jakob). Corresponding data not included in 1910.			
	EL-förbrukningsavgift	37500	kWh	🟩				
	EL-förbrukningsavgift	42500	kWh	🟩				
	EL-förbrukningsavgift	55000	kWh	🟩				
	EL-förbrukningsavgift	35000	kWh	🟩				
	EL-förbrukningsavgift	45000	kWh	🟩				
	EL-förbrukningsavgift	85000	kWh	🟩				
	EL-förbrukningsavgift	35000	kWh	🟩				
	EL-förbrukningsavgift	60000	kWh	🟩				
	EL-förbrukningsavgift	70000	kWh	🟩				
57110	Bilfrakter							

Turbilstransport Ramirent	915,6	st	Excluded based on uncertainties in means of transport, amount of transported material and distance.
Bilfrakter. Vestre	20,384615	st	

Table A.2. Bill of quantities for design 2

Design alternative 2

🟨 Assessed outside of Klimatkalkyl
🟩 Included in inventory Klimatkalkyl

		Amount			Name in Klimatkalkyl	Recalculation	Unit	Comments
41111	Fyllnadsjord							
	Fyllnadsjord (ton) inkl. trp	104664	ton	🟩	Jord Fall B, Fyll	65415	m3	D=1,6 ton/m3 for earth masses (Klimatkalkyl based on Erlandsson (2010)). Divide mass by density of earth masses/gravel to get the volume.
41112	Växtjord							
	Växtjord klass 1 typ A (ny gräsyta) inkl.trp. (ton) Lysegården	29,0352	ton	🟩	Jord Fall B, Fyll	18,147	m3	D=1,6 ton/m3. Assumed that the density is the same for these soils as for earth masses in Klimatkalkyl.
	Planteringsjord Hasselfors E-jord inkl.trp. (ton)	600,1528	ton	🟩	Jord Fall B, Fyll	375,0955	m3	D=1,6 ton/m3. Klimatkalkyl/(Erlandsson, 2010).
	Växtbädd-ytlager inkl.trp. (ton) pris?	647,9928	ton	🟩	Jord Fall B, Fyll	404,9955	m3	D=1,6 ton/m3. Klimatkalkyl/(Erlandsson, 2010).
	Hasselfors Trädgårdsjord E (ton)	257,4	ton	🟩	Jord Fall B, Fyll	160,875	m3	D=1,6 ton/m3. Klimatkalkyl/(Erlandsson, 2010).
	Skelettjord komplett (bedömt)	0	m3		-	-	-	
41120	Grusmaterial							
	Sorterat grus 0-8 mm (ton) inkl. trp	1153,684	ton	🟩	Berg Fall B, Fyll	769,1226667	m3	D=1,5 ton/m3 (Klimatkalkyl via Erlandsson (2010)). Assumed that gravel can be approximated as being in the same category as crushed rock.
	Bakbar sand 0-4 mm (ton)	231,44	ton	🟩	Jord Fall B, Fyll (sand)	165,3142857	m3	Assumed that the impact of sand can be classified as earth, depending mainly on transport. D = 1,4 ton/m3 (Snabbgrus, accessed 2020, a)
	Kabelsand inkl trp (ton) inkl. trp	144,375	ton	🟩	Jord Fall B, Fyll (sand)	103,125	m3	Same reasoning as above. D= 1.4 ton/m3 (Snabbgrus, accessed 2020, a)
	Kullersten 100-200 mm (m³)	51,9	m3	🟩	Granit	77,85	ton	D=1,5 ton/m3 for cobblestone (source: Snabbgrus, accessed 2020, b). Added as "granite" in Klimatkalkyl.
	Väggrus 0-18 mm inkl trp (ton)	890,817	ton	🟩	Berg Fall B, Fyll	593,878	m3	D=1,5 ton/m3 (Klimatkalkyl via Erlandsson (2010)). Assumed that gravel can be approximated as being in the same category as crushed rock.
41122	Sorterat grus (ej std)							
	Rörgravsgrus 0-8 mm inkl. trp	11126,83475	ton	🟩	Berg Fall B, Fyll	7417,889833	m3	D=1,5 ton/m3 (Klimatkalkyl via Erlandsson (2010)) and Snabbgrus (accessed 2020, c).
41131	Råbergmaterial							
	Sprängsten (ton)	3900	ton	🟩	Bergschakt Fall A	2166,666667	m3	D=1,8 ton/m3. Density of crushed rock (Klimatkalkyl, based on Erlandsson (2010)).
	Kreditering i kross	498,980641	ton		-	-	-	Excluded, unknown exatctly what this refers to.
41133	Krossat bergmaterial							
	Makadam 4-8 mm (ton) inkl. trp	322	ton	🟩	Berg Fall B, Fyll	247,6923077	m3	Erlandsson (2010)/IVL: Density = 1,3 ton/m3
	Samkross 0-18 mm (ton) inkl. trp	15,7152	ton	🟩	Berg Fall B, Fyll	8,730666667	m3	If D=1.8.
	Samkross 0-32 mm (ton) inkl. trp	23875,15833	ton	🟩	Berg Fall B, Fyll	13263,97685	m3	
	Samkross 0-40 mm (ton) inkl. trp	11321,4348	ton	🟩	Berg Fall B, Fyll	6289,686	m3	
	Samkross 0-40 mm inkl.trp. (ton)	49,2336	ton	🟩	Berg Fall B, Fyll	27,352	m3	
	Samkross 0-63 mm inkl.trp. (ton)	714,582	ton	🟩	Berg Fall B, Fyll	396,99	m3	
	Samkross 0-90 mm (ton) inkl. trp	44060,55966	ton	🟩	Berg Fall B, Fyll	24478,0887	m3	
	Samkross 0-150 mm (ton) inkl. trp	55	ton	🟩	Berg Fall B, Fyll	30,55555556	m3	
	Makadam 8-16 mm (ton) inkl. trp.	664,7	ton	🟩	Berg Fall B, Fyll	474,7857143	m3	Erlandsson(2010)/IVL: Density = 1,4 ton/m3
41210	Fabriksbetong							
	Betong C20/25 S2 trög 32	2,001	m3	🟩	Betong	2,001	m3	Average concrete as in Klimatkalkyl is assumed.
	Betong C20/25 XC 1 16 S4 Cem II	897,435	m3	🟩	Betong, klass 2	897,435	m3	Cem II = Concrete , class 2 in Klimatkalkyl
	Betong C30/37 S3 lätt 32	31,248	m3	🟩	Betong	31,248	m3	Klimatkalkyl concrete assumed
	Jordfuktig betong, inkl transport med kranbil	778,766667	m3	🟩	Betong	778,766667	m3	Klimatkalkyl concrete assumed
	Betong under vatten	809,235	m3	🟩	Betong	809,235	m3	Klimatkalkyl concrete assumed
	Betongplatta till VA-ledning AS1400btg // 100x2x? m // komplett // Pris?	120	m2	🟩	Betong	60	m3	Missing dim. = ca 0,5 m (Jakob Persson). V = A * t.
	Plastgjuten betongbassäng Stn Lindholmen // vägg/ kant 297 lpm // komplett // bedömt	42	m3	🟩	Betong	42	m3	Klimatkalkyl concrete assumed
	Plastgjuten betongbassäng Stn VR // vägg/ kant 198 lpm // komplett // bedömt	28	m3	🟩	Betong	28	m3	Klimatkalkyl concrete assumed
	Plastgjuten betongbassäng Stn Lindholmen botten 1169 m2 // komplett // bedömt	234	m3	🟩	Betong	234	m3	Klimatkalkyl concrete assumed
	Plastgjuten plint till spång dim 20 cm, h= 1m	312	st	🟩	Betong	39,20707632	m3	Volume calculated. The bottom has round shape (Jakob Persson).
	Plastgjuten betongbassäng Stn VR botten 1217 m2 // komplett // bedömt	243	m3	🟩	Betong	243	m3	Klimatkalkyl concrete assumed
	Plastgjuten stödmur, ramp Stn W // bedömt	167	m3	🟩	Betong	167	m3	Klimatkalkyl concrete assumed
	Kammarbrunn för S1400BTG infällt på bef S1400 // pris?	48,3	m3	🟩	Betong	48,3	m3	Klimatkalkyl concrete assumed
	C35/45 vct 0,40 S3 - XD3, XS3, XF4	22547,85276	m3	🟩	Betong	22547,85276	m3	Klimatkalkyl concrete assumed
41222	Plattor och marksten av betong							
	Gräsarmsten Typ A 600x400x100 142 kg/m2	276,15	m2	🟩	Betong	16,338875	m3	Recalculated to volume via the given weight and the density of concrete
	Marksten hög kvalité	11583,6	m2	🟩	Betongmarkplattor	11583,6	m2	No thickness is given. Assume default thickness as in Klimatkalkyl (done in 1902 as well).
	Betongplatta 500x500x50 grå (St:Eriks)	2013,9	m2	🟩	Betong	100,695	m3	Recalculated to volume via the given weight and the density of concrete
41224	Kantstöd av betong							
	Hållplatskantstöd 400x1000x320 mm	60,9	m	🟩	Betong	7,7952	m3	Assumed that each support lies next to each other on the length. The total volume will then be 0,40m*60,9m*0,32m. Steel rebars are not considered. Judged reasonable since steel constitute less that 0.5% of the total weight (Benders, 2015).
	Kantstöd Benders frakt	11,6	ton		-	-	-	Excluded to avoid doublecounting with the above volume
41230	VA- material av betong							
	Avser nedstigningsbrunn dim 1000 mm, komplett	26	st	🟩	Brunn, nedstigningsbrunn betong	26	st	Assumed same dim. as in Klimatkalkyl

	Rensbrunn dim 400 mm komplett	4	st	🟩	Brunn, nedstigningsbrunn betong (estimated)		4	st	Estimated with other concrete well in Klimatkalkyl
	Elementbrunn för S1400BTG // Pris?	1	st	🟩	Brunn, nedstigningsbrunn betong (estimated)		1	st	Estimated with other concrete well in Klimatkalkyl
	Brunn för D500BTG // Pris?	1	st	🟩	Brunn, nedstigningsbrunn betong (estimated)		1	st	Estimated with other concrete well in Klimatkalkyl
	Fraktkostnad VA material av betong inkl pallar o dyl 0-900 kr/ton	401,72475	ton		-	-			Excluded since this concerns the transport cost. Packaging and other material may also be included in the tranpsort. Excluded to avoid doublecounting.
	225 Oarm rakt rör l=1700 112kg/m	115,5	m	🟩	Betong		5,39	m3	Non-reinforced objects are approximated as "concrete"
	300 Oarm rakt rör l=2000 140 kg/m	315	m	🟩	Betong		18,375	m3	
	400 Oarm rakt rör l=2200 330 kg/m	157,5	m	🟩	Betong		21,65625	m3	
	225 Oarm kortrör l=500 61 kg/st	0	st		-	-			
	300 Oarm kortrör l=500 88 kg/st	5	st	🟩	Betong		0,183333333	m3	
	400 Oarm kortrör l=500 138 kg/st	11,25	st	🟩	Betong		0,646875	m3	
	225x225 Oarm grenrör 45° 116 kg/st	0	st		-	-			
	300x225 Oarm grenrör 45° 152 kg/st	0	st		-	-			
	400x225 Oarm grenrör 45° 218 kg/st	0	st		-	-			
	225 Oarm krokrör 7°-45° 27-49 kg/st	0	st		-	-			
	300 Oarm krokrör 7°-45 38-99 kg/st	0	st		-	-			
	400 Oarm krokrör 7°-22.5° 63-95 kg/st	15	st	🟩	Betong		0,49375	m3	Average value of 63 and 95 kg/st has been assumed because the exact weight was not known, only this range
	VA- material för infällning av AS1400-ledning	2	x						Excluded due to lack of data
	600 Arm hk 110 raktrör l=2200 466 kg/m	168	m	🟩	Betongrör m. arm.		78,288	ton	Added as new emission factor, see main report
	800 Arm hk 110 raktrör l=2200 855 kg/m	78,75	m	🟩	Betongrör m. arm.		67,33125	ton	
	1400 Arm hk 135 raktrör l=2200 1864 kg/m	63	m	🟩	Betongrör m. arm.		117,432	ton	
	500 Arm hk 200 raktrör l=2200 400 kg/m	115,5	m	🟩	Betongrör m. arm.		46,2	ton	
	500 Arm hk 200 kortrör l=1000 340 kg/st	1,2	st	🟩	Betongrör m. arm.		0,408	ton	
	600 Arm hk 165 kortrör l=1000 450 kg/st	9,6	st	🟩	Betongrör m. arm.		4,32	ton	
	800 Arm hk 165 kortrör l=1000 860 kg/st	7,5	st	🟩	Betongrör m. arm.		6,45	ton	
	Dagvattenbrunn dim 400 mm, komplett, inkl. 3 m rör dim 160 mm	7	st	🟩	Brunn, nedstigningsbrunn betong (estimated)		7	st	Estimated with other concrete well in Klimatkalkyl
	Spillvattenbrunn dim 400 mm, komplett, inkl. 3 m rör dim 160 mm	7	st	🟩	Brunn, nedstigningsbrunn betong (estimated)		7	st	Estimated with other concrete well in Klimatkalkyl
	Rännstensbrunn dim 400 mm, komplett, inkl. 3 m rör dim 160 mm	8	st	🟩	Brunn, nedstigningsbrunn betong (estimated)		8	st	Estimated with other concrete well in Klimatkalkyl
41262	Markprodukter av natursten								
	Råkantsten - RV 4. Import Rak sten. (81 kg/m)	8030	m	🟩	Granit		650,43	ton	Weight calculated
41269	Övriga naturstensmaterial								
	Skiffer till mur - vägg	37,8	m2						Uncertainties in amount, no corresponding category in Klimatkalkyl
	Skiffer till mur - beklädnad	63	m						
41311	Trävirke								
	Virke 50x200 sågat gran G4-2	2750	m	🟩	Trä		27,5	m3	
	K-virke 45x95 gran C14	163,7	m	🟩	Trä		0,6998175	m3	
	Trekantsläkt 21x21 snedsågad	6506,032505	m	🟩	Trä		1,434580167	m3	
	Virke 45x70 dim. hyvlat imp NTR/AB	312	m	🟩	Trä		0,9828	m3	
	Förtillverkade ribbor med stålregel bedömt	63	m2						One missing dim.
	K-virke 45x145 C14 imp NTR/A	2496	m	🟩	Trä		16,2864	m3	
	Formbräda 22x95 G4-4	18253,56683	m	🟩	Trä		38,14995467	m3	
	Formregel 45x95 G4-4	14067,43949	m	🟩	Trä		60,13830381	m3	
	Kompositstag < 1,2m inkl kapkostnad	1116,514805	m		Difficult to estimate due to unknown dim. and materials of form work				
	Periform grundkostnad	346,17159	m2						
	Periform hyra	1753,453196	m2						
	Skivform med brädor	972,625482	m2						
41420	Armering								
	Armering B500B ILF (klippt o bockat) ca	2832672,332	kg	🟩	Stål, armering		2832,672332	ton	
	Armeringsnät NPS500 8100	1097,25	kg	🟩	Stål, armering		1,09725	ton	
41530	VA- material av plast och metall								
	Rördelar 25%	5570	x		Excluded because ype and amount of material is not known exactly. Also, the material should only be a small part of the total amount of piping in the project (Jakob Persson).				
	Rördelar diverse.	2420	x						
	Infiltrationskassetter	340	m3		Excluded				
	Infiltrationskassetter oförutsätt	340	m3						
	63 PE elsvetsmuff PN 10	17,5	st	🟩	PE		4,025	kg	m=0,23 kg (Markvaruhuset, 2020)
41531	Självfallsledningar (ej std)								
	200 PP-markrör l=6m	1331	m	🟩	Ledning av plaströr, dränrör dim 200		1331	m	
	200x174 PP-markrör Pragma PP l=6m	393,75	m	🟩	PP		2706,436911	kg	
	315x276 PP-markrör Pragma PP l=6m	367,5	m	🟩	PP		5987,44893	kg	
	200x110 PP-markgrenrör	60,5	st	🟩	PP		121	kg	Weight for markgrensrör with the same dimensions as in the BoQ is 2,0 kg (Uponor, 2017)
	200/226 Forshedamanschett	1	st		SBR (styrene-butadiene rubber)		0,76	kg	Forshedamanchett 0,76 kg (Rsk-databasen, 2013). Negligible impact, excluded.
41532	Tryckledningar (ej std)								
	150 VRS Pro rakt rör	183,75	m	🟩	Segjärn		5083,75	kg	Assuming that VRS Pro has rougly the same weight as other VRS pipes of the same size: 150: 166 kg/6m (Gustavberg rörsystem, 2012)
	200 VRS rakt rör	315	m	🟩	Segjärn		12022,5	kg	pipe weight 200 229 kg per 6 m (Gustavberg rörsystem, 2012)
	250 VRS rakt rör	105	m	🟩	Segjärn		5320	kg	pipe weight 250: 304 kg per 6 m (Gustavberg rörsystem, 2012)
	300 VRS rakt rör	63	m	🟩	Segjärn		4053	kg	pipe weight 300: 386 kg per 6 m (Gustavberg rörsystem, 2012)
	150 VRS skjutmuff	0	st	-	-	-	-		
	150 låselement VRS	29,16725	st	🟩	Segjärn		23,3338	kg	(Gustavsbergs rörsystem, 2012): 0,8 kg/st
	200 låselement VRS	0	st	-	-	-	-		
	300 låselement VRS	0	st	-	-	-	-		
	150 klämring VRS	0	st	-	-	-	-		
	200 klämring VRS	0	st	-	-	-	-		
	250 klämring VRS	0	st	-	-	-	-		
	300 klämring VRS	0	st	-	-	-	-		
	63 PEM-rör PN10, L=100m	367,5	m	🟩	PEM (polyeten med medeldensitet). Assume PP?		9,059095869	kg	Thickness 5,8 mm. (Ahlsell, n.d.)

	Rördelar tryck 20 %	0	x	-	-	-	-	
41533	Dränledningar (ej std)							
	110/95 DV-dräneringsrör L=4m	966	m		PE			
41534	Kabelskydd (ej std)							
	Kabelmarkeringsband bredd 125 mm	3300	m					
	50/42 PEH GULA kabelrör SRN	402,5	m		PEH			
	110/98 PEH GULA kabelrör SRN Tät	6540	m		PEH			
41536	Brunnar och betäckningar (ej std)							
	Färdig RB av plast inkl betäckning	34,666667	st					
	Färdig spolbrunn brunn av plast inkl betäckning & stuprörs anslutning	46	st					
41537	Ventiler / Armaturer (ej std)							
	1,2-2 Hawle teleskopgarn. DN 50-200	7	st		Excluded			
	63 Hawle Slussventil M Muffar (Ahlsell)	7	st					
	Belos slussventilbetäckning med rund ram flytande	7	st					
41650	Geotextil							
	Geotextil N2	6812,5	m2	🟩	Lager av geotextil	6812,5	m2	
	Geotextil kl 3	7826,5	m2	🟩	Lager av geotextil	7826,5	m2	
	Geotextil N3	4243,75	m2	🟩	Lager av geotextil	4243,75	m2	
	Geotextil kl N4 (ahlsell)	61365,7	m2	🟩	Lager av geotextil	61365,7	m2	
41860	Kemikalier							
	Formolja Formlen fat 220L	306,791171	lit					Excluded
41890	Övrigt kemiskt- tekniskt material							
	Övrigt kemiskt tekniskt material	100	x					Excluded because specfic amounts cannot be seen from this template.
	Desinfektionsmtrl f metallrör(1kr/d=100)	100	x					
	Gödsel NPK	196,72	kg					The manure should not have a relevant environmental impact.
41910	Fästmaterial							
	Dubbelhuvad spik, räfflad, 75-3,4	9,087274	frp					Assumed to have a neglible climate impact
	Trådspik blank lös i låda 75x2,8 3000 st/frp	9,087274	frp					
41916	Armerings och formsättningstillbehör							
	Formstag 8 mm 100-500 ändknopp std	156,24	st					Excluded. Difficult to estimate from this template. (The rebars themselves are assessed under another category).
	Armeringstillbehör rakstål	1133068,933	x					
	Formstag av kolfiber, 1st/m2 x längd stag	2055,683716	m					
42132	Pumpstationer							
	Pumpstation vattenspegel Stn Lindholmen // komplett, bedömt	2	st					No data found
42161	Stödmurar och terrängtrappor							
	L-stödmur 20 kN/m2 2000/2000/1350	40,925	st	🟩	Betong	21,894875	m3	Weight data for 20kN, h=1300mm, l=2000mm--> 1284 kg (Tranås cementvarufabrik, 2020) (Not exactly the same (1000 width of the third dim.) Approximation.
	Blocksteg av btg, natur, bredd=2000 (150x300)	260	st	🟩	Betong	23,4	m3	
	Släntsteg av btg, tillägg håltagning för räcke	400	st	🟩	Betong	27	m3	Assumed same dim. as blocksteg in this category.
	Halkskyddsbehandling blocktrappa (bedömt)	100	st		-	-	-	
	Konstrastmarkering blocktrappa (bedömt)	28,571429	st					Markings: No data and likely negligble impact.
	Blocksteg av btg, natur, bredd=1500 (150x300)	350	st	🟩	Betong	23,625	m3	
42163	Fundament i mark							
	Belysningsfundament	10	st					Dimensions not possible to assess from this data
42165	Stängsel, staket och räcken							
	Trappräcke TRA avsl.del vfz	62	st					Unkown exactly how these would look and what dimensions they would have. (Vfz=varmförzinkat)
	Trappräcke TRB mellandel vfz	226	st					
	Trappräcke TRC startdel vfz	62	st					
42166	Parkmöbler, lek och idrottsutrustning							
	Parkmöbler, lek och idrottsutrustning inkl. montering för stn Järntorget // schablon	1	x		Based on templates. Uncertainties in how these would look and which materials and amounts that would be included. "Pollare" was aslo excluded since no other objects in this category was included even though a specific number was given.			
	Parkmöbler, lek och idrottsutrustning inkl. montering för stn Lindholmen // schablon	1	x					
	Parkmöbler, lek och idrottsutrustning inkl. montering för stn Västra Ramberget // schablon	1	x					
	Parkmöbler, lek och idrottsutrustning inkl. montering för stn Wieselgrensplatsen // schablon	1	x					
	Parkmöbler, lek och idrottsutrustning inkl. montering för Torn A // schablon	1	x					
	Parkmöbler, lek och idrottsutrustning inkl. montering för Torn C // schablon	1	x					
	Parkmöbler, lek och idrottsutrustning inkl. montering för Torn B // schablon	1	x					
	Parkmöbler, lek och idrottsutrustning inkl. montering för Torn D // schablon	1	x					
	Parkmöbler, lek och idrottsutrustning inkl. montering för Torn E // schablon	1	x					
	Parkmöbler, lek och idrottsutrustning inkl. montering för Torn F // schablon	1	x					
	Landskapsanläggning änd stn // schablon	2	x					
	Landskapsanläggning mellan stn // schablon	2	x					
	Pollare. Vestre	451	st					
42169	Övrig markutrustning							
	Buffertcontainer	1	st		Excluded. These would likely be reused.			
	Mätcontainer	1	st					
	pH-justerare	0,666667	st					
	Partickelavskiljare lamell/container	1	st					
	Kemikaliecontainer	1	st					
	Slamhantering	1	st					
	Styrpumpar	2	st					
	Vintersäkring	1	st					
	El + kablage	0,333333	st					
42183	Träd, buskar och växter							
	Gräsfrö	7,89	kg					Vegetation excluded (also, negligible impact)
42210	Grundläggnings och förstärkningsvaror							
	Schaktsläde 1.7x2.8x8.0 (BHL)	5,5	x					Assumed reuse (also small impact and same between the alternatives)
43100	Markanläggningsentreprenader							
	Återställning diverse anläggningar, ytor för stn Järntorget // schablon	100	m2					
	Återställning diverse anläggningar, ytor för Torn A // schablon	100	m2					

	Återställning diverse anläggningar, ytor för Torn B // schablon // Ökat pga osäker omfattning	1000	m2		Not possible to assess the climate impact (quite similar between the alternatives).			
	Återställning diverse anläggningar, ytor för Torn C // schablon	100	m2					
	Återställning diverse anläggningar, ytor för stn Lindholmen // schablon	200	m2					
	Återställning diverse anläggningar, ytor för Torn D // schablon	100	m2					
	Återställning diverse anläggningar, ytor för stn Västra Ramberget // schablon	100	m2					
	Återställning diverse anläggningar, ytor för Torn E // schablon	100	m2					
	Återställning diverse anläggningar, ytor för Torn F // schablon	100	m2					
	Återställning diverse anläggningar, ytor för stn Wieselgrensplatsen // schablon	450	m2					
43111	Rivning, flyttningsentreprenader							
	Rivning bef P-Hus, Lindholmen	1	x					Excluded. Hard to asses since demolition in Klimatkalkyl only concerns road, not buildings
43123	Masstransportsentreprenader							
	Masstransportentreprenad - Förorenat	1231,2	ton					Exclusion due to probable overlap with earth and rock masses included in other categories.
	Masstransportentreprenad - Förorenat	205,2	ton					
43126	Muddringsentreprenader							
	Utläggning massor från pråm (bedömt)	1700	m3					Exclusion due to possible overlap with earth and rock masses included in other categories.
	Muddringsentreprenad	1700	m3					
43135	Fjärrvärme / fjärrkylentreprenader							
	Omläggning FV, FK & Gas enl. Swecos kostnadsförslag dat.	1	x		Not possible to assess amounts of material from this data. Excluded.			
	Fjärrvärmentreprenad dim ?? mm	100	m					
	Fjärrvärmentreprenad servis Lindholmen	100	m					
	Fjärrvärmentreprenad servis Wieselgrensplatsen	150	m					
	Fjärrvärmentreprenad stn Järntorget, budget Sweco	100	m					
	Omläggning Gasledning Lindholmen	1	x					
	Omläggning Fjärrvärmeledning Torn D	1	x					
	Omläggning Fjärrvärmeledning stn Västra Ramberget	1	x					
	Omläggning Gasledning Torn E	1	x					
	Fjärrkylentreprenad dim ?? mm	0	m					
43137	Vägbelysningsentreprenader							
	Vägbelysningsarmatur	10	st					Excluded
	Ledbelysning på mur	63	m					Excluded
	Stolpe eftergivlig L=12 m (vägbelysning)	10	st					
43141	Bergsprängning / losshållningsentreprenader							
	Losshåll berg Hus volym (Ducimus)	5865,3	m3		Not possible to estimate emissions, some possible overlap with rock masses in Klimatkalkyl.			
	Losshåll berg Hus Yta (Ducimus)	1220,291935	m2					
	Losshåll berg tillägg med elekrtoniska tändare (?)	1220,291935	m2					
	Losshållning VA Hm>0,7	1858,170213	m2					
	Losshåll berg ledningsgrav Hm>0,7m	2468,170213	m3					
	Tätsöm berg c/c 600 (Ducimus)	0	m2					
	Vajersågning bergslänt (bedömt)	1700	m2					
	Bergskrotning vägg klass 1A	1219,125683	m2					
	Bergskrotning vägg klass 2A	0	m2					
	Borrning för betongbalk spontfot m bakåtförankring	186	st					
43142	Bergförstärkningsentreprenader							
	Bergbult 25 mm l=6 m	140	st	🟩	Bergbult	140	st	Klimatkalkyl, made of steel, 12 kg/st
43152	Asfaltbeläggningsentreprenader							
	40 mm ABS 8 B70/100 (NCC Roads)	1790,1	m2	🟩	Bitumenbundna lager (180 mm)	397,8	m2	The asphalt is first recalculated into volume by taking depth*area. Then it is recalculated into the area that it would correspond if the depth was 0,18 m = 180 mm (by dividing the total volume with 0,18 m).
	70 mm AG 22 B70/100 (NCC Roads)	1790,1	m2	🟩	Bitumenbundna lager (180 mm)	696,15	m2	
	32 mm ABT 11 (NCC Roads)	13813	m2	🟩	Bitumenbundna lager (180 mm)	2455,644444	m2	
	32 mm ABT 16 (NCC Roads) 70 mm AG 16 (NCC Roads)	20947	m2	🟩	Bitumenbundna lager (180 mm)	5934,983333	m2	Thickness distribution unknown. Mean thickness assumed. (32+70)mm/2
	Tillfällig asfaltbeläggning vid Hjultvätt	100	m2	🟩	Bitumenbundna lager (180 mm)	17,77777778	m2	Unkown thickness. If 32 mm i assumed based on it being temporary and thus probably not needing to be as robust.
43156	Väg och ytmarkeringsentreprenader							
	Ytmarkeringar för trafik (schablon) // stn Järntorget	1	omg		Markings. Probably negligible impact. Based on cost templates. The length/area to mark is not visible through this document.			
	Ytmarkeringar för trafik (schablon) // Torn A	1	omg					
	Ytmarkeringar för trafik (schablon) // stn Lindholmen	1	omg					
	Ytmarkeringar för trafik (schablon) // Torn E	1	omg					
	Ytmarkeringar för trafik (schablon) // Torn F	1	omg					
	Ytmarkeringar för trafik (schablon) // stn Wieselgrensplatsen	1	omg					
	Ytmarkeringar för trafik (schablon) // Torn C	1	omg					
	Ytmarkeringar för trafik (schablon) // Torn D	1	omg					
	Ytmarkeringar för trafik (schablon) // stn Västra Ramberget	1	omg					
43164	Platt- och markbeläggningsentreprenader							
	Sättning skiffer per m	63	m					The same material as shown in other categories above. Excluded here to avoid double-counting.
	UE stensättning råkantsten RV4	8030	m					The same material as shown in other categories above. Excluded here to avoid double-counting.
43165	Stängsel, staket och räckesentreprenader							
	Flätv stängsel h=0.8m plastad ståltråd	63	m		Unknown amount and type. Possibly the material in a category above is used here.			
	Stängsel, räcken, grindar komplett arb. för stn Lindholmen // schablon	1	x					
	Stängsel, räcken, grindar komplett arb. för stn Västra Ramberget // schablon	2	x					
	Stängsel, räcken, grindar komplett arb. för stn Wieselgrensplatsen // schablon	1	x					
	Stängsel, räcken, grindar komplett arb. för stn Järntorget // schablon	1	x					
43180	Trädgårdsentreprenader							
	Lövfällande träd, standardtyp	45	st					
	Plantering buskar	100	m2					
	Vegetationsytor, plantering, träd mm för stn Järntorget // schablon	1	x					
	Vegetationsytor, plantering, träd mm för Torn A // schablon	1	x					

	Vegetationsytor, plantering, träd mm för Torn B // schablon	1	x	Vegetation is outside of scope and likely has a negligible climate impact.
	Vegetationsytor, plantering, träd mm för stn Lindholmen // schablon	1	x	
	Vegetationsytor, plantering, träd mm för stn Wieselgrensplatsen // schablon	1	x	
	Vegetationsytor, plantering, träd mm för Torn C // schablon	1	x	
	Vegetationsytor, plantering, träd mm för Torn D // schablon	1	x	
	Vegetationsytor, plantering, träd mm för Torn E // schablon	1	x	
	Vegetationsytor, plantering, träd mm för Torn F // schablon	1	x	
	Grässådd	4818	m2	
43214	Jordförstärkningsentreprenader			
	Jetpelare, komplett inkl. omh. av slurry PRIS ANTAL KALKYL 1. I KALKYL 2 LÄGGER VI POSTEN I RM	645,276641	st	Too little data is known for these different contractors, excluded in both designs
43224	Broisoleringsentreprenader			
	Isoleringsmatta Länkplatta	40	m2	
	Isoleringsmatta Länkplatta	40	m2	
	Tätskikt bottenplattor	752	m	
43225	Skyddsimpregneringsentreprenader			
	Klotterskydd	590	m2	
43235	Spåranläggningsentreprenader			
	Ny spåranläggning Lindholmen inkl. grundläggning (komplett)	0	m	
	Återställning spåranläggning // 1 spår, vändzon inkl. grundläggning (komplett)	110	m	
43239	Övriga speciella anläggningsentreprenader			
	Leitner	1	x	The CABLE CAR TECHNOLOGY
43320	Betongentreprenader			
	Betongentreprenader, inkl pelarstomme	1397	m2	The actual concrete material used here is shown under Fabriksbetong. Excluded here to avoid double-counting.
	Betongentreprenader, inkl pelare krypgrund	1690	m2	
	Stomme - prefab betong bjl o pelare	242	m2	
	Stomme - prefab betong bjl o pelare	652	m2	
	Stomme - platta på mark	170	m2	
	Stomme - platta på mark	170	m2	
	Stomme - platta på mark	295	m2	
	Stomme - platta på mark	150	m2	
	Armering bottenplatta	0	ton	
	Form bottenplatta H 0.60-3.00	0	m2	
	Gjutning tätkaka/grovbetong	0	m3	
	Gjutning tätkaka/grovbetong	0	m3	
	Gjutning tätkaka/grovbetong	0	m3	
	Gjutning tätkaka/grovbetong	0	m3	
	Gjutning bottenplatta 1% lutning	0	m3	
	Form Pelare	0	m2	
	Timtid diverse arbeten	0	tim	
43340	Stålentreprenader			
	Stålentreprenader	1	x	Same materials as in towers (Jakob persson, personal communication). Not included here to avoid double-counting.. See separate source from NCC for towers.
	Stålentreprenader	1	x	
	Stålentreprenader	1	x	
	Stålentreprenader	1	x	
	Stålentreprenader	1	x	
	Stålentreprenader	1	x	
	Stålentreprenader	1	x	
	Stålentreprenader	1	x	
	Stålentreprenader	1	x	
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	Stålentreprenader	1	x	
	Stålentreprenader	1	x	
	Stålentreprenader	1	x	
	Stålentreprenader	1	x	
	Stålentreprenader	1	x	
	Stålentreprenader	1	x	
	Stålentreprenader	1	x	
	Stålentreprenader	1	x	
	Stålentreprenader	1	x	
	Stålentreprenader	1	x	
	Ingjutningsgods Torn	24	st	
43421	Tätskiktsentreprenader			
	Yttertak - Med vinklar och "nedvik"	684	m2	Shown as inventory tables. Emissions assessed outside of Klimatkalkyl.
	Yttertak - Med vinklar och "nedvik"	997	m2	
	Yttertak - Med vinklar och "nedvik"	968	m2	
	Yttertak - Med vinklar och "nedvik"	709	m2	
	Yttertak - Takfot	156,5	m	
	Yttertak - Takfot	172,5	m	
	Yttertak - Takfot	117,5	m	
	Yttertak - Takfot	154,5	m	
	Yttertak - Inv ytskikt/Undertak av träribbor	684	m2	
	Yttertak - Inv ytskikt/Undertak av träribbor	997	m2	
	Yttertak - Inv ytskikt/Undertak av träribbor	968	m2	
	Yttertak - Inv ytskikt/Undertak av träribbor	744	m2	
	Yttertak - Inv ytskikt/Undertak av marmorocskivor	1605	m2	
	Yttertak - Standard	70	m2	
	Yttertak - Standard	130	m2	
	Yttertak - Standard	65	m2	
	Yttertak - Standard	2346	m2	
	Yttertak - Standard	200	m2	
43470	Glasfasadentreprenader			
	Inklädnad / vägg	1070	m2	
	Tg tak	160,5	m2	
	Inklädnad rulltrappa sidor (glas/plåt)	560	m2	
	Inklädnad rulltrappa tak	168	m2	
	Inklädnad rulltrappa sidor (glas/plåt)	280	m2	

	Inklädnad rulltrappa tak	84	m2	
	Inklädnad rulltrappa sidor (glas/plåt)	280	m2	
	Inklädnad rulltrappa tak	84	m2	
	Inklädnad hiss sidor	400	m2	
	Tg inklädnad hiss tak	40	m2	
	Inklädnad hiss sidor	200	m2	
	Tg inklädnad hiss tak	20	m2	
	Inklädnad hiss sidor	180	m2	
	Tg inklädnad hiss tak	18	m2	
	Inklädnad hiss sidor	180	m2	
	Tg inklädnad hiss tak	18	m2	
	Fasader - Glas	3337	m2	
	Fasader - Glas	147	m2	Shown as inventory tables. Emissions assessed outside of Klimatkalkyl.
	Fasader - täta delar	6820	m2	
43500	Stomkompletteringsentreprenader			
	Installationsgolv	53		
	Installationsgolv	37		
	Installationsgolv	33		
	Installationsgolv	33		
	Installationsgolv	55		
	Installationsgolv	29		
	Installationsgolv	17		
	Installationsgolv	25		
	Installationsgolv	10		
	Installationsgolv	17		
	Installationsgolv	13		
	Stomkomplettering Teknik	405		
	Stomkomplettering Teknik	19		
	Stomkomplettering Teknik	205		
	Stomkomplettering Teknik	101		
	Traforum komplett bygg, inkl inst golv	1	st	
	Traforum komplett bygg, inkl inst golv	1	st	
	Traforum komplett bygg, inkl inst golv	1	st	
	Stomkomplettering Plattformsyta	1335	m2	
	Stomkomplettering Garage	1393	m2	
	Stomkomplettering, Tvättrum	20	m2	
	Stomkomplettering Publik WC	211		
	Personalrum (wc-dusch)	92	m2	Shown as inventory tables. Emissions assessed outside of Klimatkalkyl.
	Entré/kommunikation	311		
437	Ytskiktsentreprenader			
	Invändiga ytskikt Teknik/miljö	471,5		
	Invändiga ytskikt Teknik	205		
	Inv ytskikt, inredning, Kontrollrum	211	m2	
	Inv ytskikt, inredning, Garage	1393	m2	
	Invändiga ytskikt Tvättrum	20		
	Invändiga ytskikt Plattformsyta	344		
	Invändiga ytskikt Plattformsyta	330		
	Invändiga ytskikt Plattformsyta	335		
	Invändiga ytskikt Plattformsyta	326		
	Invändiga ytskikt Entre/kommunikation	51		
	Invändiga ytskikt Entre/kommunikation	60		
	Invändiga ytskikt Entre/kommunikation	155		
	Invändiga ytskikt Entre/kommunikation	45		Shown as inventory tables. Emissions assessed outside of Klimatkalkyl.
	Inv ytskikt, inredning, Personalrum	92	m2	
44100	VS- installationsentreprenader			
	Installationer - Sanitet/Värme	51	m2	
	Installationer - Sanitet/Värme	60	m2	
	Installationer - Sanitet/Värme	45	m2	
	Installationer - Sanitet/Värme	0	m2	
	Installationer - Sanitet/Värme	0	m2	
	Installationer - Sanitet/Värme	155	m2	
	Installationer - Sanitet/Värme	0	m2	
	Installationer - Sanitet/Värme	0	m2	
	Installationer - Sanitet/Värme	29	m2	
	Installationer - Sanitet/Värme	0	m2	
	Installationer - Sanitet/Värme	0	m2	
	Installationer - Sanitet/Värme	0	m2	
	Installationer - Sanitet/Värme	56	m2	
	Installationer - Sanitet/Värme	0	m2	
	Installationer - Sanitet/Värme	17	m2	
	Installationer - Sanitet/Värme	25	m2	
	Installationer - Sanitet/Värme	0	m2	
	Installationer - Sanitet/Värme	205	m2	
	Installationer - Sanitet/Värme	12,5	m2	
	Installationer - Sanitet/Värme	10	m2	
	Installationer - Sanitet/Värme	0	m2	
	Installationer - Sanitet/Värme	1	m2	
	Installationer - Sanitet/Värme	1	m2	
	Installationer - Sanitet/Värme	1393	m2	
	Installationer - Sanitet/Värme	38	m2	
	Installationer - Sanitet/Värme	5	m2	
	Installationer - Sanitet/Värme	17	m2	
	Installationer - Sanitet/Värme	0	m2	
	Installationer - Sanitet/Värme	31	m2	
	Installationer - Sanitet/Värme	13	m2	
	Installationer - Sanitet/Värme	0	m2	
	Installationer - Sanitet/Värme	1	m2	
	Installationer - Sanitet/Värme	86	m2	
	Installationer - Sanitet/Värme	92	m2	
	Installationer - Sanitet/Värme	15	m2	Emissions from installations are assessed outside Klimatkalkyl.
	Installationer - Sanitet/Värme	0	m2	
44120	Sprinklerinstallationsentreprenader (ej std)			
	Installationer - Sprinkler	1393	m2	Shown as inventory in report, but no emission factor was found.
44200	Luftbehandlingsentreprenader			
	Installationer - Luft	51	m2	
	Installationer - Luft	60	m2	
	Installationer - Luft	45	m2	
	Installationer - Luft	53	m2	
	Installationer - Luft	37	m2	
	Installationer - Luft	155	m2	

	Installationer - Luft	55	m2	
	Installationer - Luft	19	m2	
	Installationer - Luft	29	m2	
	Installationer - Luft	33	m2	
	Installationer - Luft	34	m2	
	Installationer - Luft	24	m2	
	Installationer - Luft	56	m2	
	Installationer - Luft	25	m2	
	Installationer - Luft	17	m2	
	Installationer - Luft	25	m2	
	Installationer - Luft	344	m2	
	Installationer - Luft	205	m2	
	Installationer - Luft	12,5	m2	
	Installationer - Luft	10	m2	
	Installationer - Luft	101	m2	
	Installationer - Luft (kanalfläkt, brandspjäll, styr)	1	st	
	Installationer - Luft (kanalfläkt, brandspjäll, styr)	1	st	
	Installationer - Luft	1393	m2	
	Installationer - Luft	38	m2	
	Installationer - Luft	5	m2	
	Installationer - Luft	17	m2	
	Installationer - Luft	330	m2	
	Installationer - Luft	31	m2	
	Installationer - Luft	13	m2	
	Installationer - Luft	335	m2	
	Installationer - Luft (kanalfläkt, brandspjäll, styr)	1	st	
	Installationer - Luft	86	m2	
	Installationer - Luft	92	m2	
	Installationer - Luft	15	m2	Shown as an inventory (in m2) and assessed from another source than Klimatkalkyl
	Installationer - Luft	326	m2	
44300	Kraft-, tele- och belysningsentreprenader			
	Installationskostnad Partickelavskiljare lamell/container	1	st	
	Kraft-, tele- och belysningsentreprenader (enl kalkyl Rejlers dat 190912)	1	st	
	Kraft-, tele- och belysningsentreprenader	1	st	
	Installationskostnad	1	st	
	Installationskostnad Mätcontainer	1	st	
	Installationskostnad pH-justerare	0,666667	st	
	Rörlig kostnad / år pH-justerare	1,333333	st	
	Installationskostnad Kemikaliecontainer	1	st	
	rörlig kostnad /år Kemikaliecontainer	1	st	
	Installationskostnad Slamhantering	1	st	
	rörlig kostnad /år Slamhantering	1	st	
	Installationskostnad Styrpumpar	2	st	
	rörlig kostnad /år el + kablage	1	st	
	Kraft-, tele- och belysningsentreprenader (enl kalkyl Rejlers dat 190912)	1		
	Kraft-, tele- och belysningsentreprenader (enl kalkyl Rejlers dat 190912)	1	st	
	Kraft, tele och belysningsentr.// Hsp kabel Pris?	300	m	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för stn Järntorget	1	x	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-12-21för Torn A	1	x	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för stn Lindholmen	1	x	
	Flytt av betalstation, komplett (bedömt)	1	x	
	El- och telekabel o_d från station till torn, dim? skarvar?	4050	m	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för Torn B (behövs ej)	1	x	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för stn Lindholmen // gällande trafo, under utredning	1	x	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för stn Västra Ramberget // gällande trafo, under utredning	1	x	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-12-21 för Torn C	1	x	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för Torn D	1	x	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för stn Västra Ramberget (behövs ej)	1	x	
	Ledningar HSP, LSP, styr, tele komplett arb.	400	m	
	Skarvar LSP, styr, tele komplett arb.	10	st	
	Extra enl. Linus	1	x	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för Torn E	1	x	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för Torn F	1	x	
	Flytt & omläggning av el-,tele- & optoledningar enl. Swecos kostnadsförslag dat. 2018-09-21 för stn Wieselgrensplatsen	1	x	
	Ny telebrunn (bedömt)	3	x	
	Ny vägbelysning, markbelysning för stn Järntorget // schablon	1	x	
	Ny vägbelysning, markbelysning för Torn A // schablon	1	x	
	Ny vägbelysning, markbelysning för stn Lindholmen // schablon	1	x	
	Ny vägbelysning, markbelysning för stn Västra Ramberget // schablon	1	x	
	Ny vägbelysning, markbelysning för Torn B // schablon	1	x	
	Ny vägbelysning, markbelysning för Torn C // schablon	1	x	
	Ny vägbelysning, markbelysning för Torn D // schablon	1	x	
	Ny vägbelysning, markbelysning för Torn F // schablon	1	x	
	Ny vägbelysning, markbelysning för Torn E // schablon	1	x	
	Ny vägbelysning, markelysning för stn Wieselgrensplatsen // schablon	1	x	
	Installationer - El (sep kalkyl)	37	m2	
	Installationer - El (sep kalkyl)	155	m2	
	Installationer - El (sep kalkyl)	55	m2	
	Installationer - El (sep kalkyl	19	m2	

	Installationer - El (sep kalkyl)	29	m2	🟨	This category is approximated using the areas of electricity installations from another source. Cables etc. are excluded to avoid overlap and double-counting. Lighting are excluded based on that it is expressed with the unit "x", making it difficult to asses. (Facade lightnning is expressed in 1x per station in 1910, making a comparison difficult even though it is expressed in m2 in 1902).			
	Installationer - El (sep kalkyl)	33	m2	🟨				
	Installationer - El (sep kalkyl)	34	m2	🟨				
	Installationer - El (sep kalkyl)	24	m2	🟨				
	Installationer - El (sep kalkyl)	56	m2	🟨				
	Installationer - El (sep kalkyl)	25	m2	🟨				
	Installationer - El (sep kalkyl)	17	m2	🟨				
	Installationer - El (sep kalkyl)	25	m2	🟨				
	Installationer - El (sep kalkyl)	344	m2	🟨				
	Installationer - El (sep kalkyl)	205	m2	🟨				
	Installationer - El (sep kalkyl)	12,5	m2	🟨				
	Installationer - El (sep kalkyl)	10	m2	🟨				
	Installationer - El Funktion, Miljö, Fasadbelysning (enl Rejlers bedömning Lindholmen)	1	st					
	Installationer - El (sep kalkyl	101	m2	🟨				
	Installationer - El (enl separat kalkyl)	1	m2	🟨				
	Installationer - El (sep kalkyl)	51	m2	🟨				
	Installationer - El (sep kalkyl)	60	m2	🟨				
	Installationer - El (sep kalkyl)	1393	m2	🟨				
	Installationer - El (sep kalkyl)	38	m2	🟨				
	Installationer - El (sep kalkyl)	5	m2	🟨				
	Installationer - El (sep kalkyl)	17	m2	🟨				
	Installationer - El (sep kalkyl)	330	m2	🟨				
	Installationer - El (sep kalkyl)	31	m2	🟨				
	Installationer - El (sep kalkyl)	13	m2	🟨				
	Installationer - El Funktion, Miljö, Fasadbelysning (enl Rejlers bedömning Lindholmen)	1	st					
	Installationer - El (enl separat kalkyl)	1	m2	🟨				
	Installationer - El (enl separat kalkyl)	1	m2	🟨				
	Installationer - El (sep kalkyl)	45	m2	🟨				
	Installationer - El Funktion, Miljö, Fasadbelysning (enl Rejlers bedömning Lindholmen)	1	st					
	Installationer - El (sep kalkyl)	86	m2	🟨				
	Installationer - El (sep kalkyl)	53	m2	🟨				
	Installationer - El (sep kalkyl)	92	m2	🟨				
	Installationer - El (sep kalkyl)	15	m2	🟨				
	Installationer - El (sep kalkyl)	326	m2	🟨				
	Installationer - El Funktion, Miljö, Fasadbelysning (enl Rejlers bedömning Lindholmen)	1	st					
	Installationer - El (sep kalkyl)	335	m2	🟨				
44510	Hissinstallationsentreprenader							
	Hiss	1	st	🟩	Hiss	1	st	
	Hiss	2	st	🟩	Hiss	2	st	
	Hiss	1	st	🟩	Hiss	1	st	
	Hiss	1	st	🟩	Hiss	1	st	
	Rulltrappa	2	st	🟩	Rulltrappa	2	st	
	Rulltrappa	4	st	🟩	Rulltrappa	4	st	
	Rulltrappa	2	st	🟩	Rulltrappa	2	st	
45140	Markkomprimeringsmaskiner							
	Envalsvält självg vibr ramstyrd 5-7 ton (Dynapac CA152D)	344,868692	bd			Vibrovält: 0,02 l/m2. Not possible to assess based on this data		
	Envalsvält självg vibr ramstyrd 10-13 ton (Dynapac CA302D)	19,466635	bd			Vibrovält: 0,02 l/m2		
	Envalsvält självgående vibr ramstyrd 20 ton (Dynapac CA6000D)	83,333333	bd			Vibrovält: 0,02 l/m2		
	Vibratorplatta 465 kg (Swepac FB465)	13,1625	bd	🟩	Diesel MK1	70,551	liter	IVL Miljödata för arbetsfordon (Erlandsson, 2013): Vibroplatta 510 kg (diesel): Bränsleåtgång = 1,34 L/h. Utnyttjandegrad = 0,5 h/h. Assume 8h/bd (8h/day assumed in IVL)
	Vibratorplatta 450-700 kg (Swepac FB700)	482,343477	bd	🟩	Diesel MK1	2585,361037	liter	IVL Miljödata för arbetsfordon: Vibroplatta 510 kg (diesel): Bränsleåtgång = 1,34 L/h. Utnyttjandegrad = 0,5 h/h. Assume 8h/bd (8h/day assumed in IVL)
45150	El- och värmeutrustning							
	Generator bensin <3-7 kVA	1,555556	bd					Likely negligible. Excluded in both
	Kompressor på hjul diesel 4 m3/min (KaeserM38	0	bd					
45180	Byggmaskiner							
	Avtappningsslang 6"	25200	bd		Excluded from the scope due to difficulty in approximating emissions for all kinds of machinery. Done in both design alternatives. Also, several of these objects does not consume any fuel and the material in the tool itself is outside the scope.			
	Kompressor på ram för provtryckning 150 l/min	0	bd					
	Kompressor på hjul diesel 6 m3/min (Atlas XAS186DD)	11,613594	bd					
	Centrifugalpump el 550 l/min (Grindex Minex)	0	bd					
	Centrifugalpump el <1900 l/min (Grindex Minor)	252	bd					
	Centrifugalpump el <2400 l/min (Grindex Major H)	2016	bd					
	Centrifugalpump el <5900 l/min (Grindex Master N)	252	bd					
	Mejselhammare luft < 6 kg	0	bd					
	Asfaltkap	20,447736	bd					
	Kärnborrningsutrustning	0,125	bd					
	Svetsmaskin för rör d < 400 mm	0,972222	bd					
	Svetsmaskin för elektrosvets. Dim 110-110 mm. (Bedömd hyra 2.500:-/vecka)	0,583333	bd					
	Provtryckningspump handpump	0	bd					
45210	Lastbilar, dumprar, truckar							
	Vattenbil med tank	0,063898	tim					Excluded, negligible impact
	Tippbil 4-axl 17t	12,552972	tim					Potential overlapp with earth and rock in Klimatklkyl, but also relatively low environmental impact
	Kranbil 3-axl 7t/15tm	18	tim	🟩	Diesel MK1	86,4	liter	IVL Miljödata: Mobile crane, lower effect assumed for both designs. 75-130 kw: 12L/h, load factor 0,4
	Kranbil 3-axl 9t/22tm	336	tim	🟩	Diesel MK1	1612,8	liter	IVL Miljödata: Mobile crane, lower effect assumed for both designs. 75-130 kw: 12L/h, load factor 0,4
45220	Grävmaskiner							How to handle machinery? Overlap in Klimatkalkyl? Eg. Fall B, lastbil
	Grävmaskin bandb 1,0 -1,2 m3 Lång sticka	3033,737333	tim	🟩	Diesel MK1	1820,2424	liter	IVL Miljödata för arbetsfordon: "Minigrävmaskin (minigrävare)" (type not exactly known, probably either <1,3-1,9 ton or 1,8-6.0 ton): Bränsleåtgång =2,4 or 3,5 L/h respectively . Utnyttjandegrad = 0,25 for both cases. Assume smallest type in both designs
	Grävmaskin bandb (21.1325) 21-24 ton	470,9	tim	🟩	Diesel MK1	4614,82	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1325: Bränsleåtgång = 14 L/h. Utnyttjandegrad = 0,7
	Grävmaskin bandb (21.1328) 33-40 ton	3156,573	tim	🟩	Diesel MK1	68181,9768	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1328: Bränsleåtgång = 27 L/h. Utnyttjandegrad = 0,8
	Grävmaskin bandb (21.1322) 14-16 ton	676,033333	tim	🟩	Diesel MK1	6625,126663	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1322 not found, instead 14-28 ton category is used: Bränsleåtgång = 14 L/h. Utnyttjandegrad = 0,7

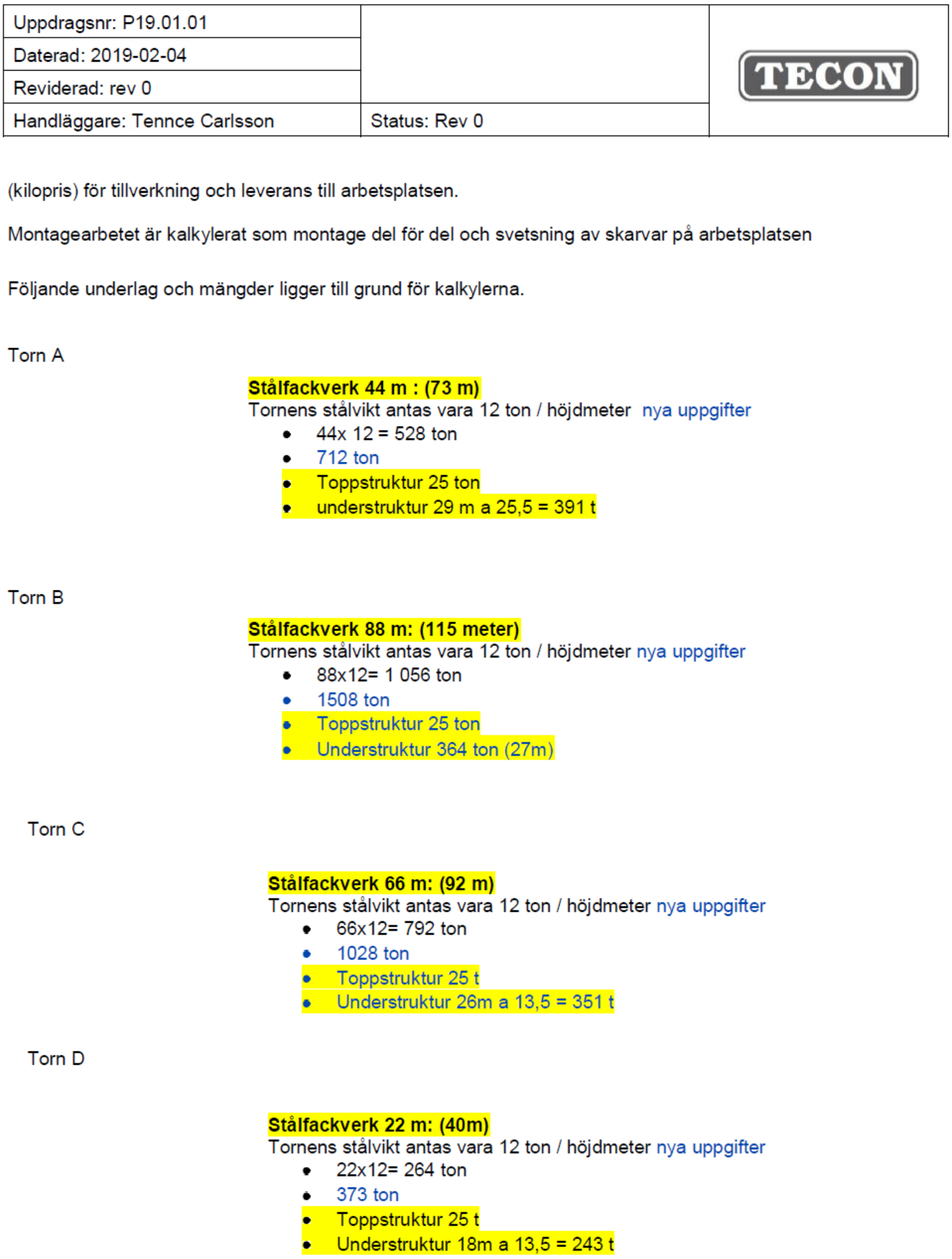
	Grävmaskin bandb (21.1326) 24-28 ton	43,375	tim	🟩	Diesel MK1	425,075	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1326, instead 14-28 ton category is used: Bränsleåtgång = 14 L/h. Utnyttjandegrad = 0,7
	Grävmaskin bandb (21.1327) 28-31 ton	9364,833088	tim	🟩	Diesel MK1	149837,3294	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1327: Bränsleåtgång = 20 L/h. Utnyttjandegrad = 0,8
	Grävmaskin bandb 40t m teleskopsticka	676,033333	tim	🟩	Diesel MK1	14602,31999	liter	IVL Mijlödata för arbetsfordon: Two possibilities: 33-40t or 40-66t. Exact type unknown. Do a conservative assumption and assume the smallest since that would fulfill the 40t demand with a smaller fuel consumption? Bränsleåtgång = 27 L/h. Utnyttjandegrad = 0,8
	Grävmaskin hjulb (21.2418) 0.9-1.0 m3 m vagn	2596,240952	tim	🟩	Diesel MK1	25443,16133	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.2418: Bränsleåtgång = 14 L/h. Utnyttjandegrad = 0,7
	Grävmaskin hjulb (21.2417) 17-20 ton	6	tim	🟩	Diesel MK1	58,8	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.2417: Bränsleåtgång = 14 L/h. Utnyttjandegrad = 0,7
	Hydraul btghammare -30tons maskin	146,166667	tim			No emission data in sou		IVL Miljödata för arbetsfordon: Hydraulhammare (data only given in "per ton of crushed stone/mountain". Probably overlapping with masses, which may apply to several of these...
	Grävmaskin bandb (21.1327) 28-31 ton - bro	362,88	tim	🟩	Diesel MK1	5806,08	liter	IVL Miljödata för arbetsfordon: Maskinklass 21.1327: Bränsleåtgång = 20 L/h. Utnyttjandegrad = 0,8
45230	Hjul och bandlastare, bandschaktare							
	Hjullastare 1.9 m3 - 2.8 m3	76,686417	tim	🟩	Diesel MK1	241,5622136	liter	IVL Miljödata för arbetsfordon: hjullastare capacity assumed to be the lowest at under 13 tonnes: 4,5 L/h, load factor = 0,7
	Hjullastare (22.1517) 18-24 ton	4583,319617	tim	🟩	Diesel MK1	91666,39234	liter	IVL Miljödata för arbetsfordon: hjullastare capacity 17-24 ton: 25 L/h, load factor = 0,8
45240	Väghyvlar							
	Väghyvel	0,666667	tim	🟩	Diesel MK1	8,4000042	liter	IVL Miljödata för arbetsfordon: Assume lowest capacity: 18 L/h, load factor = 0,7
45250	Betongpumpar							
	Betongpump FB M46 pumpad m3	22547,85276	m3					Not included due to double-counting of concrete
	Betongpump FB M42 grundavgift inkl 25 m3 pumpn	5	st		-	-	-	The material in the actual machinery is not assessed, only the fuel consumption during use
	Betongpump FB M46 grundavgift inkl 25 m3 pumpn	103	st		-	-	-	
	Betongpump FB M46 per timme	4303,860057	tim	🟩	Diesel MK1	34430,88046	liter	IVL Miljödata för arbetsfordon: Betongpump 130-560kW: Bränsleåtgång = 40 L/h. Utnyttjandegrad = 0,2
46230	Trafikomläggningsentreprenader							
	Tillfälliga trafikomläggningar, % på MK för stn Järntorget	0	x		-	-	-	
	Tillfälliga trafikomläggningar, % på MK för Torn B	0	x		-	-	-	
	Temorär flytt av flytbrygga // PRIS?	0	x		-	-	-	
	Nytt permanent läge flytbrygga // PRIS?	0	x		-	-	-	
	Tillfälliga trafikomläggningar, % på MK för Torn A	0	x		-	-	-	
	Tillfällig bro för GC-väg över schakten	1	x					Temporary changes in traffic. Excluded due to lack of data.
	Tillfälliga trafikomläggningar, % på MK för stn Wieselgrensplatsen	0	x		-	-	-	
	Tillfällig hållplats för spårvagn för stn Wieselgrensplatsen	1	x					Temporary changes in traffic. Excluded due to lack of data.
	Tillfälliga trafikomläggningar, % på MK för Torn F	0	x		-	-	-	
	Tillfälliga trafikomläggningar, % på MK för stn Lindholmen	0	x		-	-	-	
	Tillfälliga trafikomläggningar, % på MK för Torn C	0	x		-	-	-	
	Tillfälliga trafikomläggningar, % på MK för Torn D	0	x		-	-	-	
	Tillfälliga trafikomläggningar, % på MK för stn Västra Ramberget	0	x		-	-	-	
	Tillfälliga trafikomläggningar, % på MK för Torn E	0	x		-	-	-	
46250	Ställningsentreprenader							
	Ställning	3337	m2		Assuming that the scaffolding will be reused many times, the climate impact allocated to the cable car project should be small (the more uses, the less impact per use). Data on the number of reuses of scaffolding is hard to find. Temporary construction should not be considered if reused. Assumed to be reused enough for the climate impact here to be negligible.			
	Ställning	6820	m2					
	Ställning	1070	m2					
	Ställning	560	m2					
	Ställning	147	m2					
	Ställning	280	m2					
	Ställning	280	m2					
	Ställning	400	m2					
	Ställning	200	m2					
	Ställning	180	m2					
	Ställning	180	m2					
46310	Renhållningsavgifter inkl hyra sopcontainer							
	Tippavgift brännbart inkl. trp. (ton)	120	ton		Excluded. End-of-life is outside of the scope and possible doublecounting with material from other categories that are waste in this step.			
	Tippavgift plaströr inkl. trp. (ton)	96	ton					
	Tippavgift osorterat inkl. trp. (ton)	20	ton					
	Tippavgift el, tele kablar inkl. trp. (ton)	24,77	ton					
	Tippavgift div. obrännbart (ton)	260	ton					
46313	Deponiavgifter (ej std)							
	Tippavgift betong < 500 mm inkl trp (ton)	1420,1	ton		This category only refers to the cost of landfill (deponi). Excluded to avoid double-counting with other categories such as earth masses or residues from concrete etc.			
	Tippavgift SGN-rör inkl trp (ton)	87,5	ton					
	Tippavgift FJV ledning inkl trp (ton)	294	ton					
	Tippavgift bänkar, papperskorgar, pollare, staket inkl trp (ton)	70	ton					
	Tippavgift ytskikt asfalt, betongplattor, kantstöd inkl trp (ton) PRIS?	10316,8	ton					
	Tippavgift asfalt inkl trp (ton)	741,312	ton					
	Tippavgift jordschakt inkl trp (ton)	150	ton					
	Tippavgift jordschakt KM < MKM 110 kr/ton inkl trp, schaktbil 17t 55 kr/ton	109973,2126	ton					
	Tippavgift jordschakt MKM < FA 250 kr/ton inkl trp, schaktbil 17t 55 kr/ton	2794,743	ton					
	Tippavgift jordschakt < KM 45 kr/ton inkl trp, schaktbil 17t 55 kr/ton	29648,7534	ton					
	Tippavgift berg 0 kr/t + trp 55 kr/t	23444,71107	ton					
46410	Handverktyg, redskap							
	Diamantklinga	11,684421	st					No data to assess climate impact (same and excluded from both designs) alternatives)
46630	Formutrustning							
	Arbetsställning	20304,7118	m3		Excluded due to possible reuse and lack of exact data.			
	Formmaterial för avstängning	1348,552137	m2					
	Formkostnad Cuplock	14534,67856	m3					
	Peri form bottenplatta H 1500	2871,315521	m2					
	Peri form bottenplatta H 2500	461	m2					
	Peri form bottenplatta H 3000	373	m2					
46690	Övrigt hyresmaterial							

	Gallervält b=1000	4,276522	bd		Excluded: Rented material, will be reused, low use time
47400	Kontroller och provningar				
	Filmning av rörledning	1310	m	Control and testing is excluded from the scope due to dificulty in approximating data.	
	TV-inspekt av rörledn	700	m		
	Slamsugning brunn	14	st		
	Spolning självfallsledning	700	m		
	Täthetsprovning av självfallsledningar	700	m		
	Täthetsprovning nedstigningsbrunn dim 1000	0	st		
	Täthetsprovning nedstigningsbrunn dim 600	0	st		
	Täthetsprovning nedstigningsbrunn dim 400	14	st		
	Täthetsprovning nedstigningsbrunn dim 200	0	st		
	Täthetsprovning, spolning/rensning samt kloering av tryckledningar dim PE25-160 (bedömt)	985	m		
57110	Bilfrakter				
	Bilfrakter. Vestre	17,346154	st		Excluded based on uncertainties in means of transport, amount of transported material and distance.

A.2 Towers

Data for the towers has been supplied by NCC (via Jakob Persson, personal communication).

Design alternative 1



Uppdragsnr: P19.01.01		TECON
Daterad: 2019-02-04		
Reviderad: rev 0		
Handläggare: Tennce Carlsson	Status: Rev 0	

(kilopris) för tillverkning och leverans till arbetsplatsen.

Montagearbetet är kalkylerat som montage del för del och svetsning av skarvar på arbetsplatsen

Följande underlag och mängder ligger till grund för kalkylerna.

Torn A

Stålfackverk 44 m : (73 m)
Tornens stålvikt antas vara 12 ton / höjdmeter nya uppgifter

- 44x 12 = 528 ton
- 712 ton
- Toppstruktur 25 ton
- understruktur 29 m a 25,5 = 391 t

Torn B

Stålfackverk 88 m: (115 meter)
Tornens stålvikt antas vara 12 ton / höjdmeter nya uppgifter

- 88x12= 1 056 ton
- 1508 ton
- Toppstruktur 25 ton
- Understruktur 364 ton (27m)

Torn C

Stålfackverk 66 m: (92 m)
Tornens stålvikt antas vara 12 ton / höjdmeter nya uppgifter

- 66x12= 792 ton
- 1028 ton
- Toppstruktur 25 t
- Understruktur 26m a 13,5 = 351 t

Torn D

Stålfackverk 22 m: (40m)
Tornens stålvikt antas vara 12 ton / höjdmeter nya uppgifter

- 22x12= 264 ton
- 373 ton
- Toppstruktur 25 t
- Understruktur 18m a 13,5 = 243 t

Torn E

Stålfackverk 44 m: (68m)

Tornens stålvikt antas vara 12 ton / höjdmeter nya uppgifter

- 44x12 = 528 ton
- 712 ton
- Toppstruktur 25 t
- Understruktur 24m a 13,5 = 324 t

Torn F

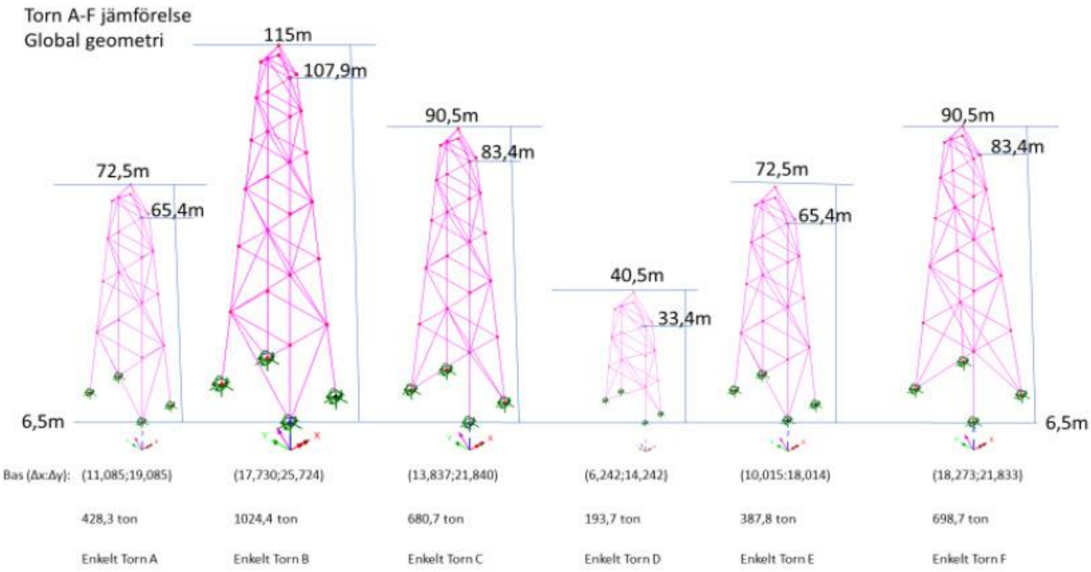
Stålfackverk 66 m: (91 m)

Tornens stålvikt antas vara 12 ton / höjdmeter nya uppgifter

- 66x12= 792 ton
- 1028 ton
- Toppstruktur 25 t
- Understruktur 25m a 13,5 = 337 t

Figure A.1 *Steel weights for alternative 1. The steel weight is calculated by adding the weight of the main body (the blue text) to the under structure. The top structure is not included since this is a cable car component as described in the main report. Data source: NCC.*

Design alternative 2



Bas (Δx:Δy):	(11,085;19,085)	(17,730;25,724)	(13,837;21,840)	(6,242;14,242)	(10,015:18,014)	(18,273;21,833)
	428,3 ton	1024,4 ton	680,7 ton	193,7 ton	387,8 ton	698,7 ton
	Enkelt Torn A	Enkelt Torn B	Enkelt Torn C	Enkelt Torn D	Enkelt Torn E	Enkelt Torn F

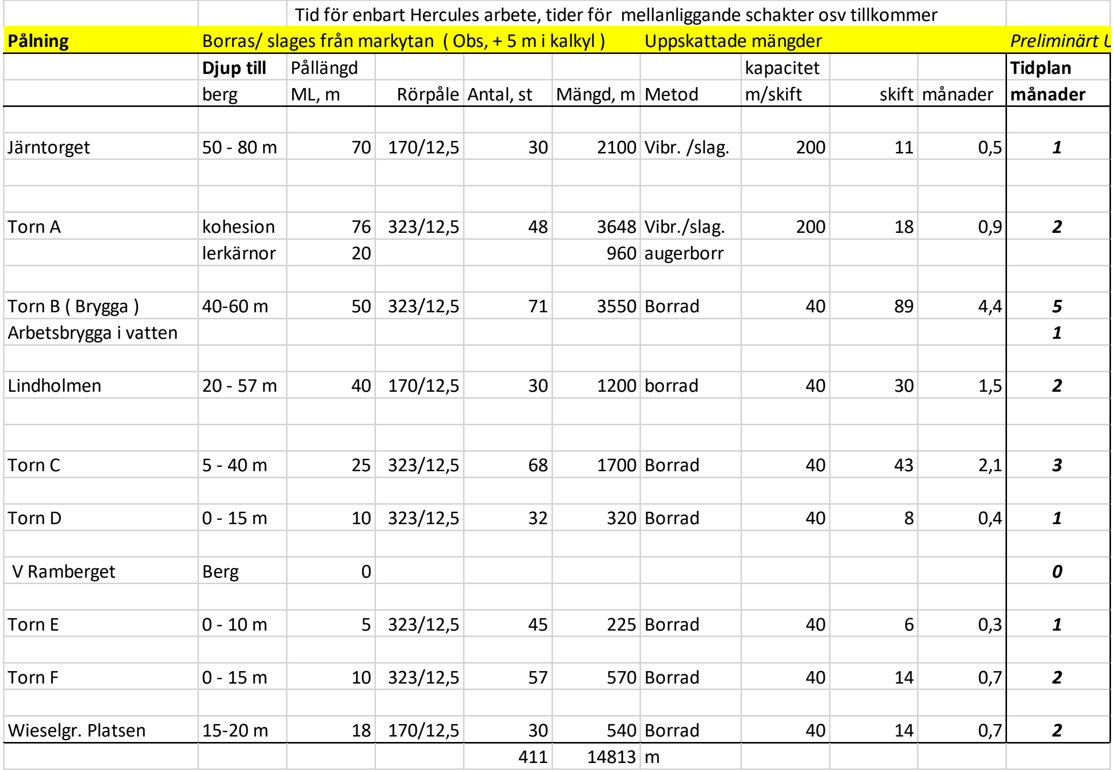
Figure A.2 *Steel weights for alternative 2. Data source: NCC.*

A.3 Piles and Sheet Piling

The source for the data on piling and sheet piling is NCC that have created the bill of quantities. Supplied by Jakob Persson, NCC.

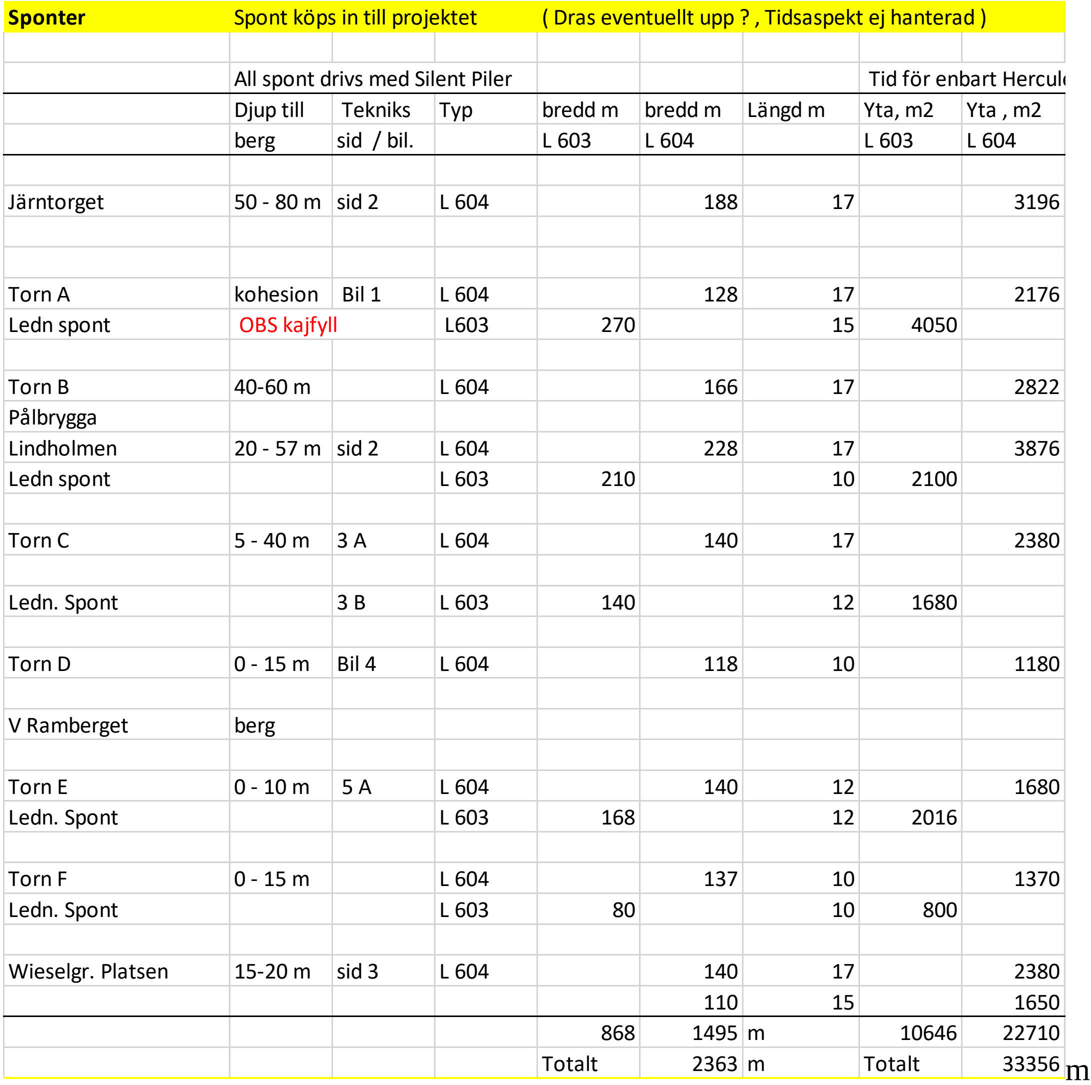
Design alternative 1

Table A.3 Showing the amount of piles for design alternative 1. Data by NCC.



		Tid för enbart Hercules arbete, tider för mellanliggande schakter osv tillkommer								
Pålning	Borras/ slages från markytan (Obs, + 5 m i kalkyl)					Uppskattade mängder				*Preliminärt*
	Djup till berg	Pållängd ML, m	Rörpåle	Antal, st	Mängd, m	Metod	kapacitet m/skift	skift	månader	**Tidplan månader**
Järntorget	50 - 80 m	70	170/12,5	30	2100	Vibr. /slag.	200	11	0,5	***1***
Torn A	kohesion	76	323/12,5	48	3648	Vibr./slag.	200	18	0,9	***2***
	lerkärnor	20			960	augerborr				
Torn B (Brygga)	40-60 m	50	323/12,5	71	3550	Borrad	40	89	4,4	***5***
Arbetsbrygga i vatten										***1***
Lindholmen	20 - 57 m	40	170/12,5	30	1200	borrad	40	30	1,5	***2***
Torn C	5 - 40 m	25	323/12,5	68	1700	Borrad	40	43	2,1	***3***
Torn D	0 - 15 m	10	323/12,5	32	320	Borrad	40	8	0,4	***1***
V Ramberget	Berg	0								***0***
Torn E	0 - 10 m	5	323/12,5	45	225	Borrad	40	6	0,3	***1***
Torn F	0 - 15 m	10	323/12,5	57	570	Borrad	40	14	0,7	***2***
Wieselgr. Platsen	15-20 m	18	170/12,5	30	540	Borrad	40	14	0,7	***2***
				411	14813	m				

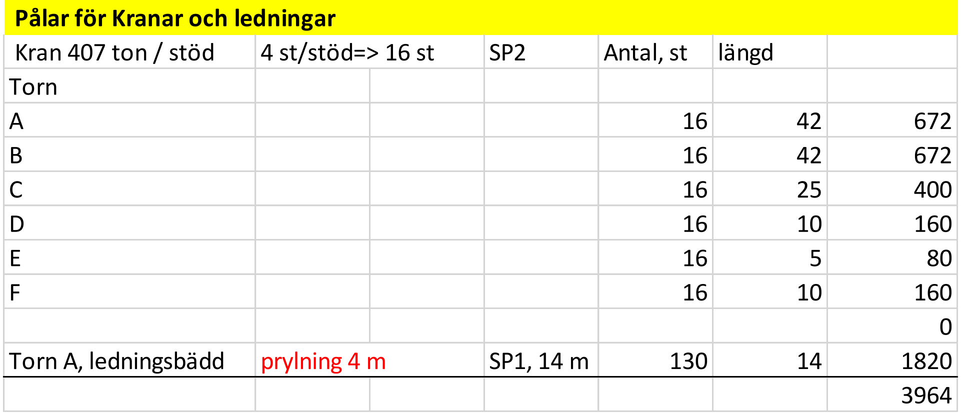
Table A.4 *Showing the amount of sheet piling for design alternative 1. Data by NCC.*



Sponter	Spont köps in till projektet			(Dras eventuellt upp ? , Tidsaspekt ej hanterad)				
	All spont drivs med Silent Piler						Tid för enbart Hercul	
	Djup till berg	Tekniks sid / bil.	Typ	bredd m L 603	bredd m L 604	Längd m	Yta, m2 L 603	Yta , m2 L 604
Järntorget	50 - 80 m	sid 2	L 604		188	17		3196
Torn A	kohesion	Bil 1	L 604		128	17		2176
Ledn spont	OBS kajfyll		L603	270		15	4050	
Torn B	40-60 m		L 604		166	17		2822
Pålbrygga								
Lindholmen	20 - 57 m	sid 2	L 604		228	17		3876
Ledn spont			L 603	210		10	2100	
Torn C	5 - 40 m	3 A	L 604		140	17		2380
Ledn. Spont		3 B	L 603	140		12	1680	
Torn D	0 - 15 m	Bil 4	L 604		118	10		1180
V Ramberget	berg							
Torn E	0 - 10 m	5 A	L 604		140	12		1680
Ledn. Spont			L 603	168		12	2016	
Torn F	0 - 15 m		L 604		137	10		1370
Ledn. Spont			L 603	80		10	800	
Wieselgr. Platsen	15-20 m	sid 3	L 604		140	17		2380
					110	15		1650
				868	1495	m	10646	22710
				Totalt	2363	m	Totalt	33356

m^2

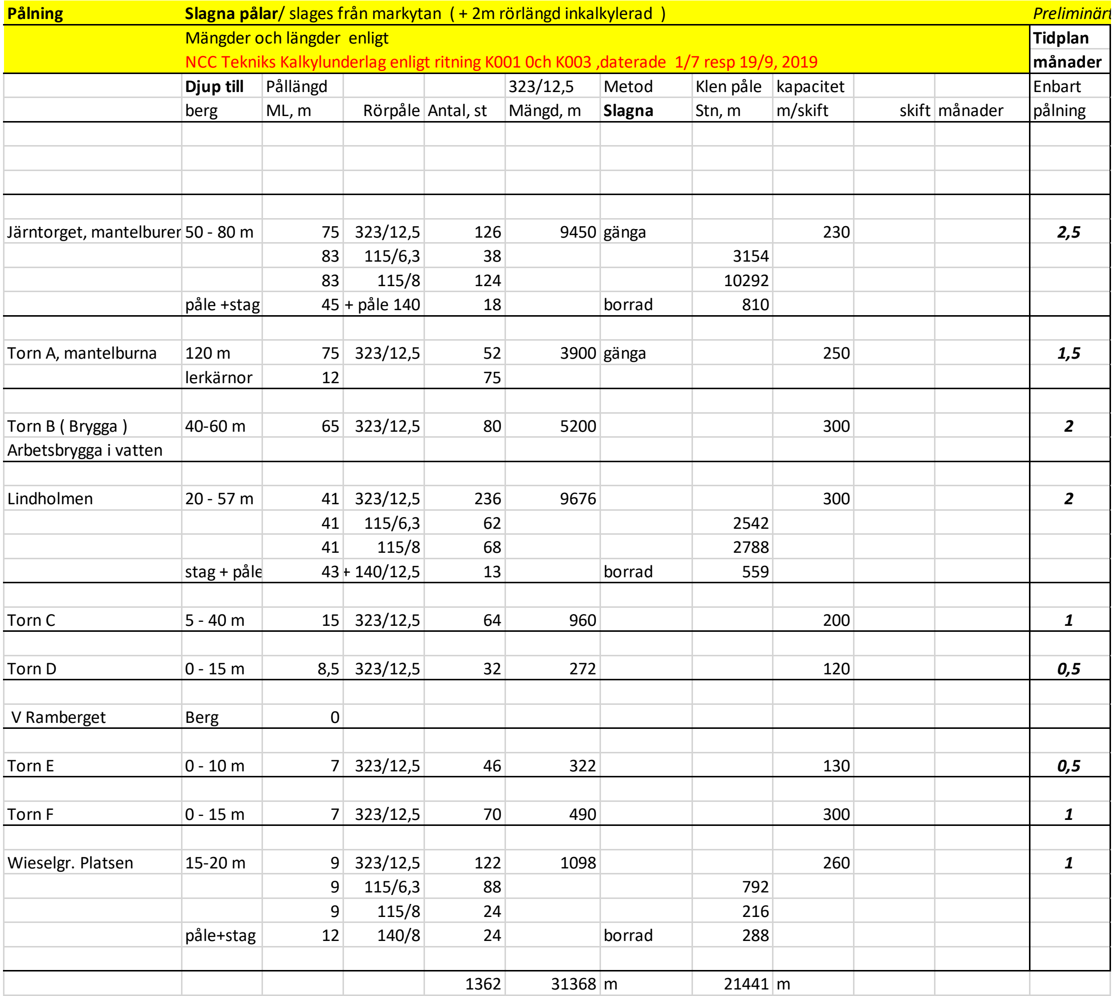
Table A.5 *Showing the amount of concrete piles for cranes and cables in design alternative 1. Data by NCC.*



Pålar för Kranar och ledningar						
Kran 407 ton / stöd	4 st/stöd=> 16 st		SP2	Antal, st	längd	
Torn						
A				16	42	672
B				16	42	672
C				16	25	400
D				16	10	160
E				16	5	80
F				16	10	160
						0
Torn A, ledningsbädd	prylning 4 m		SP1, 14 m	130	14	1820
						3964

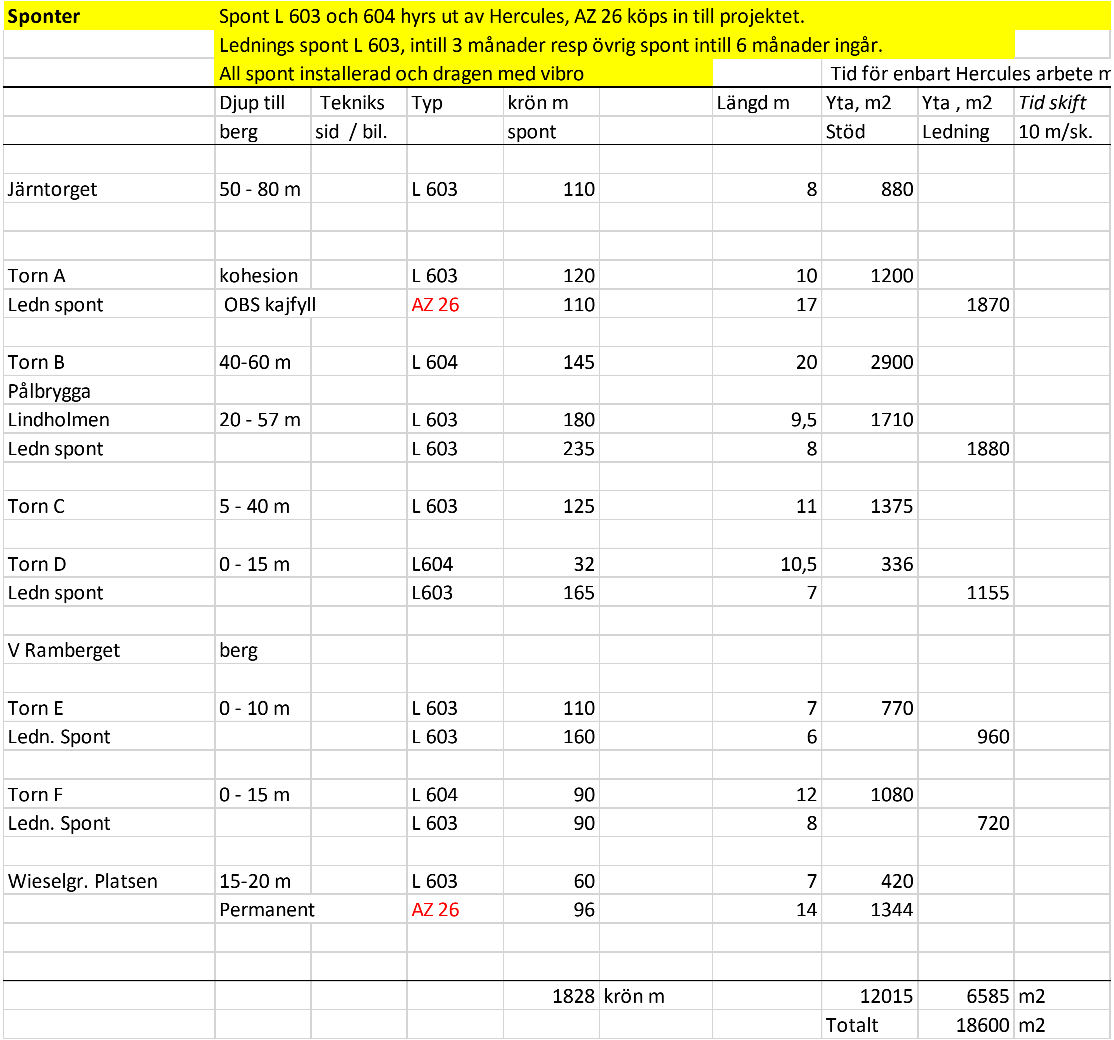
Design alternative 2

Table A.6 Table A.3 Showing the amount of piles for design alternative 2. Data by NCC.



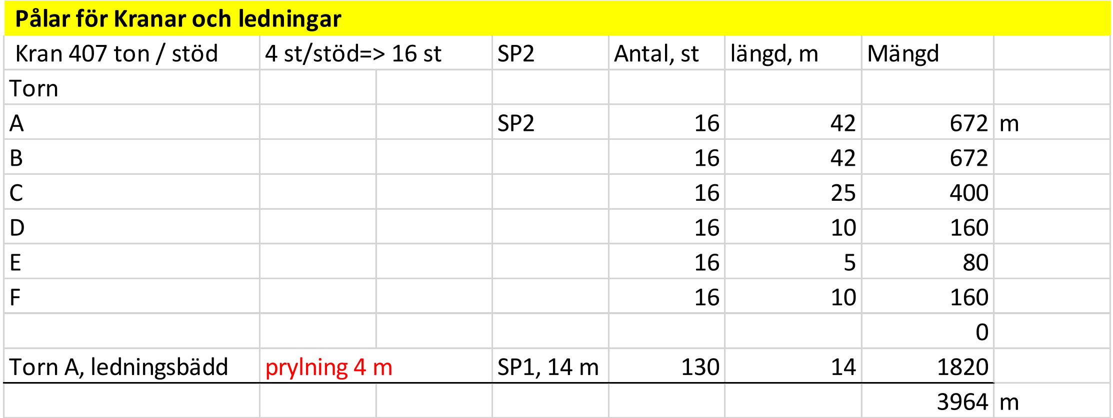
Pålning	**Slagna pålar**/ slages från markytan (+ 2m rörlängd inkalkylerad)										*Preliminär*
	Mängder och längder enligt										**Tidplan**
	NCC Tekniks Kalkylunderlag enligt ritning K001 0ch K003 ,daterade 1/7 resp 19/9, 2019										**månader**
	Djup till	Pållängd			323/12,5	Metod	Klen påle	kapacitet			Enbart
	berg	ML, m	Rörpåle	Antal, st	Mängd, m	**Slagna**	Stn, m	m/skift	skift	månader	pålning
Järntorget, mantelburer	50 - 80 m	75	323/12,5	126	9450	gänga		230			***2,5***
		83	115/6,3	38			3154				
		83	115/8	124			10292				
	påle +stag	45	+ påle 140	18		borrad	810				
Torn A, mantelburna	120 m	75	323/12,5	52	3900	gänga		250			***1,5***
	lerkärnor	12		75							
Torn B (Brygga)	40-60 m	65	323/12,5	80	5200			300			***2***
Arbetsbrygga i vatten											
Lindholmen	20 - 57 m	41	323/12,5	236	9676			300			***2***
		41	115/6,3	62			2542				
		41	115/8	68			2788				
	stag + påle	43	+ 140/12,5	13		borrad	559				
Torn C	5 - 40 m	15	323/12,5	64	960			200			***1***
Torn D	0 - 15 m	8,5	323/12,5	32	272			120			***0,5***
V Ramberget	Berg	0									
Torn E	0 - 10 m	7	323/12,5	46	322			130			***0,5***
Torn F	0 - 15 m	7	323/12,5	70	490			300			***1***
Wieselgr. Platsen	15-20 m	9	323/12,5	122	1098			260			***1***
		9	115/6,3	88			792				
		9	115/8	24			216				
	påle+stag	12	140/8	24		borrad	288				
				1362	31368	m	21441	m			

Table A.7 Showing the amount of sheet piling for design alternative 1. Data by NCC.



Sponter	Spont L 603 och 604 hyrs ut av Hercules, AZ 26 köps in till projektet.								
	Lednings spont L 603, intill 3 månader resp övrig spont intill 6 månader ingår.								
	All spont installerad och dragen med vibro						Tid för enbart Hercules arbete m		
	Djup till berg	Tekniks sid / bil.	Typ	krön m spont		Längd m	Yta, m2 Stöd	Yta , m2 Ledning	*Tid skift* 10 m/sk.
Järntorget	50 - 80 m		L 603	110		8	880		
Torn A	kohesion		L 603	120		10	1200		
Ledn spont	OBS kajfyll		AZ 26	110		17		1870	
Torn B	40-60 m		L 604	145		20	2900		
Pålbrygga									
Lindholmen	20 - 57 m		L 603	180		9,5	1710		
Ledn spont			L 603	235		8		1880	
Torn C	5 - 40 m		L 603	125		11	1375		
Torn D	0 - 15 m		L604	32		10,5	336		
Ledn spont			L603	165		7		1155	
V Ramberget	berg								
Torn E	0 - 10 m		L 603	110		7	770		
Ledn. Spont			L 603	160		6		960	
Torn F	0 - 15 m		L 604	90		12	1080		
Ledn. Spont			L 603	90		8		720	
Wieselgr. Platsen	15-20 m		L 603	60		7	420		
	Permanent		AZ 26	96		14	1344		
				1828	krön m		12015	6585	m2
							Totalt	18600	m2

Table A.8 Showing the amount of concrete piles for cranes and cables in design alternative 2. Data by NCC.



Pålar för Kranar och ledningar							
Kran 407 ton / stöd	4 st/stöd=> 16 st		SP2	Antal, st	längd, m	Mängd	
Torn							
A			SP2	16	42	672	m
B				16	42	672	
C				16	25	400	
D				16	10	160	
E				16	5	80	
F				16	10	160	
						0	
Torn A, ledningsbädd	prylning 4 m		SP1, 14 m	130	14	1820	
						3964	m

A.4 Areas and Installations

In this section, the GWP of the different installations and areas that are assessed outside of Klimatkalkyl are shown. The areas are based on the bill of quantities for each alternative. The areas have been compiled into these tables and are used as a basis of calculating the GWP for each category.

Surface layers

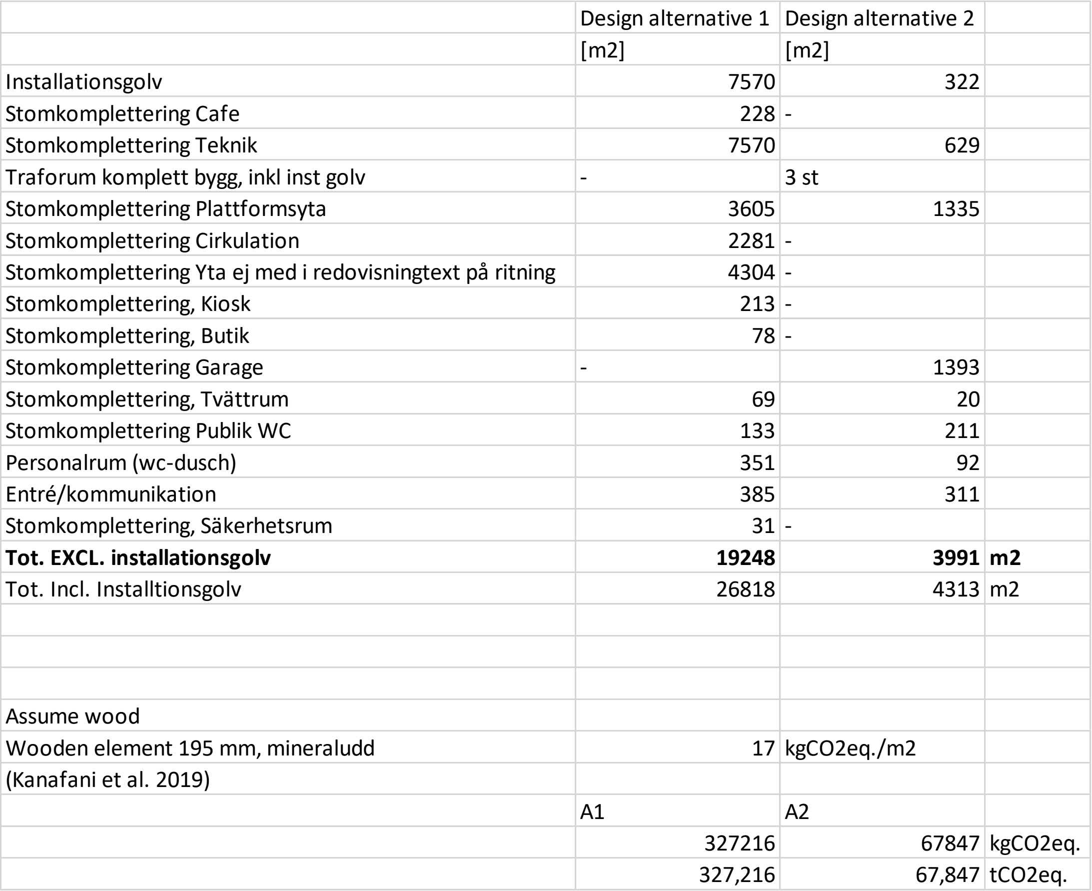
Table A.9 This material was not finally decided but examples of possible materials include concrete plates on the floor and paint and plaster on the walls. An average emission factor of these materials is used. Source for the emission factors is Kanafani et al. (2019). All areas in the category is approximated with this average value to provide a rough estimate of the climate impact.

Ytskiktsentreprenader						
	ALTERNATIVE 1					
	Invändiga ytskikt Entré/kommunikation	385	m2			
	Invändiga ytskikt Teknik/miljö	1276	m2			
	Inv ytskikt, inredning, Kontrollrum	88	m2			
	Inv ytskikt, inredning, Cirkulation	1431	m2			
	Inv ytskikt, inredning, Cirkulation	328	m2			
	Inv ytskikt, inredning, Cirkulation	522	m2			
	Inv ytskikt, inredning, Säkerhetsrum	31	m2			
	Inv ytskikt, inredning,Cafe/Kiosk/Handel	519	m2			
	Invändiga ytskikt WC	45	m2			
	Invändiga ytskikt Tvättrum	69	m2			
	Invändiga ytskikt Plattformsyta	3605	m2			
	Invändiga ytskikt Yta ej med i redovisningtext på ritning	3360	m2			
	Inv ytskikt, inredning, Personalrum	351	m2			
	SUM	12010	m2			
	ALTERNATIVE 2					
	Invändiga ytskikt Teknik/miljö	471,5	m2			
	Invändiga ytskikt Teknik	205	m2			
	Inv ytskikt, inredning, Kontrollrum	211	m2			
	Inv ytskikt, inredning, Garage	1393	m2			
	Invändiga ytskikt Tvättrum	20	m2			
	Invändiga ytskikt Plattformsyta	344	m2			
	Invändiga ytskikt Plattformsyta	330	m2			
	Invändiga ytskikt Plattformsyta	335	m2			
	Invändiga ytskikt Plattformsyta	326	m2			
	Invändiga ytskikt Entre/kommunikation	51	m2			
	Invändiga ytskikt Entre/kommunikation	60	m2			
	Invändiga ytskikt Entre/kommunikation	155	m2			
	Invändiga ytskikt Entre/kommunikation	45	m2			
	Inv ytskikt, inredning, Personalrum	92	m2			
	SUM	4038,5	m2			
This can be both flooring and cover for walls etc.						
Two examples are stone flooring and paint (Jessica Ekberg, personal communication).						
Emission factors						
Floor, concrete, relatively low		13	kgCO2eq/m2			
Painting and plaster, ca		20	kgCO2eq/m2			
Assume 50/50		**16,5**	**kgCO2eq/m2**			
GWP						
A1		198165	kgCO2	=	**198,165**	**tCO2eq.**
A2		66635,25	kgCO2	=	**66,63525**	**tCO2eq.**

Additions/complements to the main frame

This category is represented by wooden elements. In reality, several other materials may also be included but the approximation is done because the exact material was not decided. Source for emission factors: (Kanafani et al., 2019)

Table A.10 The materials that the additions and complements to the main frame would consist of was not finally decided. Here, the total area has been approximated with wooden elements to give a rough estimate. In reality, several other materials may also be included but the approximation is done because the exact material was not decided. Source for emission factors: (Kanafani et al., 2019). Installation flooring is not considered since this was included in a category expressed as a template of 3x below (the category "Träforum komplett bygg"). Since the area was not known for alternative 2, the comparison could be misleading if only the area for alternative 1 had been included.



	Design alternative 1	Design alternative 2	
	[m2]	[m2]	
Installationsgolv	7570	322	
Stomkomplettering Cafe	228	-	
Stomkomplettering Teknik	7570	629	
Traforum komplett bygg, inkl inst golv	-	3 st	
Stomkomplettering Plattformsyta	3605	1335	
Stomkomplettering Cirkulation	2281	-	
Stomkomplettering Yta ej med i redovisningtext på ritning	4304	-	
Stomkomplettering, Kiosk	213	-	
Stomkomplettering, Butik	78	-	
Stomkomplettering Garage	-	1393	
Stomkomplettering, Tvättrum	69	20	
Stomkomplettering Publik WC	133	211	
Personalrum (wc-dusch)	351	92	
Entré/kommunikation	385	311	
Stomkomplettering, Säkerhetsrum	31	-	
Tot. EXCL. installationsgolv	**19248**	**3991**	**m2**
Tot. Incl. Installtionsgolv	26818	4313	m2
Assume wood			
Wooden element 195 mm, mineraludd	17	kgCO2eq./m2	
(Kanafani et al. 2019)			
	A1	A2	
	327216	67847	kgCO2eq.
	327,216	67,847	tCO2eq.

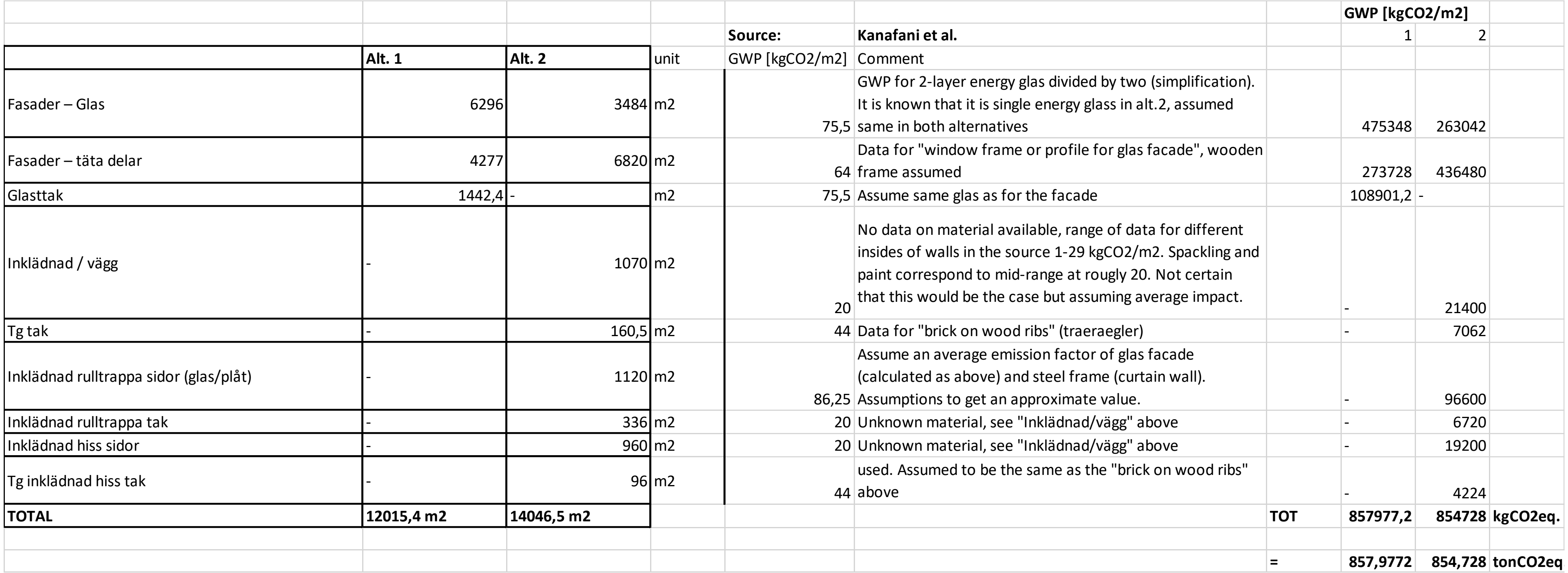
Waterproofing and roofs

Table A.11 Each sub-category has been approximated with corresponding data for GWP. For the first category, waterproofing of epoxy, data for epoxy resin from KBOB et al. (2016) is used as an approximation. For the other emission factors, data from Kanafani et al. (2019) was used. For the outer roofs, trapezoidal steel panels on wooden ribs was used for an approximation of roughly the same materials that would be included in the cable car. It was assumed that the inner roof of wooden ribs and marmoroc-plates was included in the emission factor for the outer roof since this included panels on wooden ribs (the inner roof thus being assumed to be equivalent to those wooden ribs). As the other areas, this is an approximation. In reality, the materials could differ more between the two design alternatives but this difference is not fully captured by this assessment as the roofs are approximated with a similar emission factor (although the areas differ).

Waterproofing and roof								
TÄTSKIKTSENTREPRENADER								
ROOF (Yttertak) &	Design alternative 1	Design alternative 2				Alt1	Alt2	Comments
	[m2]	[m2]	GWP			[kgCO2eq.	[kgCO2eq.]	
Tätskikt typ epoxy	15107	-	10	kgC02eq./m2		151070	-	Epoxy resin (KBOB et al.)
Yttertak – Med vinklar och ”nedvik”	8173,6	3358	43			351464,8	144394	Steel, trapezoidal panels on wooden ribs
Yttertak - Takfot	-	601 m	-			-	-	Needs to be area to fit the source data
Yttertak – Inv ytskikt/Undertak av träribbor	-	3393				-	-	Assumed to be included in the "steel, trapezoidal panels on wooden ribs'"
Yttertak – Inv ytskikt/Undertak av marmorocskivor	9616	1605				-	-	Assumed that this roof is placed under the outer roof and that it is also assessed by the above emission factor
Yttertak - Standard	648,55	2811	43			27887,65	120873	Steel, trapezoidal panels on wooden ribs
					SUMMA	530422,5	265267	
						530,4225	265,267	tCO2eq.

Facades

Table A.12 Estimation of GWP from facades based on areas. Data for emission factors in the table are based on Kanafani et al. (2019). Explanations for the different emission factors can be seen in the column "Comment" in the table. The last two columns show GWP calculated by multiplying the area with the corresponding emission factor for each case.



							GWP [kgCO2/m2]		
				Source:	**Kanafani et al.**		1	2	
	Alt. 1	**Alt. 2**	unit	GWP [kgCO2/m2]	Comment				
Fasader – Glas	6296	3484	m2	75,5	GWP for 2-layer energy glas divided by two (simplification). It is known that it is single energy glass in alt.2, assumed same in both alternatives		475348	263042	
Fasader – täta delar	4277	6820	m2	64	Data for "window frame or profile for glas facade", wooden frame assumed		273728	436480	
Glasttak	1442,4	-	m2	75,5	Assume same glas as for the facade		108901,2	-	
Inklädnad / vägg	-	1070	m2	20	No data on material available, range of data for different insides of walls in the source 1-29 kgCO2/m2. Spackling and paint correspond to mid-range at rougly 20. Not certain that this would be the case but assuming average impact.		-	21400	
Tg tak	-	160,5	m2	44	Data for "brick on wood ribs" (traeraegler)		-	7062	
Inklädnad rulltrappa sidor (glas/plåt)	-	1120	m2	86,25	Assume an average emission factor of glas facade (calculated as above) and steel frame (curtain wall). Assumptions to get an approximate value.		-	96600	
Inklädnad rulltrappa tak	-	336	m2	20	Unknown material, see "Inklädnad/vägg" above		-	6720	
Inklädnad hiss sidor	-	960	m2	20	Unknown material, see "Inklädnad/vägg" above		-	19200	
Tg inklädnad hiss tak	-	96	m2	44	used. Assumed to be the same as the "brick on wood ribs" above		-	4224	
TOTAL	**12015,4 m2**	**14046,5 m2**				**TOT**	**857977,2**	**854728**	**kgCO2eq.**
						=	**857,9772**	**854,728**	**tonCO2eq**

Installations

Table A.13 Showing the total areas of different types of installations. A range of different emission factors are shown as comparison. The values that are used in the calculations are marked with bold font. Values in the lower range were chosen as in order to not overestimate the climate impact. At the bottom under "Scenario", it is shown how the total GWP from installations were calculated. Data for emission factors are based on KBOB et al. (2016).

		Inventory		**Unit**		**Emission factor**		**Source**	**Comments**	**GWP [kgCO2eq]**		
		Alternative 1	Alternative 2						(All data for lifecyle stages A1-A3)	Alternative 1	Alternative 2	
INSTALLATIONS												
	Sanitation/heating	15121	2358,5	m2		0,512	kg CO2eq./m2	KBOB et al.	**Heating, power requirement 10W/m2**	7741,952	1207,552	
						1,53	kg CO2eq./m2	KBOB et al.	Heating, power requirement 30W/m2	23135,13	3608,505	
						2,56	kg CO2eq./m2	KBOB et al.	Heating, power requirement 50W/m2	38709,76	6037,76	
						3,33	kg CO2eq./m2	KBOB et al.	**Sanitation, office, simple, including appliances and pipes**	50352,93	7853,805	
						8,05	kg CO2eq./m2	KBOB et al.	Sanitation, office, complex, including appliances and pipes	121724,05	18985,925	
	Sprinkler	14518	1393	m2		-	-	-	No data found in EOiB			
	Air	15632	4071,5	m2		12,3	kg CO2eq./m2	KBOB et al.	**Ventilation, air volume 1 m3/hm2 EBF**	192273,6	50079,45	
						16,6	kg CO2eq./m2	KBOB et al.	Ventilation, air volume 2 m3/hm2 EBF	259491,2	67586,9	
						25,2	kg CO2eq./m2	KBOB et al.	Ventilation, air volume 4 m3/hm2 EBF	393926,4	102601,8	
						33,7	kg CO2eq./m2	KBOB et al.	Ventilation, air volume 6 m3/hm2 EBF	526798,4	137209,55	
						42,3	kg CO2eq./m2	KBOB et al.	Ventilation, air volume 8 m3/hm2 EBF	661233,6	172224,45	
	Electricity	15726	4074,5	m2		9,3	kg CO2eq./m2	KBOB et al.	Electricity, living house	146251,8	37892,85	
						22,4	kg CO2eq./m2	KBOB et al.	**Electricity, office building**	352262,4	91268,8	
	Electricity Facade Lightning *	10553	-	m2		-	-	-	Excluded (Only shown as areas in alt.1 but as "1 st" per station in alt. 2, making a comparison difficult)			
Scenario												
Assuming the following emission factors												
Sanitation/heating: A mean value of the most basic heating and simple sanitation in an office building								1,921	kg CO2eq./m2	29047,441	4530,6785	
Sprinkler: Excluded due to lack of data								-		-	-	
Air: Assume lowst emission factor								12,3	kg CO2eq./m2	192273,6	50079,45	
Electricity: Assume office building which is in line with type of template buildings that NCC used when they calculated areas for installatio								22,4	kg CO2eq./m2	352262,4	50116,35	
									Scenario total	573583,441	104726,479	Kg CO2eq.
										573,583441	**104,726479**	**Tonne CO2eq**

A.5 Explanation of Inventory Calculations Based on the Bills of Quantities

In this section, a motivation and explanation of calculations and delimitations for each category in the bill of quantities is presented. 1902 refer to design 1 and 1910 to design 2, based on the year and month when each bill was created. Recalculations of amounts is often done due to the need to change the unit from the one in the bill of quantities to another required for input into Klimatkalkyl. The calculations and delimitations described here are specific for each category, more general assumptions and descriptions of the methodology are explained further throughout the main report. The calculation procedure is the same for both design alternatives unless otherwise stated. As far as possible, the same methodology is used for the corresponding categories in both design alternatives in order to make as fair a comparison as possible. Some exceptions occur due to differences in information or materials in the bill of quantities for the alternatives.

Regarding treatment of temporary constructions in Klimatkalkyl, that is included in several categories below, Trafikverket states "A temporary construction that is included as a cost in the cost calculation should be included if it is expected to have an influence on the climate impact. The temporary construction is added as a building part incl. material and fuel (for recycled temporary construction no emissions from material is included, but only fuel for processing/building and demolition. No operation and maintenance are added for the temporary construction" (Trafikverket, 2018).

41111. Fyllnadsjord
The density of earth masses is 1.6 ton/m^3 according to Klimatkalkyl, based on Erlandsson (2010). Dividing the mass by the density gives the volume in m^3. Masses can be classified as case B (Jakob Persson, personal communication).

41112. Växtjord
It is assumed that all types of soil included here have the same density as earth masses in Klimatkalkyl, ρ = 1.6 ton/m^3 (Erlandsson, 2010). Recalculation from weight to volume is done. Masses are classified as case B similar to the above category.

41120. Grusmaterial
Gravel is only included in Klimatkalkyl as a resource that is either part of building parts or included in construction and maintenance activities. Since it is not included as a standalone material in the model, it is assumed to have a similar environmental impact as crushed rock and is classified as such in the inventory. The density for (dry) gravel is set to be 1.5 ton/m^3 as recommended by Erlandsson (2010). Sand is approximated as earth, assuming that the main impact comes from transport and is largely dependent on the weight. Cable sand with the dimension 0-4 mm has a density of 1.4 ton/m^3 (Snabbgrus, accessed 2020, a). No specific density is given for "bakbar sand", but since it has the same particle dimensions it is assumed that the density is the same as for cable sand. The density of cobblestones is 1,5 yon/m^3 (Snabbgrus, accessed 2020, b). Cobblestones in 1910 does not exist in Klimatkalkyl. Instead, this is approximated as "granite" (manually added to Klimatkalkyl). This is based on that the emission factor for granite include finding or creating small rock pits and breaking the rock, removal of the rock with heavy machinery, transportation to storage and further treatment for

cutting or shaping of the material (Trafikverket, 2017). It is assumed that similar treatments will occur for other types of natural rock such as cobblestones. Cobblestones in the bill of quantities (BoQ) have a dimension range of 100-200 mm. Within this range, the density of cobblestone is 1,5 ton/m3 (Snabbgrus, accessed 2020, b). All types of gravel and sand in the category is classified as Case B masses.

41122. Sorterat grus
The density for (dry) gravel is set to be 1.5 ton/m^3 (Erlandsson, 2010; Snabbgrus, accessed 2020, c). and the emission factor is assumed to be the same as for crushed rock. These masses can be classified as case B.

41131. Råbergsmaterial
Blasted rock can be defined as blasted masses of rock irrespectively of the size of the rock fragments (NE, accessed 2020). As the range of particle dimensions is not specified, it is assumed that blasted rock has the same density as crushed rock: 1,8 ton/m^3 (Klimatkalkyl). “Credit in crushed rock” (*kreditering i kross*) is excluded since it is not known exactly known what it refers to and to avoid potential double-counting, but this amount is a relatively small part of the category (Jakob Persson, personal communication).

41133. Krossat bergmaterial
Erlandsson (2010) gives densities for macadam with the same specific dimensions as in the bill of quantities; 1,3 ton/m^3 for macadam with the size 4-8 mm and 1,4 ton/m^3 for the size 8-16 mm. For the rest of the crushed rock, the dimensions (and type) in Erlandsson (2010) does not match those in the bid item lists. It is thus assumed that all other crushed rock has a density of 1,8 ton/m^3 which is the value that is listed in Klimatkalkyl for crushed rock although in reality the exact density would vary depending on the properties and size distribution of the crushed rock.

41210. Fabriksbetong
Most concrete is already given in the required unit m^3. The other parameters (various objects made of concrete in 1910) are recalculated to volumes using their dimensions and the density of concrete used in Klimatkalkyl, 2400 kg/m^3. The concrete in the project is based on CEM I (Jakob Persson, personal communication), *concrete* in Klimatkalkyl. An exception is where it is explicitly stated that the concrete is made of CEM II (*concrete, class 2*). Some additional data regarding the dimension and geometry of two objects were supplied by Jakob Persson (personal communication).

41222. Plattor och marksten av betong
For paving stones, no thickness is specified in the BoQ. For this reason, the building part *betongmarkplattor* (paving stones) in Klimatkalkyl is used where the input is an area and a thickness is assumed. For the other objects included in 1910, all dimensions are specified making it possible to calculate the volume. For this reason, they are classified as “concrete” rather than as paving stones (no thickness needs to be assumed).

41224. Kantstöd av betong
It may be noted that the length of the supports, and the mass transported, is the same in both alternatives. The only difference is that the two different items in 1902 has been summed up into one in 1910. The given transported weight also contain material used in packaging (Jakob Persson, personal communication), it would therefore be

misleading to approximate the whole transported weight as concrete. Instead the volume of the supports is calculated and approximated as pure concrete while the transported weight is excluded to avoid double-counting. It is assumed that each support lies next to each other lengthwise. Steel rebars are not considered which is judged reasonable since they only constitute less than 0,5 % of the total weight (Benders, 2015).

41230. VA-material av betong

Different types of concrete wells are approximated with an existing well in Klimatkalkyl. Non-reinforced concrete pipes are simply categorized as ordinary *concrete*. First, the concrete mass for each type of pipe is calculated by multiplying either the total pipe length by the weight per length or by multiplying the number of pipes with the weight per pipe. The weight of concrete is then recalculated to volume. For pipes where the weight is in a range between two different numbers an average value is used. The weight given in association with the transport includes packaging material, pallets etc. and does thus not give the weight of concrete. The transported weight is thus excluded to avoid double-counting and instead the weight of each separate item is calculated to give a more exact result. For concrete piles reinforced with rebars, the total weight is calculated (since the emission factors for pipes with rebars is weight-based).

41262. Markprodukter av natursten

The natural stone has been approximated as granite. The total weight is calculated based on the given weight per meter.

41269. Övriga naturstensmaterial

This category includes shale for the second design alternative (1910). The volume is not known for certain and the category was excluded due to uncertainties.

41311. Trävirke

The wood is recalculated into the input unit of wood in Klimatkalkyl, cubic meters. It is difficult to estimate the climate impact of formworks or supports that are used. These could possibly also be reusable. They are thus not considered. Their climate impact would likely be relatively low since they are based on wood.

41323. Plywoodskivor

This category is only included in design 1902. Plywood is not included in Klimatkalkyl, instead it is here approximated as wood. In reality, there could be a difference in climate impact between plywood and "pure" wood since different processes are part of the life cycle and different additives could be used in the plywood. However, the amount is small enough that this assumption will likely not impact the overall results.

41420. Armering

For the reinforcement with steel rebars used together with concrete, the pre-set value in Klimatkalkyl, with a global average value, is used. (Klimatkalkyl and Trafikverket, 2017).

41530. VA- material av plast och metall

The exact distribution between plastic and metal in this material is not known, nor is the size of the different parts as this is based on a template made for estimating the cost without the need to know the specific amount of material. An industry average could potentially be used to approximate the material composition but this category would only constitute a small part of the total “VA material” (Jakob Persson, personal communication). Thus, it is excluded based on uncertainties. Data was found for a specified components of PE plastic with the weight 0,23 kg per unit (Markvaruhuset, 2020).

41531. Självfallsledningar (ej std)
All pipes in the category are made from PP-plastic. Weight for branch pipes was found to be 2,0 kg (Uponor, 2017). For pipes with the specified dimension 200 mm, the corresponding building part in Klimatkalkyl. For pipes with other dimensions, no corresponding dimensions were included in Klimatkalkyl. Instead, the total mass per meter of plastic was calculated using Equation (A.1) and the density of PP, 900 kg/m^3 (Uponor, 2007). The mass of material in a pipe wall can be calculated if the outer and inner diameters are known.

$$m = \frac{\rho * \pi}{4} * (d_o^2 - d_i^2) \tag{A.1}$$

41532. Tryckledningar (ej std)
VRS pipes consists of ductile iron with coatings of other materials on the surface (Gustavsberg rörsystem, 2012). The coatings are not taken into account in the assessment. The material of “lock element” is assumed to be the same as the rest of the VRS pipe system. An emission factor for ductile iron was found in (Venkatesh et al., 2009). The mass of medium-density polyethylene (PEM) plastic is calculated by using Equation (A.1), the thickness of the PEM pipes, 5,8 mm (Ahlsell, n.d.) and the density of PEM. The density was in the range 926 – 940 kg/m^3 (Polymer database, 2019). An average value (933 kg/m^3) was used.

41533. Dränledningar (ej std)
Excluded, the climate impact is likely negligible.

41534. Kabelskydd (ej std)
Excluded, the climate impact is likely negligible.

41536. Brunnar och betäckningar (ej std)
Excluded, the climate impact is likely negligible.

41537. Ventiler/Armaturer (ej std)
No emission factor was found and the material quantity is likely negligible.

4160. Geotextil
Geotextile is a building part in Klimatkalkyl expressed in m2. No recalculations is needed.

41860. *Kemikalier*
The only chemical included is form oil. No emission factors were found for this and it was excluded.

41890. Övrigt kemiskt-tekniskt material

This category is excluded. The template is made for estimating the cost, and the amount and specific chemicals are not specified. It is thus not possible to know exact emission factors for this category. Manure likely has a negligible climate impact.

41910. Fästmaterial
Nails, excluded because of the small volume and the negligible contribution to the climate impact.

41916. Armerings och formsättningstillbehör
Excluded, difficult to estimate the material amount from this template. (The rebars themselves are assessed under another category).

42132. Pumpstationer
Only included in 1910. No data was found for the pump station and it was thus excluded.

42161. Stödmurar och terrängtrappor
The number of concrete walls and stairs are recalculated to a total concrete volume for each type of item. For the L-shaped wall, the weight per unit is assumed to be 1284 kg per unit of wall (Tranås cementvarufabrik, 2020). This is an approximation based on a wall with similar dimensions as the exact dimensions was not found in the source. The weight is then recalculated into volume. For the other objects, the volume is calculated from the dimensions given in the BoQ. For the type of step-stone where no dimensions were given (*släntsteg*), the dimensions are assumed to be the same as for the type where they were given (*blocksteg*). It is assumed that the walls and stairs purely consist of concrete, rebars are not considered. Markings and slip protection on the stairs are not included due to lack of data and a likely negligible climate impact.

42163. Fundament i mark
The structure and size of these foundations for lightning was unknown (but the amount is the same in both alternatives). Since the dimensions were not known, the category was excluded.

42165. Stängsel, staket och räcken
The design and dimensions were not known for these different parts of guardrails, they were thus excluded.

42166. Parkmöbler, lek och idrottsutrustning
These outdoor furniture and equipment are based on templates. The amounts or type that would be used are not known. The only specific amount to be given is the number of bollards. However, these were also excluded. Partly for consistency since no other item in this category was included, but also since the exact material composition was not known and no building part in Klimatkalkyl existed for bollards.

42169. Övrig markutrustning
Several types of containers and equipment. These objects would likely be reused and few of each object are used, the category is thus excluded.

42183. Träd, buskar och växter
This category only involves seed of grass in 1910 and is excluded.

42210. Grundläggnings och förstärkningsvaror
This category includes sleds used for transport in connection to excavation of masses. These are assumed to be reused, and only 5,5 is used in each design alternative, likely making the climate impact negligible. The category is thus excluded.

42230. Speciella anläggningsvaror
Only part of 1902. Includes equipment for heating and cooling of concrete. The material or amount is not specified enough to be able to assume any material and this category is thus excluded.

43100. Markanläggningsentreprenader
The category includes restoration of facilities and areas around stations and towers. The total area would not differ much between the alternatives, 2100 m^2 in alternative 1 and 2350 m^2 in alternative 2. The activities involved in the restorations are not possible to assess based on the BoQ. The category is thus excluded.

43111. Rivning, flyttningsentreprenader
Demolition of existing parking garage at Lindholmen. Excluded because of difficulty to assess climate impact. *Demolition* is an activity in Klimatkalkyl but only concerns road, not buildings. Since construction machinery is shown in another category, it is possible that the climate impact from these will cover parts of this category if machinery is used here.

43123. Masstransportsentreprenader
Exclusion due to possible overlap with earth and rock masses included in other categories.

43126. Muddringsentreprenader
Exclusion due to possible overlap with earth and rock masses included in other categories.

43135. Fjärrvärme/fjärrkylentreprenader
Not possible to assess amounts of material from the data in the BoQ.

43137. Vägbelysningsentreprenader
No data was found for assessing the climate impact of this category.

43141. Bergsprängning/losshållningsentreprenader
No data was found for estimating the climate impact from this category. There might be some possible overlap with rock masses that has been included in the climate assessment but this is not certain.

43142. Bergförstärkningsentreprenader
Rock bolt is a building part in Klimatkalkyl with the same unit as in the BoQ, no recalculation is necessary.

43152. Asfaltsbeläggningsentreprenader
Bitumen-bound layers (asphalt) are given in several different depths in the BoQ; 32, 40 or 70 mm respectively. In Klimatkalkyl, the thickness is 180 mm and the unit should

be given in m^2. The dimensions in the BoQ are all converted to 180 mm. First, the total volume of asphalt is calculated by multiplying the area by the thickness for each case in the BoQ. The volume is then divided by 180 mm to give the corresponding area for input in Klimatkalkyl. For the case when asphalt of both thickness 32 and 70 is given within the same category, an average value between these thicknesses is used. For a small area of temporary asphalt (100 m^2) no thickness is given, here 32 mm is assumed.

43156. Väg och ytmarkeringsentreprenader
Markings for traffic. The length or area to mark is not known, nor any other data. The climate impact is thus not possible to assess based on the BoQ.

43164. Platt- och markbeläggningsentreprenader
Excluded to avoid double counting as the material shown here is already shown in another category (This category refers to the cost for the contractor).

43165. Stängsel, staket och räckesentreprenader
Possibly, this material is included in category 42165, the material was not possible to quantify based on the BoQ.

43180. Trädgårdsentreprenader
Vegetation is not considered, the influence on the climate impact is likely negligible.

43214. Jordförstärkningsentreprenader
Not included. The material and dimensions are not possible to asses from the BoQ.

43224. Broisoleringsentreprenader
The material was known. The data given in meters is difficult to convert to full dimensions of the objects in the category.

43225. Skyddsimpregneringsentreprenader
Excluded, unknown material.

43235. Spåranläggningsentreprenader
Facilities for tram, given in meters. Difficult to assess the climate impact of this from the given data.

43239. Övriga speciella anläggningsentreprenader
The actual cable car technology from Letiner is included here. As can be seen, no amounts of specific materials are given. This is outside the scope based on lack of data as described in the main report.

43320. Betongentreprenader
The actual concrete to be used here is shown in category 41210 (Jakob Persson, personal communication). Excluded here to avoid double-counting.

43340 Stålentreprenader
Only included in 1910. This category shows contractors connected to steel. Steel used in the towers is included here (Jakob Persson, personal communication). These amounts are shown in the data for the towers, see Section A.2. It is possible that some steel is

also connected to the stations but this is not possible to assess solely from the data in the BoQ.

43421. Tätskiksentreprenader
Expressed as areas. Emissions assessed outside of Klimatkalkyl as described in the report. For impact assessment, see Table A.11.

43470. Glasfasadentreprenader
Expressed as areas. Emissions assessed outside of Klimatkalkyl as described in the report. For impact assessment, see Table A.12.

43500. Stomkompletteringsentreprenader
Expressed as areas. Emissions assessed outside of Klimatkalkyl as described in the report. For impact assessment, see Table A.10.

437. Ytskiktsentreprenader
Expressed as areas. Emissions assessed outside of Klimatkalkyl as described in the report. For impact assessment, see Table A.9.

44100. VS-installationsentreprenader
Installations expressed as areas. Emissions assessed outside of Klimatkalkyl. For impact assessment, see Table A.13.

44120. Sprinklerinstallationsentreprenader (ej std)
Shown as areas. Areas compiled but no data on emission factors for sprinklers was found on sprinklers in the source used for other types of installations. It was thus excluded from both alternatives.

44200. Luftbehandlingsentreprenader
Installations expressed as areas. Emissions assessed outside of Klimatkalkyl. For impact assessment, see Table A.13.

44300. Kraft-, tele- och belysningsentreprenader
Installations expressed as areas. Emissions assessed outside of Klimatkalkyl. For impact assessment, see Table A.13. All components in this category were not expressed as areas. Those not expressed as areas were excluded to avoid double-counting. Instead, everything was approximated through the areas as shown in Table A.13.

44400. Styr- och övervakningsentreprenader
Only included in 1902. Expressed as area and in meters. Unknown what exactly what activities this refers to and not possible to assess climate impact from the given data.

44500. Transportutrustningsentreprenader
Elevators and escalators in 1902. Added based on emission factors from outside Klimatkalkyl (see main report). The climate impact of the adjustable platforms could not be assessed.

44510. Hissinstallationsentreprenader
Elevators and escalators in 1910. Added based on emission factors from outside Klimatkalkyl (see main report).

45140. Markkomprimeringsmaskiner
Diesel consumption for the vibrator plates are based on Erlandsson (2013). For the other machinery, the source gave the diesel consumption per square meter. The area was not possible to assess from the bill of quantities.

45150. El- och värmeutrustning
No data on material, and likely negligible climate impact. Excluded in both alternatives.

45172. Bygghissar
Only included in 1902. Excluded due to unknown data.

45173. Liftar
The data for the elevator driven by diesel was taken from Erlandsson (2013). No data on electricity consumption was known for the two elevators driven by electricity. They are thus excluded due to lack of data.

45180. Byggmaskiner
There are a larger range of different building machinery in design alternative 1 compared to alternative 2. However, this category is excluded from the scope. Several of the items does not consume fuel and assessment of the material in the actual tools are outside the scope, especially since they will likely be reused in other projects. Also, difficult to assess climate impact but this is probably small in comparison to, for instance, the diesel that is included in other categories.

45210. Lastbilar dumprar, truckar
Diesel consumption is calculated based on Erlandsson (2013). The dumper and water truck are excluded due to lack of data in the source. However, the use time is small so the environmental impact should be negligible.

45220. Grävmaskiner
Diesel consumption is calculated based on Erlandsson (2013). Except for the hydraulic concrete hammer since no data was available for the fuel consumption of this, but this is likely small compared to other fuel consumption based on the relatively low use time compared to other machinery and vehicles in the category.

45230. Hjul- och bandlastare, bandschaktare
Diesel consumption is calculated based on Erlandsson (2013).

45240. Väghyvlar
Diesel consumption is calculated based on Erlandsson (2013).

45250. Betongpumpar
Diesel consumption is calculated based on Erlandsson (2013). The concrete volume is not included to avoid double-counting because the concrete is already excluded above.

45270. Mobilkranar
Diesel consumption assessed based on Erlandsson (2013). The smallest variant of mobile crane in the source is assumed since the exact type is unknown. Only included in 1902.

46230. Trafikomläggningsentreprenader
Temporary changes in traffic and temporary constructions. Also, data on the size of objects or the material included in the temporary constructions are not possible to assess based on the bill of quantities.

46250. Ställningsentreprenader
Temporary constructions that is assumed to be reused. It is thus excluded from the scope.

46270. Kran och hissentreprenader
Includes establishing, service and removal of building crane. Climate impact not possible to assess based on the available data. Only included in 1902.

46310. Renhållningsavgifter inkl hyra sopcontainer
End-of-life stage is excluded from the scope. The material might also already have been included in the assessment in other categories before as this is residues and waste.

46313. Deponiavgifter (ej std)
End-of-life stage excluded. Also, the residues or masses that are part of the amounts here may also be included in other categories above.

46410. Handverktyg, redskap
Diamond blade, no data to assess climate impact. May also be reused in other projects.

46630. Formutrustning
This category is excluded from the scope because of difficulty in finding data for material and because it might be reused.

46640. El, vatten, värme och ventilationsutrustningar
Since the electrical installations are instead approximated based on areas, these electric cables are excluded to avoid double-counting. Category only part of 1902.

46650. Ställningar, skyddsräcken, arbetsbockar och stegar
Assumed that these are reused in other projects. Excluded based on difficulty to allocate climate impact and assess material quantity. Category only part of 1902.

46680 Väderskyddsutrustning
The weight of each unit is given by Jensen Protect AB (n.d.). The material is given to be polyethylene. Category only part of 1902.

46690. Övrigt hyresmaterial
Rented material that will be reused, has a low use time and will probably not consume fuel.

47300. Besiktningar
Only included in 1902. Excluded, difficult to assess the climate impact of this based on the given information.

47400. Kontroller och provningar

Excluded due to difficulty of finding data. Also, can be counted as maintenance which is excluded.

53120. El-förbrukningsavgifter
Included for 1902. Electricity used during construction but probably a small part of the total electricity consumption (Jakob Persson, personal communication).

57110. Bilfrakter
The only transportation that is included is car transportation from the company Vestre. Since no other exact transport of goods is specified this is excluded as well in order to be consistent. Furthermore, the number of "transportations" is given but the distance, type of truck, load and transported cargo is not given, making it difficult to estimate the diesel consumption from transport.

A.6 References in the Appendix and Bills of Quantities

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Personal Communication

Jakob Persson, engineer, NCC. Personal communication occurred at times during the period from February to April, 2020.

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