Hoppet - the first fossil free preschool

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Hoppet - the first fossil free preschool

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Abstract. Residential and commercial buildings give rise to about one fifth of the greenhouse gas emissions in Sweden. One important goal of the City of Gothenburg is to be a climate neutral city with fair emission levels of greenhouse gases in 2030. In order to reach this goal, a demonstration project has been initiated with the aim to build a fossil free preschool - Hoppet. Hoppet will be built with a minimal climate impact and with no fossil resources. This includes everything from production and transport of materials to energy usage in the building. The fossil content and the climate impact of a standard preschool has been calculated, to be used as a benchmark for Hoppet. The result shows that all 250 building products in the reference preschool have a climate impact but finding fossil free and climate neutral alternative products has been found challenging. The climate impact of the building products in the reference preschool is calculated to more than 220 kg CO_2-eq. per m^2. Strategies to decrease climate impact for Hoppet preschool has been developed. For example, product development and innovation has been identified as key issues as well as increased collaboration between different actors in the construction industry. Communicating the project internationally is of high importance to find partners and innovations that don't exist in Sweden as well as to engage other stakeholders to help transform the building sector.

1. Introduction

The City of Gothenburg, in Sweden has set very ambitious goals to take an active role in mitigating climate change. In 2030, Gothenburg is to be climate-neutral, with a sustainable and fair level of greenhouse gas emissions, in order to contribute to the 1.5 degree-target **[1]**. As one of the first municipalities, Gothenburg has set goals, also including emissions occurring outside the city's geographical boundaries, from production of services and goods that are consumed within the city **[2]**. Construction has been identified as one of the city's activities with the largest climate impact. The City of Gothenburg has high standards for energy efficiency in all new construction projects, but so far, no restrictions when it comes to climate impact for building products. The City of Gothenburg is planning to build a lot of residential and public buildings in the coming years. Investments of 8 billion SEK (about 760 million EUR) are planned for 2020-2023.

During the last 10-20 years, the Swedish building sector has been focusing on energy efficiency measures and accordingly, greenhouse gas emissions from heating of buildings have decreased by more than 80% in 1997-2017 [3]. The next challenge is to reduce climate impact from the manufacturing of building products and from fuels used in transportation and on the construction site, considering all parts of a building´s life cycle.

In 2017 the city council of Gothenburg decided to give the city administration a big challenge – to build a fossil free preschool – Hoppet (the name can be translated both to "The hope" and "The leap"). Hoppet is to be built with as much fossil free material and climate neutral construction solutions as possible. The preschool will be finalised in 2021. Another goal for Hoppet is to promote fossil free building products and identify methods and strategies with the potential to be scaled up and eventually to be applied to all building projects in Gothenburg.

1.1. Fossil free construction and system boundaries

The innovation project, Hoppet considers all parts of a building's life cycle, as presented in figure 1, from extraction of raw material, manufacturing of material and products, through transport, to the energy usage at the construction site. Operation and maintenance of the building is also included, as well as demolition. No fossil-based material should be used as raw material and no fossil fuels should be used in production processes, in transportation of products or at the construction site. Reuse and recycled fossil based products are accepted as an alternative to products based on virgin fossil raw material. To minimize the overall climate impact, it is important and to consider the life cycle of the building, in this case in a one hundred years perspective. Thus, for example emissions of greenhouse gases, such as carbon dioxide released when limestone is converted to cement is included.

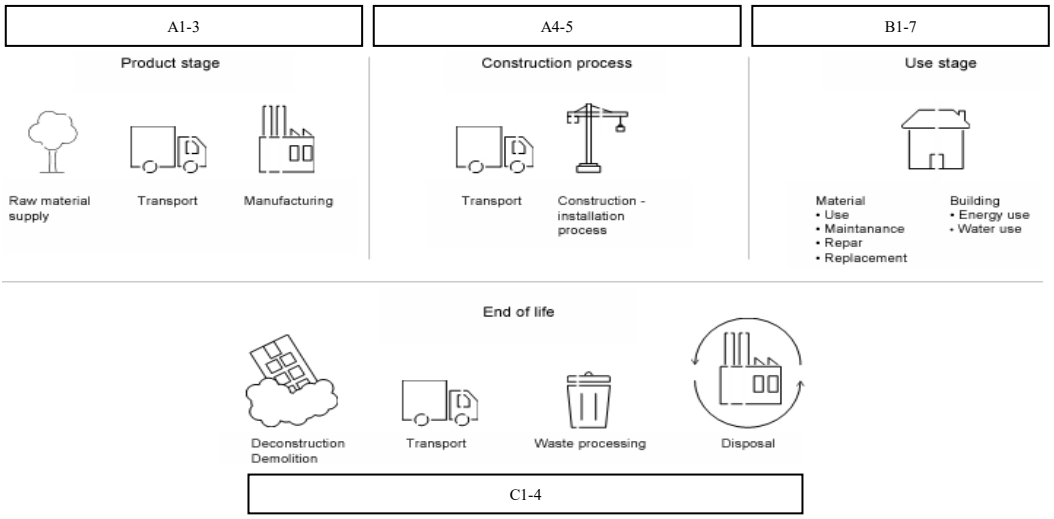

Figure 1. Life cycle stages for a building. Production of building products is referred to as building stages A1-A3, transportation to site is A4 and construction processes is A5. Operation and usage of the building, including energy usage and maintenance, is referred to as stages B1-7. End of life is referred to as C1-4.

2. Methodology – reference preschool and strategies

To get a better understanding of what challenges we need to manage, a first step was to make an inventory of a standard preschool, Byvädersgången, built by the City of Gothenburg. An inventory of the petroleum-based content was made, and a climate impact assessment was carried through for Byvädersgången, which is similar in size as Hoppet. The results are presented in this study, followed by the identified strategies for succeeding in constructing a fossil free preschool.

2.1. Inventory of fossil content in the reference preschool

The preschool, Byvädersgången is considered to represent a standard preschool, built by the City of Gothenburg. The starting point for the inventory was the 230 building products in the preschool registered in the Swedish material evaluation system, Byggvarubedömningen [4]. As a first step, an

investigation was carried through to identify the petroleum-based content of all 230 building products. Fossil fuels used in the production processes and transports have not been included in this inventory.

2.2. Climate impact assessment of the reference preschool

As a second step, the climate impact of the preschool was assessed, including lifecycle stages A1-A4 and A5.1. The product list for Byvädersgången in Byggvarubedömningen was supplemented with data for missing products and quantities from contractors and subcontractors. In total, around 20 products were added to the product list. A newly developed calculator for the Swedish construction sector "Environmental impact calculator for construction" has been used to calculate the climate impact [5]. Each product and its climate impact has been compiled in the calculator. When selecting climate data, the following ranking order has been used:

1. Climate data from environmental product declarations (EPDs) with specific or generic data. [6]
2. Climate data from EPDs for similar products. EPDs for products from the same supplier have been prioritized.
3. Generic climate data for the product.
4. In cases where neither EPD nor generic data for the product have been found, generic data for the containing materials have been used to calculate the climate impact.

The ranking order has been verified by IVL Swedish Environmental institute [7]. Generic data in the calculator has been used to calculate climate impact of transportations of products to the construction site (A4) for each building product. Energy usage at the construction site has not been included.

The total climate impact of Byvädersgången has been calculated as the sum of the impacts of the purchased products, according to equation 1.

$$Total\ climate\ impact_{preschool} = \sum_{i=1}^{i=n}[Product(kg) \times Climate\ impact\ (kg\ CO_2eq./kg)]_n \quad (1)$$

The list of materials for Byvädersgången is based on purchased quantities, hence waste material on the construction site is included (A5.1).

2.3. Strategies for fossil free construction

In order to reduce the climate impact from construction a large part of the construction industry has joined the initiative *Fossil Free Sweden* and created a roadmap for a Fossil Free Construction Sector. The roadmap describes what technological solutions need to be developed, what investments need to be made and what obstacles need to be removed. In the roadmap it is concluded that there need to be a higher focus on the climate impact from the manufacturing of building products and from fuels used in transportation and on the construction site. Therefore, different strategies were identified in order to reach this goal and several of them have been applied in the project Hoppet. Additional strategies have been identified within the project Hoppet through an iterative process where different stakeholders in the industry has participated in workshops and seminars initiated by the Hoppet project team. [8]

3. Results – reference preschool

The results from both the inventory of the petroleum-based content and the climate impact of the reference preschool is presented in this section.

3.1. Results – Petroleum-based content

The result of the inventory of the 230 building products for Byvädersgången is presented in figure 2 and in table 1. A large part of the products is petroleum based, but to various extents. For example, 16% of the building products consist of 80-100% petroleum-based content. [9]

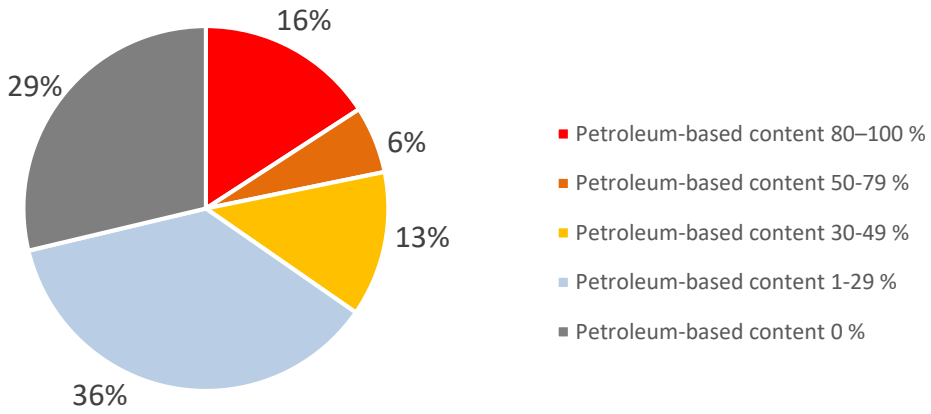

Figure 2. The proportion of the total number of building products (%) in the reference preschool, Byvädersgången. The products are sorted into groups with various share of petroleum-based content.

The result indicates that about 70% of the building products for Byvädersgången consist of materials with petroleum-based origin. The remaining 30% products mainly consist of:

- Metal in plumbing installations; pipes, valves, dampers and mixers (reinforcement in concrete is not included in the inventory),
- Cement or concrete for foundation, staircase, facade, roof and outdoor environment,
- Different types of insulation of stone or glass wool as well as some type of plasterboard,
- Ceramics and leca blocks for bathrooms, kitchens and the outdoor environment,
- Wood products outdoors and in interior decor.

From a life cycle perspective, building products without fossil content can have a large climate impact. For example, the processes for extraction and manufacturing of metals, cement and concrete are energy-intensive and have large climate impact. In addition, limestone in cement and concrete could be classified as a fossil material, which has not been considered in this investigation. Other product groups, such as wood products can in some cases have a relatively high climate impact due to emissions from transports and production processes.

Tabell 1. Building products with various share of petroleum-based content, in the reference preschool

Categories	Products
Red products (petroleum- based content 80-100%)	Pipes and plumbing products, insulation. electrical products, waterproofing and plastic film, foil etc.
Orange products (petroleum-based content 50-79%)	Pipes and plumbing products, cables, artificial grass, foil, surface layers etc.
Yellow products (petroleum-based content 30-49%)	Cables, finishes, concrete joints and color etc.
Blue products (petroleum-based content 1-29%)	Cables, paint, concrete joints, plumbing products, doors and windows, insulation
Grey products (0% petroleum-based content)	Plumbing products (metal), concrete and cement, steel profiles, wood products, leca blocks and ceramics

3.2.

3.3. Results – Climate impact

The results from the calculations are presented for different building components as well as for groups of building products, in figures 3 and 4, respectively. The allocation of building products to the different components, in this investigation, is presented below:

- Basic reinforcement and basic construction: edge support, support walls, factory concrete, primer, concrete base elements and insulation,
- Climate shell and frame: Concrete, insulation, steel profiles, windows, exterior doors, roof boilers, roof drainage, wind protection panels, window drives, sheet metal, rubber strips, sealing layers, plastic foil, sealants and joints,
- Frame supplements: plywood, plaster, coarse concrete, screed, fire joint, internal doors, concrete staircase, leca blocks, fire joint, freezing room joint, steel profiles, walls,
- Plumbing and ventilation: ducts, pipes, dampers, well, motor, donors, housings, insulation, mixers, luminaire grease, WC chair and shower set,
- Electrical and telecommunication systems: cables, VP pipes and flex pipes,
- Transport system: elevator,
- Surface layer: Paint, topcoat, joint, floor, underlay, substructure, washer, tile, panels, adhesive, adhesive floor, linoleum, fire paint, vapor barrier/primer, sealing membrane and plastic mat,
- Other furnishings: cabinets, hatches, drawer fronts, closets, countertops and counters.

The following products have not been included: escape routes, luminaires, push buttons, screws, fasteners, handles, cover strips, ventilation grilles and cover plates etc. in the kitchen/activity rooms. These products have been excluded due to lack of information and/or that the product is not considered to be a significant part of the building's climate impact.

The results from the calculation show that the climate impact of the preschool is 223 kg CO_2-eq per m^2 BTA. Climate shell, frame, foundation and frame supplements together represent 80% of the total climate impact, see figure 3. About 40% of the total climate impact can be allocated to the climate shell and the frame. Surface layers and plumbing represent 12% and 6% respectively. In figure 4 the climate impact for different groups of materials is presented. Products made of concrete, prefabricated concrete, steel and sheet products and insulation have a significant climate impact.

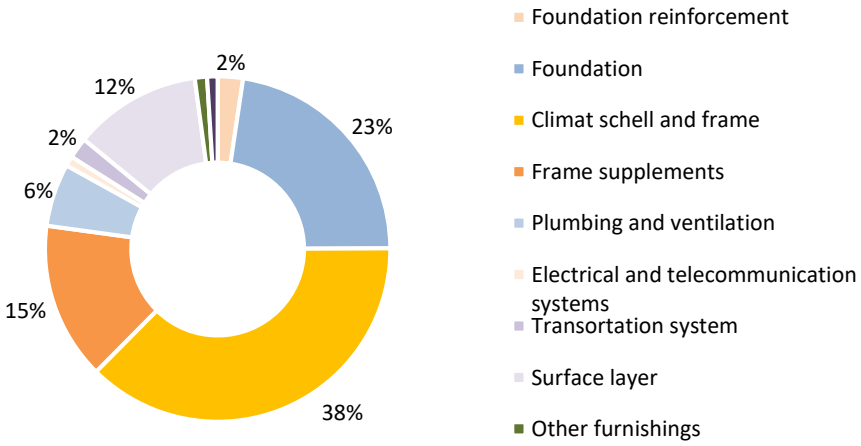

Figure 3. Climate impact of construction components in the reference preschool, Byvädersgången. Life cycle stages A1-A4 and A5.1 are included in the analysis.

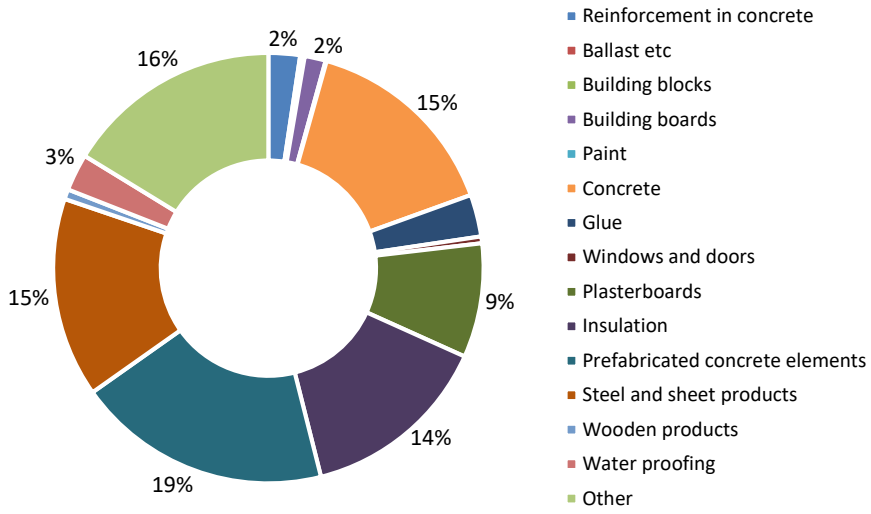

Figure 4. Climate impact of building products in the reference preschool, Byvädersgången. Life cycle stages A1-A4 and A5.1 are included in the analysis.

4. Strategies for fossil free construction

After investigating possibilities for replacing construction materials, by doing a thorough inventory, the project found a sparse selection of fossil free building product already available on the market. The project group then concluded that innovation and new ways of using existing materials were necessary. This, in combination with guidelines from the roadmap for a fossil free construction sector and seminars with stakeholders in the industry, resulted in the establishment of a strategy for progress:

- Biobased building products
- Reused and recycled building products
- Exclude and minimize usage of materials
- Requirements for building products in a life cycle perspective
- Fossil free construction site

Communication is also a vital part of all the identified strategies. Communicating our requirements is important for engaging the appropriate contractor and supplier of building products and to inspire other organizations to set similar requirement to achieve a transformation of the construction business towards climate neutrality. Further research and development is needed for the transition to a fossil free construction sector. Therefore, Hoppet has initiated and take part in several research and development projects, which are described in this section. It is also important to communicate the project internationally to find new partners and innovations that don't exist in Sweden as well as communicating the ambitions of the project to engage other countries and cities to make similar demands.

4.1. Biobased building products

Replacing fossil-based building products with new and existing biobased products is crucial to reduce the climate impact in the building sector. Hoppet tries to promote and highlight such initiatives and initiate research when needed.

4.1.1. Thesis work - Climate impact from wooden construction techniques

In January 2019 a thesis project was initiated focusing on investigating the climate impact and the resource problems related to various wooden construction techniques. Today, many different sectors of

the society are looking to the forest for resources, such as the fuel industry, the packaging industry, the plastic industry, the textile industry, etc. Although the forest is a renewable resource, there is a risk that withdrawals of wood resource could become greater than the re-growth. To avoid this, Hoppet want to find the most effective way to utilize the forest raw material and analyze its climate impact. [10]

4.1.2. Research project – Wood foundation

Wood foundations are one part of a building where wood is used to a very small extent. Traditionally, concrete is used. To move towards increasingly biobased buildings, the foundation is a part of the building where an important minimization of the climate impact can be achieved by using more biobased materials. In this project, the ambition is to investigate the possibilities for industrialized production of wood foundations and to evaluate the technical performance. The project involves actors from the wooden house-building industry, developer and research institute. [11]

4.1.3. Research project - Fossil free glue and paint

Today's glue and paint products are largely based on components with fossil origin. In the research project called "Glue and paint", the aim is to replace fossil components with biobased solutions. By developing more components based on forest raw materials, the glue and paint of the future can become fossil free. The project was running from April to December 2018 and was a collaboration between research institutes, chemical companies, property developers, municipalities and many more. The aim is to find grants to continue the project. [12]

4.1.4. Research project - Policy for sustainable bio-plastics

Today, there is a large uncertainty regarding questions relating to ‘how’ and ‘if’ biobased plastics are socially and environmentally sustainable alternatives to the traditional fossil-based plastics. These uncertainties may be one of the of the obstacles to a large market breakthrough for biobased plastics. This project aims to create possibilities and guidance for sustainable decisions made by organizations which manufactures, contracts or uses biobased plastics. Further, barriers and drivers for conversion to biobased plastics will be analyzed and an action plan for how the barriers can be handled will be presented within the research project. [13]

4.2. Reused and recycled building products

Reused and recycled products have a great potential to replace products made from virgin raw material. Even though Hoppet is a fossil free preschool, products with reused or recycled fossil materials will be allowed. It is important to create recycling methods and logistics systems that can enable circularity both for fossil materials and biobased materials in the future.

4.2.1. Research project - Circularity index

This research project is an investigative project with the aim of increasing the use of circular materials. The goal of the project is to develop a new tool, Circularity Index - CIX, which can be used by the construction industry. The development of the CIX-tool will contribute to reducing both climate and environmental impact in construction projects. It is also an important step in creating conditions for more circular building projects in the design stage. The tool will be developed for a test bed, but the experience and the tool will be publicly available and usable for other projects. The project started in January 2019 and will continue for one and a half year. [14]

4.2.2. Research project - Re:pipe

Hoppet is engaged in a research project called Re:Pipe. Re:Pipe aims to recycle plastic material from old pipes into new pipes, alternatively re-using installation waste to produce new pipes. Funding for two years was granted from the Swedish Energy Agency in February 2019. [15]

4.3. Exclude and minimize usage of materials

There is a large potential in minimizing and excluding materials with fossil content or high climate impact. This is a relatively easy approach, possible to apply for any construction project, which in many cases also saves money and decrease emissions from transports. For Hoppet, for example these measures are discussed:

- Using integrated solar panels, which replaces the need of both installing roof tiles and solar panels,
- Avoiding toilet groups outside of the core of the building, which minimizes the pipe lengths,
- Using one combined technical system for lighting control, ventilation control and alarm system,
- Making more detailed solidity calculations to avoid unnecessary material in the framework.

4.4. Requirements for building products in a life cycle perspective

The results from the inventory of Byvädersgången show that it is vital to promote products with low climate impact in a life cycle perspective. A public organization, as The City of Gothenburg can do that by setting demands in the public procurement process and requesting data for greenhouse gas emissions verified by an EPD or similar. For Hoppet there will be a partnering collaboration with the contractor, to ensure that all measures are made to fulfill the goal of the project. In the procurement process all offers will be evaluated not only by financial performance, but also by cooperativeness and ability to contribute to the climate neutral goal in the Hoppet-project. Transportation of building products to the construction site also give rise to greenhouse gas emissions, but fossil free alternative biofuels are available at the market and will be required.

4.5. Fossil free construction site

The construction of a building is not the main source of climate impact in a life cycle of a building, but still have challenges to handle. For example, there are not a lot of working machines available on the market running on electricity or biobased fuels. The project group has recently started a collaboration with Business Region Gothenburg, responsible for business development in our region, to involve more actors to implement similar requirements to decrease climate impact from construction sites.

5. Concluding discussion

The assignment for Hoppet is to build a fossil free and climate neutral building. After searching the market for fossil free and climate neutral building products, the conclusion is that today it would be impossible to exchange all approximately 250 building products in an ordinary preschool to fossil free and climate neutral alternatives. Besides scouting for new materials and products, our work has been initiating research projects and trying to convert other actors and building owners to demand fossil free and climate neutral building products. However, we have found many companies that are starting to decrease their climate impact and to convert their products using fossil free or recycled materials. All promising, new and old products have to be evaluated and conscious decisions of what to use in Hoppet have to be made.

One initial goal was to create a general ranking method for material evaluation that could be used for comparing all different products or construction components. But after investigating the fossil content and making the climate assessment it became obvious that this would not favor innovation and development. Nor would it stimulate a change in attitude in the building sector. Instead, for Hoppet, decisions will be made on a case by case basis, evaluating product by product to include the potential for a product to be climate neutral in a long-term perspective. For some product groups, the fossil content can be the most challenging to replace. In that case it is most important to stimulate the development of a biobased alternative. For other products it might be the long transportation distances that have the largest climate impact. For those products it would make sense to promote them by purchasing them, resulting in stimulation of start-up of production sites closer to Gothenburg. The aim in Hoppet is to

always choose products where all steps are fossil free and have the lowest possible climate impact, but when it is not possible to find such products the project aims to promote products with the possibility to be climate neutral in the future. During spring 2019, a more detailed system for product evaluation in the design process will be developed.

The benchmark is that the solutions, systems, products and materials we choose should meet all our requirements. The City of Gothenburg's Technical Requirements and Instructions for construction exist to ensure poison free environments, energy efficiency, moisture proofing, good indoor environment and the ability to efficiently manage and operate the properties. If a fossil free solution would contradict any of those requirements, there will be a discussion with the technical specialists on how to proceed.

The task is highly challenging, but in close collaboration with experts, researchers, innovators, entrepreneurs, suppliers and decision-makers we think it is possible to build fossil free. Maybe not for the first preschool, but in a long-time perspective. To inspire change and make a progressive development, an interest and understanding of the importance of fossil free materials and methods needs to be created in all stakeholders in the construction business (nationally and internationally). Hoppet, as the first fossil free demonstration project is an important part of this progress.

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